



## Examining daily activity routines of older adults using workflow



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### ABSTRACT

We evaluated the value of workflow analysis supported by a novel visualization technique to better understand the daily routines of older adults and highlight their patterns of daily activities and normal variability in physical functions. We used a self-reported activity diary to obtain data from six community-dwelling older adults for 14 consecutive days. Workflow for daily routine was analyzed using the EventFlow tool, which aggregates workflow information to highlight patterns and variabilities. A total of 1453 events were included in the data analysis. To demonstrate the patterns and variability of each individual's daily activities, participant activity workflows were visualized and compared. The workflow analysis revealed great variability in activity types, regularity, frequency, duration, and timing of performing certain activities across individuals. Also, when workflow approach was applied to spatial information of activities, the analysis revealed the ability to provide meaningful data on individuals' mobility in different levels of life spaces from home to community. Results suggest that using workflows to characterize the daily activities of older adults will be helpful for clinicians and researchers in understanding their daily routines and preparing education and prevention strategies tailored to each individual's activity level. This tool also has the potential to be integrated into consumer informatics technologies, such as patient portals or personal health records, so that consumers may be encouraged to become actively involved in monitoring and managing their health.

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## 1. Introduction

Workflow studies have been suggested as a means to examine procedural aspects of work in health care delivery. Workflow analysis generates data that show organizational design flaws and provide useful information regarding patient outcomes in relation to clinical workflow patterns and variability. It has been used to better understand care delivery in formal institutional settings [1–4] by capturing care delivery activities. As a result, important problems related to usability [5], safety [6], and quality of care [7] have been identified, and the findings informed the design and implementation of various health information technology (IT) interventions. However, little attention has been paid to tools that can codify health-related workflow in community settings and daily living environments, which are unstructured and more diverse [8–11]. In particular, there is a lack of methods to assess the ordered tasks performed by individuals to achieve a particular goal within a home environment or to identify changes in the order or

process of performing the tasks over time. Such an exploration can identify specific environmental barriers or, more importantly, patterns that may signal an individual's functional decline. This latter feature would be of great utility in the context of gerontology and rehabilitation care and would facilitate a potentially earlier prognosis or intervention compared with a trajectory that relies solely on episodic assessments in clinical settings. Therefore, workflow analysis may be a potential tool to address these challenges by providing longitudinal visual representations of an activity process to researchers and health care providers.

### 1.1. Assessment of activity patterns among older adults

Functional ability of older adults is a critical aspect in healthy aging and independence [12,13]. As individuals age, they experience changes in function as part of the normal aging process and/or due to chronic diseases [13]. Such changes can be reflected in activities of daily living (ADLs), such as bathing, dressing, or using a toilet, and instrumental activities of daily living, such as shopping, housekeeping, or using transportation.

As part of strategies to prevent functional limitation in older adults, both researchers and clinicians have made considerable

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efforts to accurately assess older adults' functional abilities and detect early changes in daily activities. The current assessment of older adults' activity levels, whether based on self-report instruments or performance-oriented measures, does not often incorporate the use of instruments [14], which limits the ability to capture varied states of functional decline. Recently, to overcome this limitation, motion sensors have been widely adopted as a tool for continuous monitoring of human behavior [15,16]. However, unless video-type (e.g., Kinect) or acoustic-type sensors are used [17–20], it is hard to capture the whole picture of activity changes. In addition, in many cases, time series sensor data only show whether there is a decline in activity levels over time. There is lack of focus on identifying the type and timing of specific activities conducted by older adults. Despite the efforts to develop algorithms and analytic techniques for automatic detection and analysis of changes in human behavior data [21], sensor data processing is still complex and often labor intensive. Also, these types of technologies still have limitations in wide adoption and use because of privacy concerns, cost, maintenance issues, and lack of familiarity among users [22]. Therefore, there is a need for a tool that can fully reflect the dynamics of older adults' different activities over time in daily life to better understand normal variability in physical functions and lifestyle alteration, as well as to detect changes before they affect older adults' quality of life.

