Using Video Capture to Investigate the Causes of Falls in Long-Term Care

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Purpose: Falls and their associated injuries represent a significant cost and care burden in long-term care (LTC) settings. The evidence base for how and why falls occur in LTC, and for the design of effective interventions, is weakened by the absence of objective data collected on falls.

Design and Methods: In this article, we reflect on the potential utility of video footage in fall investigations. In particular, we report on findings from a Canadian Institute for Health Research-funded research project entitled “Technology for Injury Prevention in Seniors,” detailing 4 distinct methodological approaches where video footage of real-life falls was used to assist in identifying the circumstances and contributory factors of fall events in LTC: questionnaire-driven observational group analysis; video-stimulated recall interviews and focus groups; video observations of the resident 24 hr before the fall; and video incorporated within a comprehensive systemic falls investigative method.

Results and Implications: We describe various ways in which video footage offers potential for both care providers and researchers to help understand the cause and prevention of falls in LTC. We also discuss the limitations of using video in fall investigations, including the logistical, practical, and ethical concerns arising from such an approach.

Key words: Falls, Long-term care, Video
Older adults living in long-term care (LTC), given their frailty and other predisposing factors, are at an increased risk of falls with up to two thirds of residents falling at least once a year on average (Becker & Rapp, 2010). Falls are the number one cause of injury for older adults residing in LTC, representing a significant cost burden in terms of hospitalization and continued care (Quigley, 2012). Falls can also have a deleterious affect on the quality of life of the older adult, leading to decreased confidence, social isolation, and feelings of dependency as a result of post-fall restrictions on mobility (Cumming, Salkeld, Thomas, & Szonyi, 2000). Research has been conducted in LTC to examine risk factors associated with falls (Damián, Pastor-Barriuso, Valderrama-Gama, & de Pedro-Cuesta, 2013; Rubenstein, Josephson, & Robbins, 1994), identifying the contributions and interactions between both internal factors (including gait, balance, and sensory impairments) and external factors (physical hazards, inadequate lighting, and improper use of assistive aides). Preliminary research has also identified the importance of organizational risk factors in falls, for example, social situations, workplace practices, and staffing patterns (Sixsmith et al., 2013).

However, the evidence base for identifying the contributory factors of falls in LTC is undermined by weaknesses in existing reporting procedures such as falls not being witnessed, erroneous fall incident reports, or memory recall bias (Wagner, Capezuti, Taylor, Sattin, & Ouslander, 2005). This has been a barrier to developing an in-depth, holistic understanding of falls, which place the older adult as central to the phenomena surrounded by situational, contextual, and environmental factors that are important in establishing why the fall occurred. Comprehensive systemic fall investigations have been described as one potential approach to capture the contextual factors surrounding falls (Zecevic, Salmoni, Lewko, & Vandervoort, 2007; Zecevic, Salmoni, Lewko, Vandervoort, & Speechley, 2009). However, these rely heavily on the recall of those involved, limiting our ability to determine exactly how and why falls occur in LTC.

The Technology for Injury Prevention in Seniors (TIPS) program based at Simon Fraser University has partnered with two LTC facilities in Greater Vancouver, Canada to collect video footage of real-life falls experienced by residents in common areas of the facilities (Robinovitch et al., 2013). The purpose of this article is to describe the utilization of these video data in four distinct methodological approaches and examine the utility of video recordings as a tool to better understand how and why falls occur in LTC. Our results highlight the opportunities and challenges associated with each approach and provide guidance on how to best position video in future falls research and LTC practice.

**Background**

Observation is a well-practiced research method and has been used across a number disciplines to better understand what people actually do and how they interact within a specific environment (Kawulich, 2005). Traditionally, this has required that the researcher physically position themselves within the environment in order to record events, actions, and interactions as they occur. In recent years, with advances in portability and a reduction in the cost of technology, video has become a more accessible tool for monitoring behaviors of humans in public and private spaces (Adomat & Hicks, 2003). Video-captured observation and analysis has been extensively used in health (Weinger, Gonzales, Slagle, & Syeed, 2004), education (Chang & Hirsch, 1994), and nursing research (Andersen & Adamsen, 2001). Although the research approach varies by application and target group, video observations have been utilized in three main ways: as stand-alone data for analysis (e.g., of patterns of movement in and around spaces), to stimulate new data (e.g., stimulated recall used to elicit in-depth participant accounts), and as a tool to change practice (e.g., as a mechanism for reflecting on and improving professional practice; Pirie, 1996).

