Decision-Making Process of Homecare Professionals Using Telemonitoring of Activities of Daily Living for Risk Assessment in the SAPA Project: An Embedded Mixed-Methods Multiple-Case Study

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Renée-Pier Filiou[1] PhD; Mélanie Couture[1] PhD; Maxime Lussier[2] PhD; Aline Aboujaoudé[2, 3] MSc; Guy Paré[4] PhD; Sylvain Giroux[5] PhD; Hubert Kenfack Ngankam[5] PhD; Patricia Belchior[6] PhD; Carolina Bottari[3] PhD; Kevin Bouchard[7] PhD; Sébastien Gaboury[7] PhD; Charles Gouin-Vallerand[5] PhD; Faustin Armel Etindele Sosso[4] PhD; Nathalie Bier[2, 3] PhD

[1]School of Social Work Université de Sherbrooke Sherbrooke CA
[2]Centre de recherche de l'Institut universitaire de gériatrie de Montréal Montréal CA
[3]École de réadaptation Faculté de médecine Université de Montréal Montréal CA
[4]HEC Montréal Montréal CA
[5]Faculty of Sciences and Faculty of Medicine and Health Sciences Université de Sherbrooke Sherbrooke CA
[6]School of Physical and Occupational Therapy Faculty of Medicine McGill University Montréal CA
[7]Department of Mathematics and Computer Science Université du Québec à Chicoutimi Chicoutimi CA

Corresponding Author:
Renée-Pier Filiou PhD
School of Social Work
Université de Sherbrooke
2500, boulevard de l'Université
Sherbrooke
CA

Abstract

Background: Older adults with cognitive deficits face difficulties recalling daily obstacles and lack self-awareness, amplifying the challenges for homecare clinicians to obtain reliable information on functional decline and homecare needs. The result may be suboptimal service delivery. Telemonitoring of ADL has emerged as a tool to optimize ADL homecare needs evaluation. Utilizing ambient sensors, telemonitoring of ADL gathers information about an individual's ADL behaviors within the home, such as preparing meals and sleeping. However, there is a significant gap in the comprehension of how ADL telemonitoring data can be integrated into clinical reasoning to better target homecare services.

Objective: The current paper aimed to describe 1) how ADL telemonitoring data is used by clinicians in the process of maintaining care recipients with cognitive deficits at home as well as 2) the impact of ADL telemonitoring on homecare service delivery.

Methods: We used an embedded mixed-methods multiple-case study design in which our cases of interest were three health institutions located in the greater Montreal region and offering public homecare services. An ADL telemonitoring system, named NEARS-SAPA, was deployed within those three health institutions for 4 years. Within each case were embedded sub-cases (care recipient, informal caregiver, clinician(s)). For the objectives of the present paper, we used the data collected during 45-60 min interviews with clinicians only. Quantitative metadata were also collected on each service provided to care recipients before and after the implementation of NEARS-SAPA to triangulate the qualitative data.

Results: We analyzed 27 sub-cases, comprising 23 clinicians, that completed a total of 57 post-implementation interviews concerning 147 telemonitoring reports. Data analysis showed a 4-step decision-making process used by clinicians 1) Extraction of relevant telemonitoring data, 2) Comparison of telemonitoring data with other sources of information, 3) Risk assessment of the care recipient's ADL performance and ability to remain at home, and 4) Maintenance or modification of the intervention plan. Quantitative data reporting the number of services received allowed to triangulate qualitative data pertaining to step 4. Overall, the results suggest a stabilization in monthly services following the introduction of the ADL telemonitoring system, particularly in cases where services were increasing prior to its implementation. This is consistent with qualitative data indicating that, in light of the telemonitoring data, most HSCP decided to maintain the current intervention plan rather than increasing or

reducing services.

Conclusions: Results suggest that ADL telemonitoring contributed to service optimization on a case-to-case basis. ADL telemonitoring may have an important role in reassuring clinicians about their risk management and the appropriateness of services delivery, especially when questions remain as to the relevance of services. Future studies may further explore the benefits of ADL telemonitoring for public healthcare systems with larger-scale implementation studies.

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Keywords: activities of daily living; older adults; cognitive deficits; telemonitoring; clinical

decisions; public health-care system; home care services; mixed-methods; multiple-case study

Introduction

Cognitive impairments in older adults are closely tied to difficulties in performing Activities of Daily Living (ADL), resulting in a decline in functional independence [1, 2]. This decline increases the risk of neglecting hygiene, medication intake, and engaging in behaviors that may lead to adverse events like falls and kitchen fires [3]. The functional decline also contributes to a growing demand for homecare support services, which may not be optimized due to the inherent challenges in evaluating the needs of this population [4]. Older adults with cognitive deficits face difficulties recalling daily challenges and lack self-awareness, amplifying the challenges involved in obtaining reliable information on areas of functional decline[5]. Homecare intervention plans for this population, especially for those living alone, are thus often based on managing *potential* risks, leading to services being implemented to meet anticipated needs, even if not well-captured or documented [3, 5]. However, the result may be suboptimal service delivery [6], with some older adults receiving too many services and others receiving too few. Additionally, many Western countries, including Canada, face a chronic shortage of human and financial resources for public homecare services, limiting access to these services[4]. In the context of a rapidly aging population, optimization of homecare services has therefore become a high priority in Canada.