### 1.2. Workflow analysis of daily activity routines

Workflow can be defined as “the flow of work through space and time” [23, p. 27], that is, a cross-setting, temporally organized activity sequence. Studying workflow enables understanding of how work elements (including information, resources, and influence) are organized [24]. The concept of workflow is valuable for examining care delivery systems in a comprehensive and systematic way to identify quality of care and efficiency problems and to develop systematic interventions to overcome these problems. It facilitates modeling and makes complex phenomena (e.g., health management or individuals' daily routines) more comprehensible. Understanding care delivery activities and how they are organized in a systematic way has allowed researchers to examine how various resources come together and produce outcomes, and how desired or undesired outcomes are produced. Moreover, because some activities are planned and some emerge, workflow is a manifestation of various context variables [25].

Recently, workflow analysis has been used to examine patient care workflows by means of institutional electronic health records (EHRs) [4] and to understand activities and processes occurring in patient-provider encounters during telehealth visits [26]. However, there is a lack of studies using workflow analysis to identify activity patterns and detect early changes in activities that may indicate functional deterioration and safety risk, which would, in turn, inform proactive care plans to prevent adverse health outcomes or delay hospitalizations. Workflow is potentially beneficial to study daily routines of older individuals living at home because it reveals the activities they conduct and the temporal organization of these activities. Understanding these activities will allow researchers, clinicians, and IT system designers to (1) monitor changes for any possible functional ability to take proactive actions, (2) support self-management by tailoring therapy plans that are sensitive to patients' routines, and (3) develop consumer information systems that are congruent with patients' daily routines [24].

The aim of this study was to apply a workflow analysis approach to the daily activity data of older adults. This article describes the value of workflow analysis as a simple and effective

approach to identifying everyday activity patterns among community-dwelling older adults. We also provide our insights into the benefits and limitations of this approach to better inform researchers and clinicians who need information on significant lifestyle or behavior changes among older adults at risk for functional decline.

## 2. Case exemplar using workflow analysis

### 2.1. Design

Our study was based on a pilot study testing the feasibility of a home-based sensor system designed to monitor the daily activities among community-dwelling older adults, as well as the role of cultural factors in technology acceptance [27]. It is important to note that the cultural considerations for the parent study did not allow us to recruit older adults from other racial and ethnic groups and that the current study does not focus on the sociocultural context of study participants' performing daily activities. The study protocol was approved by the Human Subjects Division at the University of Washington, Seattle (#44774). We analyzed the workflow of daily activities reported by older adults to investigate the patterns of and variability in their activities over 14 days.

### 2.2. Participants

For the pilot study, we included four households comprising six community-dwelling Korean American adults aged 65 years or older who were ambulatory and had a known life expectancy of 6 months or more. Participants lived in the greater Seattle metropolitan area and were enrolled in the study for approximately 2 months.

### 2.3. Data collection

During the study period, the researchers visited the participants' homes three times—at the beginning, midpoint, and completion of the study. At the first visit, research staff captured a simple two-dimensional house plan that included the locations of motion sensors.

#### 2.3.1. Activity diary

Participants were asked to fill out an activity diary for 14 consecutive days. The diary was in paper format and consisted of daily sheets on which they wrote where they had been and what they had done every 30 min during the 14 days. To facilitate data entry, we provided participants with a list of example activities and a possible location where they might be performed, such as the bedroom (sleeping, getting up from bed, or dressing), kitchen (meal preparation or washing dishes), bathroom (showering, teeth brushing, washing face, tub cleaning, or toilet use), dining room (having a meal), living room/office (watching television, listening to music, reading, or doing paperwork), and other activities (leaving the home, returning to the home, cleaning, or doing laundry).

The participant-driven activity diary was used in the workflow analysis. The activity diary data were composed of three dimensions:

- (1) Activity type: the type of activity performed inside and outside home;
- (2) Spatial information: where a specific activity was conducted; and
- (3) Temporal information: when and how long an individual participated in a specific activity.

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