Video observations have been applied in nursing research to monitor communication between caregivers and older people living in the community, and in residential care with the intention of improving the clinical and social aspects of face-to-face care (Caldwell & Atwal, 2005; Høstgaard & Bertelsen, 2012). Video monitoring has been used to observe the lifestyle of older people, for example, converting continuous video recording into algorithms to detect progressive wandering and elopement risk among individuals living with dementia (Chen, Bharucha, & Wactlar, 2007) or to monitor the completion of activities of everyday living (Mihailidis & Boger, 2009). As a data collection aide, video has been utilized within a stimulated recall approach, for example, during interviews and focus groups with health care professionals, to illicit new insights and stimulate reflection on existing workplace practices (Hansebo & Kihlgren, 2001; van Lonkhuijzen et al., 2011). In a participatory way, video has been used as a training aide to facilitate knowledge transfer and improve health care delivery in residential care (Caris-Verhallen, Kerkstra, Bensing, & Grypdonck, 2000; Sloane et al., 2007).

One benefit of video-captured data is that they provide the opportunity to replay and review events and actions, and achieve levels of detail in observation and analysis that are difficult to capture through direct person-to-person observations (Heacock, Souder, & Chastain, 1996). It is also argued that video data are less open to subjectivity and selectivity bias, as stored video recordings allow
for multiple researchers to analyze the secondary data, improving the validity of the observations (Haidet, Tate, Divirgilio-Thomas, Kolanowski, & Happ, 2009). Yet, there are challenges with using video data. Research has explored the use of video observations from an ethical angle, debating issues of privacy and intrusiveness, especially when deployed in the home or private spaces of residential care facilities (Dorsten, Sifford, Bharucha, Mecca, & Wactlar, 2009; Minuk, 2006). Furthermore, video monitoring can affect naturally occurring behaviors, when for example individuals alter their behavior in response to “being watched”; the so-called Hawthorne effect (Fernald, Coombs, DeAlleaume, West, & Parnes, 2012).

Research has highlighted the limitations of existing falls reporting mechanisms, particularly in health care settings, where there is a high degree of unpredictability and complexity (Norris, Patterson, & Feightner, 2003). Video capture of falls has been used by our team and others (Holliday, Fernie, Gryfe, & Griggs, 1990; Robinovitch et al., 2013) to describe the biomechanical features of falls (e.g., cause of imbalance, activity at the time of falling, protective responses, and impact sites). However, video observations in isolation may be divorced from contextual factors (Latvala, Vuokila-Oikkonen, & Janhonen, 2000) and system-wide influences that are important for fall prevention (Zecevic et al., 2007, 2009). Integration of video footage into existing contextual frameworks may enhance its utility in fall prevention in residential care. To this end, this article reports on the application of four approaches to the use of video observations and analysis in LTC, identifying the various opportunities and challenges for each approach.

**Methods**

TIPS has established a unique library of more than 900 video-captured falls experienced by older adults, acquired through a network of 264 cameras installed in the communal areas (i.e., hallways, living room, dining room) of two LTC facilities in Greater Vancouver (Robinovitch et al., 2013; Yang, Schonnop, Feldman, & Robinovitch, 2013). No falls have been captured in bedrooms or bathrooms, and no audio was collected with the video recordings. As mandated by the British Columbia Health Act, care personnel at the facilities were required to complete a fall incident report for each known occurrence of a fall. TIPS researchers reviewed incident reports on a weekly basis to identify falls in common areas and retrieve corresponding video footage.

The video footage of falls were utilized within distinct subprojects of TIPS all investigating the causes and contributory factors of falls in LTC using four unique approaches: (a) questionnaire-driven observational group analysis; (b) video-stimulated recall interviews and focus groups with LTC staff; (c) video observations of the resident 24 hr before the fall; and (d) video incorporated within a comprehensive systemic falls investigative method (SFIM).