One approach to optimizing services may be to better evaluate homecare needs, such that the right service can be delivered to the right person at the right time. Telemonitoring of ADL has emerged as a tool for this optimization. Utilizing diverse sensors like wearables or ambient sensors (e.g., motion detectors, contact sensors, radio-frequency identification), it becomes possible to gather information about an individual's ADL behaviors within and outside of their home [7]. This comprehensive information provides patterns of ADL routine, including activities such as entering the kitchen, opening and closing cupboards and drawers, and using small electrical appliances. Activity recognition [8, 9] is used to derive these ADL patterns, allowing insights into daily, weekly, or even yearly routines [10]. Detection of unusual activity, performance errors, or the absence of movement [11] serve as a reflection of inadequately performed activities, indicating the need for homecare support.

Promising results regarding ADL telemonitoring for older adults' home support have been published in the last 20 years. To provide an update on the current evidence, an umbrella review was conducted by our team in 2021-2022 [7, 12] on 17 published systematic reviews. It highlights that ADL telemonitoring has been shown to have moderate evidence of effectiveness in using patterns of ADL as an indicator of independent living (e.g., as the capacity to perform ADL). However, since most published systems to date have not yet attained high levels of technology maturity, there is a scarcity of real-life implementation studies and therefore a lack of documented potential benefits for older adults, their caregivers and healthcare professionals[7]. There is also a significant gap in the comprehension of how ADL telemonitoring data is integrated into clinical reasoning to better target home care services' needs and modify or adapt service delivery.

To address this gap, our team conducted a project in close collaboration with the health care system in Quebec, Canada, between 2016 and 2022. The project was named the *SAPA Project*, and its overall objective was to co-develop and implement an ADL telemonitoring system to offer better targeted public home care services to older adults living with cognitive deficits in the community. The ADL telemonitoring system developed through this transdisciplinary project was named NEARS-SAPA (iNnovative Easy Assistance System - Support for Seniors' Autonomy program or *Soutien à l'autonomie des personnes âgées* in French), and consists in a lightweight edge computing for real-time monitoring installed in the older adults' homes [13].

The SAPA Project involved the close collaboration of all stakeholders involved in public home care services in the Province of Quebec, i.e., health institutions administrators, heads of services, health and social care professionals (HSCP), as well as older adults and their informal caregivers (see Lussier et al. [10] for detailed methodology). More specifically, we conducted an action design research (ADR) project, comprising a four-stage highly collaborative process[14] to ensure the

development of a relevant, usable and sustainable technology: 1) problem formulation; 2) building, intervention and evaluation; 3) reflection and learning; and 4) formalization of learning. ADR is generally composed of multiple development cycles, which involve repeating stages 2 and 3 in a cyclical manner. Conducted collaboratively with all stakeholders, these cycles facilitate the refinement of technology and associated interventions for subsequent implementation in real-world settings.

The SAPA Project underwent two iterative technological design cycles. The first cycle occurred from early 2016 to mid-2018, while the second cycle spanned from late 2018 to late 2022. The first cycle aimed at testing a prototype of NEARS-SAPA with a small pool of participants in one health institution located in the greater Montreal region, and to assess its feasibility and whether it was clinically viable [10, 15-17]. The second cycle aimed to further improve NEARS-SAPA as well as its deployment, evaluation and implementation, in partnership with three health institutions also located in the region of Montreal. The present study reports on data collected during the second cycle of technology development.

Objectives of the present study and hypothesis

The current paper aimed to describe 1) how the ADL telemonitoring data was used by HSCP in the process of maintaining care recipients with cognitive deficits at home as well as 2) the impact of ADL telemonitoring on service delivery. We hypothesized that ADL telemonitoring would contribute to service optimization, in that it would enable HSCP to better identify which type of services their care recipient needs throughout the evolution of their condition (e.g., adding an intervention to their clinical plan).

Methods

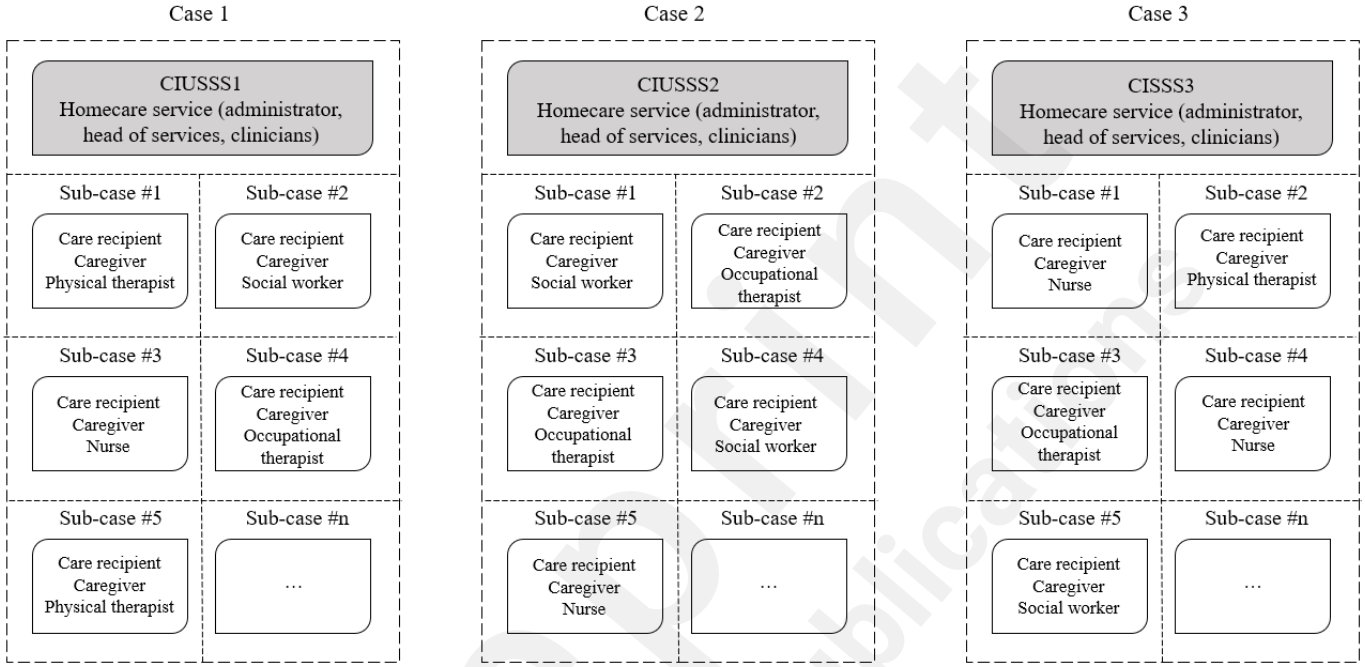
Design

To answer our objectives, we used a case study design [18]. A case study is an empirical method that investigates a contemporary phenomenon (the “case”) in depth and within its real-world context [18]. More specifically, we used an *embedded mixed-methods multiple-case study design* [18] in which the cases of interest were three health institutions located in the greater Montreal region. Multiple-case studies follow a replication design [18]. In the present study, each of the three cases were selected so that the individual case studies predict similar results (i.e., a literal replication). Within each health institution cases were *embedded sub-cases*, which included a care recipient, an informal caregiver and all HSCP in charge of their care throughout the duration of the study (see Figure 1).

In-depth understanding of real-world cases entails the involvement of multiple sources of evidence, with data needing to converge in a triangulating fashion [18]. For the objectives of the present paper, we collected both qualitative and quantitative data using an embedded, mixed (QUAL-quan) method to combine data [19]. To answer objective 1, i.e., how the ADL telemonitoring data was used by HSCP in the process of maintaining care recipients with cognitive deficits at home, we used the qualitative data collected during interviews with HSCP. Although sub-cases included care recipients and informal caregivers, the data pertaining to HSCP was most relevant to deepen our understanding of how the data generated by the ADL telemonitoring system was used in practice, and its impact on their decision-making regarding risk assessment. To answer objective 2, i.e., describe the impact of ADL telemonitoring on service delivery, we used two sources of data: 1) qualitative data collected during interviews with HSCP and 2) quantitative metadata on services provided to care recipients by the three health institutions. We then triangulated quantitative data with qualitative data [20] in order to assess how the telemonitoring reports had influenced the number of services delivered before and after the introduction of NEARS-SAPA.

The project was approved by the Aging-Neuroimaging Ethical Review Board of the CIUSSS South-Central-of-Montreal (#CER NV 17-18-10). This paper used the COREQ checklist to promote complete and transparent reporting and improve the rigor and comprehensiveness of qualitative studies.

Figure 1. Examples of cases and their embedded sub-cases



Cases Description

In the province of Quebec, the public health and social services institutions are integrated into large health and social services centers named *Centre intégré de santé et de services sociaux* (CISSS) or *Centre intégré universitaire de santé et de services sociaux* (CIUSSS), if affiliated with a university) [21]. Along with local community service centers (*Centres locaux de services communautaires* - CLSC), these health establishments are responsible for delivering care and services to the population of an assigned territory [22]. CLSCs offer front-line health and social services, including homecare through dedicated programs such as the Support for the Autonomy of Older Adults program (*Soutien à l'autonomie des personnes âgées* - SAPA) [21]. CI(U)SSS's offers four types of care services: 1) professional services (e.g., nursing, occupational therapy, physiotherapy); 2) homecare services, including assistance with basic and instrumental activities of daily living; 3) services to informal caregivers; and 4) technical support (e.g., medical and specialized supplies, assistive technologies) [23, 24]. When an older adult is eligible to receive services, a detailed needs assessment is conducted by a professional to determine the intervention plan, i.e., an individualized service organization in response to needs [23]. Services are then delivered by various categories of employees depending on the needs. Needs are reassessed over time to adjust the intervention plan in response to new needs or changing conditions. The ADL telemonitoring system was developed to support the homecare needs assessment in particular.