All project team members (4 project leads and 16 researchers) engaged in ongoing, collaborative discussion on the application of the four methods. The rationale for engaging in collaborative dialog was to share experiences across projects, engage in multidisciplinary working (cross-cutting the disciplines of kinesiology, gerontology, and health sciences) and to identify “what works” in a practice context. Engaging in collaborative dialog provided the means to share individual experiences (transfer of knowledge), reflect upon them in a group setting (cooperative inquiry) and place them in their broader context and meaning (Feldman, 1999), that is, to establish how the methods can be developed and applied within a practice context. This form of collaborative dialog has been used as a means to better understand the application of a method or approach such that it can be improved in the future (Fouche and Light, 2011). Forms of collaboration and reflective dialog practiced within the research team included the following: meetings with the entire TIPS team of academics and emerging researchers to discuss the development and issues arising from application of each approach; meetings of the individual subprojects to discuss ongoing findings (e.g., working papers, project documents) and the added value of video; and de-briefing sessions conducted between researchers working in the field. Reflective, collaborative discussion was then undertaken involving all subproject leads and research team members to identify the key advantages and disadvantages of each method. The collaborative discussion was practiced before, throughout and following the application of each of the methodological approaches. Although no structured collaborative dialog was applied to all subprojects, regular meetings and discussions were held at monthly time points, and the collaborative dialog was overseen by each subproject lead who was tasked with deciding on the type, intensity, and regularity of the dialog.

**Ethics**

The study was approved by research ethics boards at Simon Fraser University and Fraser Health Authority. At the time of admission, each resident or proxy provided permission to the LTC facility to acquire video footage in common areas, for the purpose of resident safety. These data were shared as secondary data with the TIPS team. Additional ethical approval was sought from individual residents and/or proxies for use of videos and images for educational purposes. To minimize identifiers, faces were blurred from the video images using editing software. The research team
evaluated the ability of each individual resident to provide consent based on their capacity to follow and understand the information letter and consent form. In all cases where the participant was deemed unable to provide consent (i.e., because they did not understand the nature of the study or what they were being asked to do), their next of kin was approached and asked to provide consent on their behalf. Written informed consent was also received from all LTC staff prior to engaging them as participants in the research. The consent covered participation in the interviews and focus groups and reproduction of the comments of LTC staff. An additional approval was obtained from the research ethics board at the Western University to retain de-identified data in the SFIM database.

Findings

Four different approaches are presented in this article to identify the opportunities and challenges of using video in fall investigations. In Approach 1, video was used as a stand-alone data source, analyzed by an expert team using a structured and validated questionnaire to identify the biomechanical causes of imbalance and activities leading to the fall. Approach 2 used video as a stimulated recall tool with nurses and care aides, to recreate the fall event and to reflect on what happened at the time of the fall. Approach 3 collected footage of the faller’s activities during the 24 hr preceding the fall, to identify abnormal patterns of behavior or incidents (e.g., unusual gait or sleeping patterns) that may have preceded the fall event. Approach 4 combined video data within an established SFIM as a means to capture the “gestalt” surrounding falls and identify broader organizational factors associated with falls in LTC. The opportunities, challenges, and feasibility offered by each approach are summarized in Table 1.

Approach 1: Questionnaire-Driven Observational Analysis of Fall Incident Videos

Description

In Approach 1, video clips (typical duration 4 min) of 227 falls experienced by 130 residents (having a mean age of 78 years) were analyzed using a 24-item fall video analysis questionnaire (FVAQ). The FVAQ was developed based on the literature and behaviors observed in preliminary review of fall videos (Yang et al., 2013). FVAQ was completed by a team of at least three researchers and was designed to probe key biomechanical, behavioral, situational, and environmental aspects of falls that have traditionally been difficult to understand. In this application of the FVAQ, we focused our analysis on two questions related to fall initiation: what was the person doing at the time of the fall and what was the apparent mechanism that caused them to lose their balance (Robinovitch et al., 2013)? In another analysis, we examined the prevalence of impact to the head during falls and the factors associated with head impact (Schonnop et al., 2013).

Example 1

In Figure 1(A–E), a female resident falls forward while walking due to loss of support with an external object (counter top). Head impact occurs, despite attempts to arrest the fall through hand impact. In Figure 2(A–E), a female resident falls sideways due to incorrect weight shifting during walking. Head impact was avoided through backwards rotation during descent.

Opportunities

First, falls are common in LTC and are often unobserved. Video capture provides objective evidence of falls, avoiding the usual trade-off in falls research between the high control but artificiality of the laboratory environment, and the questionable accuracy of individuals recalling the circumstances of real-life fall events. Second, the development of the FVAQ provides a reliable, structured approach for assessing key features of the initiation, descent, and impact stages of falls (Yang et al., 2013). The approach allowed us to identify the most common biomechanical causes of imbalance and activities that lead to falls in LTC (Robinovitch et al., 2013). Our results show that 41% of falls are due to incorrect weight shifting, followed by tripping (21%). Third, the use of the FVAQ allowed for targeted interventions, for example, the results show that falls occur with equal frequency during walking, standing, and sitting down, suggesting the need to target each of these activities in risk assessment. Transitions to and from walkers and wheelchairs were particular “danger periods” suggesting the need for targeted exercise programs and improved design of assistive devices (e.g., wheelchairs that automatically lock during transfers). Head impact was found to occur in 37% of falls (Schonnop et al., 2013). Forward falls created the highest risk, and backward rotation during descent was protective. Hand impact occurred in 74% of cases, but was not protective against head impact. The results indicate that improvement of residents’ upper-limb strength may reduce fall-related head injuries in older adults.

Challenges

Falls result from complex interactions between intrinsic, environmental, and situational factors. Video analysis, in isolation, can only reveal details on what is visible in the video itself. This provides robust information on “what” happened during the fall but limited insight on “why” it
happened. In particular, it cannot reveal information on the thoughts or intentions of individuals at the time of the fall, previous habits and behaviors of the faller, changes in environmental or situational factors, and clinical status of the individual. Establishing a more complete understanding of falls at the individual or population level would require linking the video footage and outcomes from the FVAQ, with information on disease diagnoses, medications, physical and cognitive status, as well as broader macro-organizational factors related to care delivery and staffing.

### Approach 2: Video-Stimulated Recall Interviews and Focus Groups

**Description**

Approach 2 used stimulated recall interview and focus groups with care aides and nurses to analyze fall incidents involving five different older adults (Sixsmith et al., 2013). A stimulated recall approach (Henry & Fetters, 2012) provided the opportunity for LTC staff to review the video sequence, narrate what happened at the time of the fall, and suggest contributory factors. A total of six video-stimulated

<table>
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<tr>
<th>Methodological approach</th>
<th>Opportunities</th>
<th>Challenges</th>
<th>Feasibility for use in LTC practice</th>
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<tbody>
<tr>
<td>1. Questionnaire-driven observational group analysis</td>
<td>Allows observations and categorization of body movements before and during the fall. Identifies potential environmental and situational contributors.</td>
<td>Does not measure clinical or physiological risk factors.</td>
<td>Video infrastructure and administrative support needed to retrieve the video.</td>
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<td>Captures multiresearcher and multidomain perspectives.</td>
<td>Does not reveal organizational level factors.</td>
<td>In-house training required for FVAQ application, group analysis, and data interpretation.</td>
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<td>Informs the development of reliable analysis tools (such as FVAQ).</td>
<td>Provides only a narrow temporal and spatial frame.</td>
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<td>2. Video-simulated recall</td>
<td>Combines video with expert carer knowledge.</td>
<td>Can create participant discomfort and guilt.</td>
<td>Potential to be incorporated within existing practice (e.g., fall review meetings for group recall).</td>
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<td>Allows for multiple perspectives from LTC staff.</td>
<td>Can lead to apportioning blame to the frontline worker or adult for the fall.</td>
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<td>Provides opportunity for reflection and feedback into workplace practices.</td>
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<td>3. Video observations in the 24 hr before the fall</td>
<td>Identifies atypical behaviours that may have contributed to the fall.</td>
<td>Difficult to establish causal links between the fall and an earlier incident.</td>
<td>Requires LTC staff familiar with the resident to review the video and identify abnormal activities.</td>
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<td>Extends the temporal frame beyond the fall episode itself.</td>
<td>Labor intensive for the researcher.</td>
<td>Potential to integrate automated video monitoring in the future.</td>
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<td>Educates staff on fall-related behaviours.</td>
<td>Difficult to identify a meaningful temporal frame for analysis.</td>
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<td>Identifies issues to guide further investigation and follow-up interviews.</td>
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<td>4. SFIM combined with video</td>
<td>Provides rich level of detail.</td>
<td>Provides potentially overwhelming amounts of data.</td>
<td>Potential to build capacity through training an in-house SFIM team.</td>
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<td>Streamlines SFIM investigation process.</td>
<td>Requires knowledge in patient/resident safety.</td>
<td>Requires top-down support to improve safety culture.</td>
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<td>Establishes patterns of behaviors.</td>
<td>Investigations are labor intensive.</td>
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<td>Reveals “hidden” patterns of falling.</td>
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<td>Compliments triangulation.</td>
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<td>Helps identify system-wide contributing factors.</td>
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**Notes:** FVAQ, fall video analysis questionnaire; LTC, long-term care; SFIM, systemic falls investigative method.