Case 1: CIUSSS1

CIUSSS1 is located on the island of Montreal. Fifteen thousand professionals work within CIUSSS1's health and social services establishments, and they serve a population of over 300 000 people. The older adult population (65 years and older) accounts for 12,9% of its care recipients, with 47,7% living alone, the highest proportion in all of Montreal. Of those, 39% also live below the low-income cut-off. The overall population of CIUSSS1 carries a heavy burden of chronic diseases and reports higher hospitalization rates than elsewhere in Montreal. Half of the overall population (50,7%) has a university degree. Less than a quarter (22,1%) of the population's mother tongue is not an official language of Canada (French or English), and 1,7% speak neither official language.

Case 2: CIUSSS2

CIUSSS2 is also located on the island of Montreal. Fourteen thousand professionals work within CIUSSS2's and serve a population of over 375 000 people. The older adult population (65 years and older) accounts for 19% of its care recipients, with 27,8% living alone, and of those, 22,5% living below the low-income cut-off. More than a third (37,3%) of the overall population has a university degree. Close to a third (32,4%) of the population's mother tongue is not an official language of Canada (French or English), and 1,9% speak neither official language.

Case 3: CISSS3

CISSS3 is located in the greater Montreal region. Thirteen thousand professionals work within CISSS3's and serve a population of over 405 000 people. The older adult population (65 years and older) accounts for 18% of its care recipients, with nearly one-third living alone. One in two elderly people live with at least one chronic disease. Materially and socially advantaged as a whole, only 6,9% of CISSS3's overall population is living below the low-income cut-off, and only 16% of people (25 years and older) have no university certificate, diploma or degree. Anglophones represent 14% of the population.

Description of the NEARS-SAPA system

NEARS-SAPA is an ADL telemonitoring system comprised of a set of ambient nonintrusive sensors, installed in different rooms of the care recipient's home, thus allowing a portrait to be drawn of the activities performed by the individual [13, 15, 25, 26]. Three types of sensors were used: (1) passive infrared (PIR) sensors, (2) magnetic contact sensors, and (3) smart electric switches. In general, for a 3-room house, we installed 7 to 8 motion detectors, 9 to 10 contact sensors, and 2 to 3 electrical sensors. Due to the nature of these sensors, which monitor overall activity levels, NEARS-SAPA is best suited for individuals living alone. Algorithms based on first-order logical rules were developed to track five key activities: (1) sleeping, (2) outings, (3) cooking, (4) personal hygiene, and (5) general activity level in the home. Each activity recognition relies on an aggregation of two or more sensor data to produce high-level knowledge, such as the presence in a room or the use of a specific device. It also includes the performance of an action, such as opening a door. From these algorithms were generated graphical representations and statistics for the care recipient's daily routines in the form of a visual dashboard, all accessible through a secure web application. The system thus performs data acquisition and analysis, but does not make recommendations in terms of decisions and actions and does not send notifications (see Lussier et al. [10]).

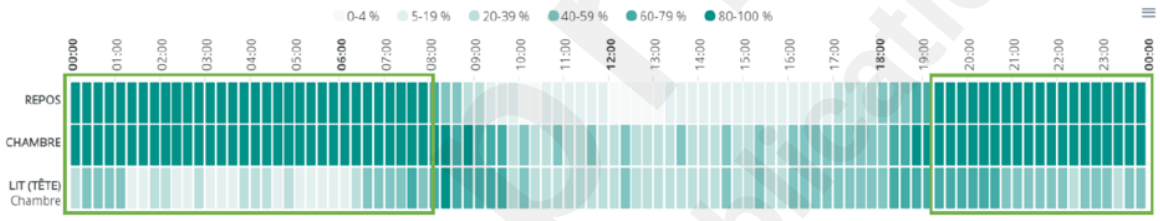
In response to the COVID-19 pandemic, modifications were made to NEARS-SAPA and to the project methodology. This served to comply with health and safety regulations as well as accommodate the limited availability of HSCP amidst heightened demand. Hence, due to restricted in-person access to healthcare institutions, the installation of secure pathways and certifications on

HSCP computers was unfeasible. Instead of relying on the web application as initially intended, the research team compiled data from various sensors into PDF reports and sent them directly to professionals via email (see Figure 2). Each report included a user guide on algorithm calculation and data description, followed by graphical representations and accompanying descriptions of activity trends. About a month after sensor installation, HSCP received a first report detailing the care recipient's activity patterns over the preceding month. Subsequent reports were issued approximately every two months, allowing professionals to track trends and changes in activities of daily living among care recipients under their care, without sending notifications as requested by the HSCP (see Lussier et al. [10]).

Figure 2. Example of ADL telemonitoring report sent to homecare professionals taking part in the SAPA Project

Sleep

The user rests in bed on average 13h49m per day [green rectangles]. It is possible that they do not sleep during all this period (e.g. they could read a book or listen to the radio), but they stay in their room and rarely leave it. On average, they get up around 8:00 am and usually go to bed around 7:15 pm. There are no signs of wandering at night and they rarely get up to go to the bathroom.



Recruitment procedures

Within each of the 3 sites, administrators and/or heads of services were tasked with requesting their clinical teams to identify the care recipients who might benefit from ADL telemonitoring, referring them to the research team. Following a presentation of the project at their workplace, interested HSCP then filled out a request form and discussed their ADL telemonitoring needs with the research coordinator (ML) by e-mail. To be recruited into the SAPA Project, HSCP had to (1) refer care recipients who had a loss of autonomy requiring homecare services; (2) who lived alone; (3) for whom their clinical concerns and/or questions fell within the technological constraints of NEARS-SAPA. When the inclusion criteria were met, the HSCP initiated contact with the care recipient to obtain verbal consent for a home visit with a member of the research team. During that visit, the research team obtained informed and written consent for both HSCP and their care recipient. In the present study, we included HSCP who completed at least one interview following the implementation of NEARS-SAPA at the care recipient's home.

Data collection

Qualitative data: Semi-structured interviews with HSCP

Interviews with HSCP were conducted over the phone or using videoconference by one member of the research team (AA) trained in qualitative research. Interviews took place during HCSP's working hours and lasted an average of 45-90 minutes. The following questions were asked: 1) "*Overall, how did you use the telemonitoring data?"*; 2) *"Can you identify the activities of daily living for which you used the telemonitoring information?"*; 3) *"Please describe the type of information that was*

useful to you"; and 4) "*How did the telemonitoring data influence the intervention plan for the care recipient?"*. The first post-implementation interview was conducted after the HSCP had received two ADL reports, then following every two reports sent (when possible), or until the end of the care recipient's participation (i.e., end of project, relocation, or death). Therefore, the HSCP were included in the study as long as their care recipient had the system installed in their home.

Changes in HSCP occurred frequently throughout a care recipient's participation in the study. When this happened, the newly appointed professional was made aware of the care recipient's participation in the study, what their participation entailed for the care recipient and themselves, and asked whether they wanted to pursue this participation. If they agreed to pursue, they signed the consent form, the research team sent them all available ADL telemonitoring reports and the interviewer then proceeded to interview the new clinician. It is worth adding that a few HSCP had more than one care recipient participating in the study. In those rare cases, the interviewer would discuss all older adults under their care, sequentially, during the same interview. However, ADL telemonitoring reports remained individualized.

All interviews were audiotaped and transcribed verbatim by a person specialized in this type of work. They were further validated by a member of the research team. All verbatim extracts included in this paper were translated from French to English by a bilingual member of the research team (RPF).

Quantitative data: Clinical services delivered to care recipients

We collected metadata on each service provided to care recipients by the CIUSSS/CISSS as recorded in ICLSC. ICSLC is the Quebec ministerial database that contains information and compiles data on service users, requests, and interventions provided by given institutions. The database is used to describe frontline services to ensure the quality and efficiency of health and social services. For this study, we examined the monthly count of services related to ADL received by the care recipients over a span of 12 months: 6 months prior and 6 months subsequent to receiving the first telemonitoring report of NEARS-SAPA. Services provided were aggregated on a monthly basis and numbered with reference to the introduction of ADL telemonitoring reports for the clinician. In this way, Months 1 to 6 represented the initial period, while Months 7 to 12 denoted the period following the introduction of reports. Each care recipient was treated as a longitudinal sub-case.

For all participants, we collected the latest Iso-SMAF profiles available in the care recipient medical database. The Iso-SMAF profiles [27] are a decision-making tool designed to guide individuals towards the resources appropriate to their needs. Their ultimate goal is to support clinical judgment, and they are widely used in all health and social service establishments across the province of Québec. When available (not systematically administered), we also collected the MMSE (Mini-Mental State Examination) [28] and MoCA (Montreal Cognitive Assessment) [29], both tools used to assess cognitive function, particularly in the context of diagnosing cognitive impairments.

Data analysis

Qualitative analysis

Qualitative analysis allows for a rich understanding of a focused and bounded phenomenon in a specific context [30]. In the present study, the phenomenon is the use of ADL telemonitoring information in the clinical decision-making process of HSCP in the context of homecare services. Data analysis was performed using Miles et al.'s method [30]. More precisely, memos, coding and matrix building were used. When analyzing a post-implementation interview with a HSCP, a memo was written to describe their decision-making process in detail, for each activity discussed with the interviewer. Data analysis was performed in a deductive-inductive approach, using the framework of

integration of ambient assisted living monitoring technologies within clinical decision-making developed by Lussier et al. [15]. The framework was supplemented by other relevant components that emerged from the present data.