*Applicable to all four approaches.*
one-to-one interviews and four video-stimulated focus groups were conducted across the five fallers involving a total of 21 participants (8 nurses and 13 care aides). The first half of the interview or focus group involved discussion on the older adult who experienced the fall, asking LTC staff to describe the individual, their typical behaviors, and what they remember about the fall from memory. At the midpoint, the video of the fall incident was shown, and LTC staff was asked to provide a narrative account of the fall event, to discuss the behaviors and decisions leading up to the fall, and to identify environmental or contextual factors that might have contributed to the incident.

Example 2
The faller was a female resident asleep in a recliner chair in the dining area. The fall occurred at approximately 3 a.m., at a time when most residents were in their bedroom and with one care aide on duty. Just prior to the fall, the resident appeared to be agitated and anxious and attempted to get up from the chair. The resident was not wearing any footwear as her slippers were on the floor. The faller made an attempt to move forward in the chair (Figure 3A), to put her slippers on, while the chair remained in the reclined position. As the resident moved toward the end of the chair, she lost her balance and slid from the chair (Figure 3B and C), falling to the floor and landing backwards (Figure 3D). Carers articulated the type of behaviors exhibited by the resident prior to falling (moving around in the seat, erratic body movements, and attempts to move down the chair) as responsive of a need to go to the bathroom. The absence of slippers was seen by care aides as contributing to the fall (reported that the resident is less confident and becomes anxious when waking up in the communal area without slippers). The carers reported the furniture as a potential contributory factor in the fall, highlighting the angle of recline from the chair and the evident difficulties that the resident had in bringing it back to a fixed position prior to the fall occurring.

Opportunities
First, video-stimulated recall interviews offered the opportunity to combine what was seen in the video of the fall with the expertise of frontline workers. Using the knowledge of frontline workers in this way allowed the descriptions of the fall to be expanded upon, by better explaining the intentions behind activities, workplace practices and behaviors, detail which failed to emerge in the first half of the interview. For example, upon watching the video, the care aide who was on shift at the time of the incident was able to relate a narrative of exactly where they were at the time of the fall and the barriers to earlier intervention. Second, video-stimulated recall allowed those frontline workers who were not present at the time of the fall to provide their understanding of what happened, allowing varied perspectives to be captured of the same fall incident. For example, care aides who delivered care in the daytime were able to share the approaches they typically used to manage the resident, such as identifying early signs of agitation as indicative of a need to go to the toilet, which care aides only identified when seeing the “exactness” of the behaviors in the video. Third, video-stimulated recall provided the potential for care aides and nurses to reflect on decision making at the time of the fall and identity future interventions. For example, the care aides proposed the implementation of a chair alarm to alert care aides when the resident sits up from her chair, which was only proposed after staff observed the ways in which the resident fell in the video.

Challenges
First, frontline staff were not always responsive when seeing themselves on the video, often feeling reluctant to speak
or experiencing discomfort when reflecting on their own behaviors. Second, there was a propensity for frontline workers to feel a sense of “guilt” as a result of observing a fall, particularly if they felt they could have intervened earlier. Third, the use of video was more likely to evoke reactions that attached blame to a specific individual. In the interview situation, it was common practice for care aides to highlight the workplace practices of coworkers when witnessing the video. For example, attributing responsibility to care staff for not observing residents closely enough. Although this could be beneficial in identifying the need for improvement, it has the potential to reinforce a person-centered blame culture, which might not be constructive. Clearly, there is a need for improved understanding of the contextual factors contributing to the behaviors of care staff at the time of the fall.

Approach 3: Video Observations of Resident Activities Prior to the Fall

Description
An improved understanding of falls may result from extending the temporal frame to analyze activities before the fall (Zecevic et al., 2007). The availability of continuous surveillance video in the participating care facilities provided the opportunity to observe the movements, activities, interactions, and behaviors of the faller while ambulating in the communal areas. For three fall incidents involving different older adults, we scanned video of activities of the resident in the 24 hr before the fall. This resulted in the collection and review of an average of 16 hr of video data per case, piecing together the movements of the faller, and through which we established a chain of events leading to each fall. By extending the temporal frame, specific actions were identified, which may have contributed to the fall. These included, for example, acts of resident-on-resident aggression, irregular sleeping patterns, and lack of nutrition or fluid intake.

Example 3
A male resident experienced multiple falls in the dining room of the care facility. Monitoring of his activities in the 24 hr prior to the fall identified several issues requiring further investigation. For example, Figure 4A and B show the resident sitting in his wheelchair and reading the newspaper. Figure 4A was recorded at 1 a.m. and Figure 4B was recorded at 5 a.m. Further video analysis revealed that the resident was awake in communal areas between 11 p.m. and 2 a.m. and 4 a.m. and 7 a.m. the evening before the fall. This could be indicative of irregular sleeping patterns impacting on fatigue and attention span, thereby limiting the ability to safely transfer and ambulate. Other examples of behaviors in the 24 hr before the fall, which required follow up included: lack of social interaction and involvement in activities; consistent attempts to stand in the absence of an assistive aide (Figure 4C and D); lack of nutrition and fluid intake; and signs of drowsiness and fatigue during the day.

Opportunities
First, by tracking the activities of the resident, it was possible to identify atypical resident behavior that could have contributed to the fall, such as poor sleeping habits. Second, the videos have the potential to generate targeted questions

Figure 3. (A–D) Fall from a recliner chair in the communal area of a LTC facility.

Figure 4. (A–D) Activities of the resident in and around the care facility in the 24 hr before the fall.
for discussion with frontline workers and further qualitative investigation. Although the video observations were interesting from a researcher perspective, the knowledge of LTC care staff is needed to better “place” those behaviors within the everyday behavior of the older adults (i.e., to identify what behaviors are “normal” and what are inconsistent). Third, an understanding of the resident activities before the fall yields information that could be used to educate and sensitize staff to fall-related behaviors to enable earlier intervention.

Challenges
First, it is difficult to establish causal links between the preceding activities observed in the video and the consecutive fall. For example, Figure 4A and B offer evidence for irregular sleeping patterns, but this may or may not have directly impacted on the fall. Second, from a practical perspective, collecting and analyzing the observational video data are a significant administrative task. Finding and tracking the individual through multiple surveillance cameras are time consuming and difficult to piece together in a coherent story. Analysis of 1-hr real-time video equated to approximately 3 hr of observational time for the researcher to monitor movements and record an accurate description of resident behavior. Finally, there is the question of selecting a meaningful timeframe for the observational analysis. For example, is the 24 hr before a fall as revealing as 1 hr, or are there advantages to monitoring resident activities over consecutive days, or just during periods of peak activity?

Approach 4: Video Analysis in Conjunction With SFIM

Description
Approach 4 utilized fall incident videos in combination with a comprehensive framework called SFIM. SFIM adopts a systems approach to falls investigations, situating the faller within the personal, environmental, situational, and organizational context within which the fall takes place (Halligan, Zecevic, Kothari, Salmoni, & Orchard, 2014; Zecevic et al., 2007, 2009). The SFIM uses case study research design with five distinct data collection sources: interviews with a variety of stakeholders; the analysis of incident reports, medical files, policy documents, statistical data; measurements and observation of physical environments; examination of hardware; and recreation of events. SFIM has not previously utilized analysis of real-time video data. SFIM investigation extends to years, days, and hours prior to the fall and establishes a detailed temporal sequence of events leading to the fall. A number of safety significant events are then identified in the sequence and further analyzed to identify contributing factors and safety deficiencies leading to the fall. In this study, we focused on a specific resident who had a very high frequency of falls, to examine the added value of video footage to the SFIM process and findings. In total, 16 interviews were completed with: two family members, two care aids, two licensed practical nurses, a physiotherapist and physiotherapist assistant, nutrition manager, recreation manager, human resources manager, IT expert, two care coordinators, a director of care, and the CEO of the LTC home. Other data sources included: falls incident reports (N = 33); a medical chart; progress notes; intake questionnaire; fall assessment tables; care conference summaries; falls and injury data analysis and action activity form; quarterly assessment forms; on-site observation; photos of the environment; and policy documents from the facility and provincial governing body. Video was analyzed in three specific ways: (a) analysis of multiple camera views of video on the day of the investigated fall; (b) analysis of continuous video collected during the evening and night preceding the investigated fall; and (c) analysis of 22 video clips of the resident’s previous falls and two video clips of falls that occurred after the investigated fall.