Coding was performed by one member of the research team (RPF) using Microsoft Word and co-validated by another team member (AA), both trained by a researcher specialized in qualitative research (MC). Having interviewed all participants, AA was best suited to co-validate the codes, i.e., to ensure that they reflected each case. The code list was then reviewed by MC, who was best suited to provide overall methodological feedback. In order to sequence the clinical decision-making process described in detail in the memos, flowcharts were drawn for each sub-case. Throughout the process, similarities in what HSCP looked at, or for, in ADL telemonitoring reports began to emerge and were grouped in descriptive codes [30] (e.g., high frequency of undesirable activity, scarcity or absence of undesirable activity). Pattern coding cycles focused mainly on causation, which is appropriate for discerning processes, as well as interrelationships and the complexity of influences on human actions [30]. Hence, coding was used to connect first-cycle descriptive codes (e.g., high frequency of undesirable activity) to codes reflecting the clinical decisions made for what was read in the report (e.g., “the activity is deemed inadequate”). Subsequent pattern coding cycles then focused on connecting the clinical decisions made by a clinical team to the actions taken (or not) as a result of these decisions (e.g., “intervention plan modified”), regardless of the activity monitored. All flowcharts belonging to HSCP (i.e., all sub-cases) within a social and health care institution (i.e., one case) were regrouped. The three flowcharts (CIUSSS1, CIUSSS2 and CISSS3) were further grouped to build a meta flow-chart.

Quantitative analysis

The quantitative data were analyzed on a per-subject basis, and thereafter, all cases were combined to yield a comprehensive measure of monthly sums of services received by the care recipients. Our aim was to investigate the impact of ADL reports on monthly service trends by comparing data collected before and after the introduction of reports.

Initial analyses involved visually inspecting graphed data to identify specific trends [31]. Graphs depicted repeated outcomes before and after NEARS-SAPA implementation (respectively the baseline and intervention timepoints), enabling visual observation of trends between these two phases. Tau-U analysis [32], a statistical method commonly employed in single-case experimental designs, was chosen to assess the stability, trend, and level of a dependent variable over time [33]. The Tau-U statistic is derived from Kendall’s Rank Correlation and Mann-Whitney U tests. We selected the Tau-U due to its ability to account for large variability in the data, small sample size, non-parametric distribution, and trend in baseline and count-type data. All calculations were conducted using the Tau-U calculator website [34]. Specifically, Tau (no trend in the baseline) or Tau-U (a trend in the baseline) statistics were computed for each care recipient sub-case and then aggregated by merging all non-overlapping parameters to derive a global measure of non-overlapping for the entire group of care recipients [32, 35].

Given our relatively large sample size for Tau-U analyses, typically used in single-case designs, we also performed repeated ANOVAs for additional robustness. These analyses were conducted using SPSS v.26, with sub-case transformed z-scores utilized to mitigate the impact of large variability between sub-cases. Intervention (before vs. after) and Months (first to last) were entered as within-subject factors.

Quantitative data were then embedded into the updated integration of ambient assisted living monitoring technologies within clinical decision-making framework [15], framework that was supplemented by the qualitative data that emerged from the present study.

Results

Study samples

Sub-cases, which include a care recipient and all HSCP in charge of their care throughout the duration of the study, were distributed as follows: CIUSSS1, n=5; CIUSSS2, n=2; CISSS3, n=20 (see Table 1).

Social and Health Care Professionals

A total of forty-one professionals were recruited to take part in the study. Seven professionals were excluded (CIUSSS1, n=3; CIUSSS2, n=2; CISSS3, n=2) from the present analysis as post-implementation interviews could not be completed. The majority of the remaining professionals (n= 23) were occupational therapists (n=11), followed by social workers (n=8), nurses (n=2), physiotherapists (n=1), and specialized educators (n=1). Eight HSCP followed more than one care recipients. Also, two care recipients were followed by two different HSCP who were both interviewed. Overall, 91% of HSCP were women. HSCP averaged 41.43±9.32 years old and 8±7.33 years of experience. The number of post-implementation interviews completed by HSCP varied according to the duration of their participation in the study. As such, 23 HSCP completed a total of 57 post-implementation interviews, concerning 147 telemonitoring reports.

Care recipients

While 31 care recipients were initially enrolled by HSCP into the study, four were later on excluded for lack of their HSCP's availability to complete post-implementation interviews. As such, the ADL telemonitoring reports concerned 27 care recipients who took part in the study. Overall, 74% of care recipients were women. Care recipients averaged 81.3±7.67 years old. Concerning Iso-SMAF profiles, 30.8% of care recipients were categorized as having a "Predominant Loss in Instrumental Activities of Daily Life," 7.7% as having a "Predominant Loss in Mobility Functions," 53.8% as having a "Predominant Loss in Cognitive Functions," and 7.6% as having "Serious Mixed Alterations". Sixteen participants completed the MMSE, with an average score of 20.94±5.49, and nine participants completed the MoCA, with an average score of 19.33±5.79. All were older adults with cognitive deficits, and the vast majority lived alone in their home or apartment. Although living alone was one of our inclusion criteria, some care recipients did not live entirely alone, but found themselves alone for long periods of time during the day. In such cases, it was possible to distinguish between the care recipient being alone and when a relative was also at home.