Example 4
A female resident with advanced Alzheimer’s disease fell in a corridor of a LTC facility after 2 hr of continuous wandering. Video analysis revealed that the night before the fall, the faller was out of her room four times and was continuously wandering in common areas. Numerous attempts by staff to settle her in bed were unsuccessful. During the last hour before the fall, the resident’s posture and gait visibly deteriorated and she was observed frequently pulling down the back of her pants. Minutes before the fall she walked slowly, stopped often, and leaned against the wall for support. Then she stopped, extended her hands in front of her in an apparent attempt to find an external support, and collapsed forward onto the floor. The usual SFIM investigation identified the following contributing factors for this fall: self-initiated lowering followed by collapse onto the floor; malnourishment; poor vision and spatial awareness; cognition; fatigue leading to poor posture; constipation; inability to verbally communicate her needs; intermittent staff supervision at peak activity times; and non-optimal scheduling of staff breaks. Over the seven months since admission, this resident experienced 33 falls, where 25 falls were captured on video. Detailed video analysis of the 25 falls identified four distinct patterns of contributing factors to falls in this resident: loss of balance after being startled by another person; hit, bump, pushing, or pulling in direct contact with other residents; loss of balance due to poor
posture secondary to fatigue; and other reasons, such as missing a chair when sitting down (Figure 5A–E).

Opportunities
First, video recordings complemented SFIM with an unprecedented level of detail, certainty on the temporal sequence of events, and clarity about the people involved and the acts performed at the time of the fall. Video analysis speeded up the SFIM investigative process by providing visual evidence of “what” happened, so “why” it happened became the focus of the investigation. Second, the availability of permanent video records allowed for repeated replay and review of historical falls, both witnessed and unwitnessed. This created an opportunity to establish patterns of behaviors for both the faller and staff. Third, video observations confirmed or disputed data collected from interviews revealing occasionally “hidden” information, such as resident-on-resident interaction or aggression. For example, the involvement of another resident was not recorded in fall incident reports or revealed in SFIM interviews. It was identified only through video analysis. Fourth, the video provided a reliable information source for the triangulation that SFIM utilizes to confirm collected data. Fifth, the review of video in days and hours before the fall helped create a more accurate and detailed sequence of events, filling gaps in the story built on interview data. For example, before falling, the resident was observed wandering through common areas without rest for 2 hr, through staff coffee and lunch breaks, and fluctuating levels of supervision. Only by combining SFIM investigation and video was it possible to reconstruct this situation.

Challenges
Among the challenges in combining video with SFIM is the potential for “information overload” due to the rich descriptive information generated in the process. This may create difficulty in deciphering important information from nonrelevant evidence and preparing meaningful investigative reports and recommendations to LTC facility management or policy makers. Second, both the SFIM investigation and video analysis were time-consuming processes that, in the presented case study, took four weeks to complete. Third, SFIM requires specific training and skill building in the investigative technique, patient/resident safety, and ability to establish interrelationships between individual factors and complex systemic influences. This requires capacity building both for the purpose of research use and LTC practice.

Summary of Findings
Table 1 summarizes the opportunities, challenges, and feasibility of the four distinct approaches using video footage of real-life falls to investigate the causes and target prevention of falls in LTC facilities. The feasibility aspects of applying these methodologies will likely differ between care facilities depending on the levels of infrastructure, administrative and IT support, and types of surveillance technology.

Discussion
Four different approaches presented in this article revealed a number of opportunities for the use of video in fall investigations deepening our understanding of the circumstances and contributory factors of fall events. Video, as a tool for observational analysis, provides opportunities for fine grained analysis of the biomechanics of fall incidents, expansion of the temporal frames of fall events, examination of recurrent falls, analysis of movements of fallers and frontline workers before the fall, and facilitates stimulated recall by combining video with contextual “insider” knowledge of LTC staff. Translating this knowledge within a LTC service context has the potential to educate frontline workers and management, and inform the development of falls prevention interventions such as improvements in medication management, assistive devices, exercise, environmental hazards and assists, use of wearable hip protectors, staffing, scheduling, and resource management.

We also identified a number of challenges for the use of video data, which have implications on the feasibility of using these methods in a context of LTC practice. Video analysis of falls required substantial investment in infrastructure and personnel to collect, analyze, and maintain the data. Integrating any or all of the four presented

Figure 5. Examples of five patterns of falling behavior for the frequent faller, identified by combining systemic falls investigative method and video analysis. From left to the right: (A) self-initiated lowering resulting in a “collapse” of the body to the floor; (B) a fall due to startle by another person passing in front; (C) direct contact with another resident that resulted in pushing and pulling; (D) an example of poor posture due to fatigue prior to the fall; and (E) other, such as missing a chair and landing on the floor.
methods in a LTC practice context would require various amounts of LTC staff training, administrative support, and technical personnel to manage the data. For example, Approach 1 would require the training of personnel in the FVAQ questionnaire, whereas Approach 4 requires the training of personnel to conduct the SFIM falls investigations. However, while for an outside research team it can take up to a month to complete an investigation, an in-house team of SFIM investigators can complete investigations within a week due to immediate access to interviewees and documentation, and familiarity with policies and standard practices. Long-term developments in facial recognition software and automated monitoring may obviate the human capacity required to monitor movement and detect falls.