Of those 27 care recipients, two were excluded from quantitative ICSLC analyses because they did not consent to sharing their metadata. In the following paragraphs, fictitious names have been assigned to care recipients to protect their identity and maintain confidentiality.

Table 1. Data collection table detailing ADL telemonitoring reports received and follow-up interviews completed in each case

	Cases			Total
	CIUSSS1	CIUSSS2	CISSS3	
Older adults	5	2	20	27
Social and health care professionals	4N; 2SW; 1OT	2SW	13OT; 8SW; 2PHYS; 1RT; 1SE	34
Telemonitoring reports delivered	39	6	102	147
Follow-up interviews	7	4	46	57

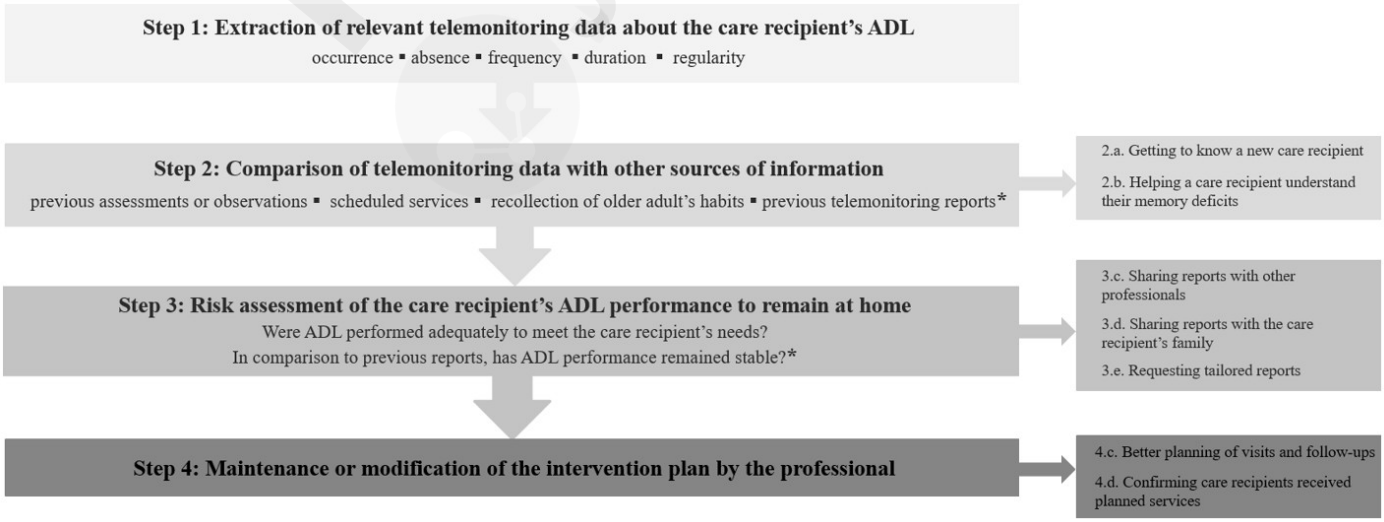
Legend: N: nurse; OT: occupational therapist; PHYS: physiotherapist; RT: respiratory therapist; SE: specialized educator; SW: social worker.

Uses of NEARS-SAPA telemonitoring reports

Figure 3 describes the most frequent uses of ADL telemonitoring reports in HSCP decision-making regarding their care recipients' homecare situation. It particularly regards their needs (met or not) relating to the five ADLs monitored by the NEARS-SAPA system (meal preparation/eating habits, personal hygiene, sleep, outings, and overall activity level).

The decision-making process comprised 4 main steps followed by most HSCP: 1) Extraction of relevant telemonitoring data, 2) Comparison of telemonitoring data with other sources of information, 3) Risk assessment of the care recipient's ADL performance and ability to remain at home, and 4) Maintenance or modification of the intervention plan. Boxes on the right-hand side represent the additional, though less frequent uses of telemonitoring reports, at each corresponding step. Figure 4 gives a more complete detailed explanation of steps 3 and 4.

Figure 3. Uses of NEARS-SAPA telemonitoring reports



Step 1: Extraction of relevant telemonitoring data about the care recipient's ADL

Upon receiving their first telemonitoring report, most HSCP explained that they began by extracting relevant telemonitoring data, in particular the occurrence/absence, duration, frequency, and regularity of engagement in relevant ADL by their care recipient.

The telemonitoring data that was deemed to be relevant varied from one HSCP to another. In fact, it depended on the needs of their care recipient, the challenges of their homecare as well as the clinical questions or concerns each HSCP had about their care recipient's ADL. Similarly, whether the relevant activities were deemed as desirable or not (i.e., aligned with their care recipient's needs and supporting their homecare or not) varied from one HSCP to another. For example, using the oven might be considered a desirable activity for a care recipient that seldom prepared meals and only snacked on chips and cookies, whereas it might be considered undesirable for another care recipient that often left the oven unattended for a prolonged period and risked causing fires.