Video observation also raises ethical issues surrounding privacy and consent which have implications on practice. LTC staff may feel that video monitoring is intrusive, that it generates discomfort or anxiety, and impacts either positively or negatively on their workplace practices which will affect overall acceptability of video within the workplace setting. Availability of the video allows monitoring of LTC staff, and it could be used by higher level management as an instrument to discipline frontline workers. Further work is needed to explore the impact of surveillance on LTC staff and the intentions of use by care facility management.

Watching video of falls that the staff were directly involved in may also lead to “observer guilt”; a feeling on behalf of the participants that they may have acted differently or intervened earlier to prevent the fall. Moreover, presenting video to frontline staff may create difficult choices regarding resident independence and autonomy, such as LTC staff implementing safety measures that are overly protective and unduly compromise the freedom of the older adult. The promotion of independence in a LTC facility (e.g., walking, engaging in social activities) carries an element of risk; although obviating this risk may reduce falls, there might be a compromise on other aspects of well-being. Applying the use of video within a practice context will require greater elaboration and understanding of these ethical issues and attendance to the potential side effects of using fall incident videos to improve LTC practice.

With the increasing deployment and relatively low cost of video technology, such tools will become an increasingly pervasive aspect of the LTC environment. Work is needed to explore how the benefits of video can be exploited, while minimizing harm. For example, the care facilities described in this study have used the video data in various ad hoc ways to influence practice (we have discussed this in more detail [Woolrych, Sixsmith, Mortenson, Robinoivitch, & Feldman, 2013]). For example, care coordinators are engaged in real-time monitoring to provide them a snapshot of activity on a particular ward and fall videos are reviewed by management to establish what happened at the time of the fall and to improve the accuracy of fall incident reports [Woolrych et al., 2013]. Although there are potential benefits of using video data as a tool for improved knowledge, education, and practice, unintended and perhaps negative applications can arise. For example, contextually isolated analysis of video data focuses on factors that are visually apparent, potentially ignoring other situational and organizational factors, such as staff training. Moreover, video evidence may be ambiguous. For example, one camera view may imply the faller was pushed by another resident, whereas another camera view clarifies lack of contact. The nature of staff–resident interactions may be difficult to confirm. Given the weaknesses with video data, it is important to develop systematically sound methods for application in a LTC context that will have a beneficial impact on understanding and preventing falls. In Table 1, we offer some early indications of the feasibility of each method within a practice context, yet recognize that the use of video will differ between care facilities (depending on capacity, existing protocols, and organizational needs). The next phase of the research is to determine how video methods can be systematically and feasibility integrated into a practice context and to identify knowledge translation strategies.

It is important to note that the four approaches described in this article were developed in partnership with two LTC facilities in British Columbia, Canada. This article does not provide an exhaustive account of all the ways in which video data can be utilized. For example, we have not explored the possibility of using video in cooperation with older adults who have experienced a fall. This might have both disadvantages (e.g., emotionally unsettling for the older adult to recreate a fall), and advantages (e.g., an aide memoir for the faller to recreate what happened at the time of the fall and identify causal influences). Additionally, due to privacy, footage was collected only in common areas of the LTC facility. However, in the facilities we studied, 60% of falls occurred in bedrooms and bathrooms, which may present a different context that requires further exploration. According to Rapp, Becker, Cameron, König, and Büchele (2012), 75% of falls in 528 German LTC facilities occurred in the residents’ rooms and only 22% were reported within the common areas. Residents with the highest care needs and greatest functional impairments had the highest relative contribution of falls during the daytime in common areas. Authors suspected that very frail residents were brought to common areas to allow them to participate in activities at the unit, but they could not be supervised continuously. Although video holds great promise for LTC practice improvement, further research is required to
refine and understand the applicability of our methods for different residential care facilities and other high-risk environments such as hospitals, assisted living facilities, senior centers, and private homes.

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**References**