In the case of Judith (CIUSSS2), the HSCP in charge worried that she did not eat appropriately or sufficiently outside of her afternoon and evening CLSC service hours. As such, the HSCP found the telemonitoring data about her activity in the kitchen especially relevant. The HSCP also considered the use of multiple kitchen appliances in the morning as a desirable activity.

> *"In the morning, she has no services. So, we look to see if she's using the coffee maker, the microwave, the toaster. It seems fine. She continues to use it. So, we can see that. Make sure she's eating well."*
>
> (HSCP in charge of Judith, CIUSSS2)

*Step 2: **Comparison of telemonitoring data with other sources of information***

Most HSCP compared the data with other non-technological sources of information about the care recipients' ADL, such as their own current and past observations or assessments of their abilities, as well as observations from family, personal care assistants or community organizations during visits to their home. HSCP also compared telemonitoring data with the care recipients' self-reported activities or routines at home, or their family's account of said activities and routines.

Others compared telemonitoring data with services already in place to support care recipients, such as in the case of Roger (CISSS3). Following a stroke, Roger lived with neurocognitive deficits and physical difficulties in a private seniors' residence. In Quebec, private seniors' residences are rental buildings occupied or intended to be occupied primarily by seniors aged 65 or over and where various services are offered, such as meals, housekeeping, nursing care and/or leisure activities[36]. Although Roger's eating habits were not problematic, the HSCP in charge of his care still wanted information about his overall routine. The telemonitoring report showed Roger left his apartment 3 times a day, exactly at the same time. The HSCP compared the data with the scheduled meals at the seniors' residence.

> *"Also, I looked at the outings. The fact that he goes out three times a day at the same times, which corresponds to the meals he gets."*
>
> (HSCP in charge of Roger, CISSS3)

Some HSCP also combined telemonitoring reports with their care recipient's recollections of their daily habits, such as in the case of Chantale (CISSS3) (step 2.b.). Chantale's personal hygiene was problematic and, although her family worried, she claimed to shower daily. The telemonitoring report showed no activity in the shower.

> *“It also enables us, in our interventions with the lady, not to confront her, but to say to her "well, what we have as data concerning you is not what you're telling us", so it gives us a kind of leverage to make her understand that maybe her memory is playing tricks on her too.”*
>
> (HSCP in charge of Chantale, CISSS3).

Step 3: Risk assessment of ADL performance

After comparing data with other sources of information, professionals proceeded to assess the risk of their care recipient’s ADL performance for their homecare (Step 3). Its sub-steps (3.a. and 3.b.) are detailed in Figure 5 and examples are given in Table 2.

ADL performed adequately (step 3.a.): ADL were considered as adequately performed when the telemonitoring report showed desirable activities being done 1) regularly (e.g., “the user ate their meals at regular hours on most days”); 2) frequently (e.g., “the user showered every day”); or 3) when the report showed they did not perform potentially dangerous or undesirable activities.

ADL performed inadequately (step 3.b.): ADL were considered as inadequately performed when the telemonitoring reports showed the care recipients performed undesirable activities 1) frequently (e.g., “the person frequently wanders out at night”; 2) for a prolonged period (e.g., “the person spends more than 13 hours a day in bed”); 3) less frequently than they used to (e.g., “the user does not go out as much as they used to”); 4) scarcely; or 5) for an insufficient duration (e.g., “the person barely sleeps at night”).

Sharing the data with others (step 3.c. and 3.d.): Whether ADL performance was adequate or not, some HSCP reported that the telemonitoring data supported their risk assessment of their care recipient’s homecare by allowing them to share information with other professionals, such as in the case of Bonnie (see Table 2). Moreover, some professionals used the telemonitoring reports to discuss their risk assessment with the family (see Marie and Maggie, in Table 2). In both Marie and Maggie’s cases, professionals shared the telemonitoring reports with their care recipients’ respective daughters, yet this led to very different outcomes. In Marie’s case, being informed of her mother’s adequate eating habits reassured the daughter about her homecare situation. On the other hand, being informed of Maggie’s inadequate sleeping habits instead supported her daughter’s decision to relocate her, as it reflected it would not deprive her of her quality of life since she slept through most days and thus received little stimulation at home.

Need for tailored telemonitoring reports (step 3.e.): When specific questions remained unanswered after the reception of a telemonitoring report, some HSCP made requests to the research team for more tailored telemonitoring reports to enable them to make an accurate risk assessment. As such, tailored telemonitoring reports differed from the more generic reports in that they were more granular and targeted specific actions, specific days and/or specific sensors. For example, Esther (CISSS3) lived alone with neurocognitive deficits and had difficulty managing her diabetes. She had suffered a severe hypoglycemic episode in the past, which had led the HSCP in charge of her care to implement a new strategy to have her take her blood sugar after dinner and eat a snack.

> *“That's why we make her take it (her blood sugar) in the evening. Basically, at suppertime, the auxiliary tells her, "Tonight, you take your blood sugar”. She takes it, and then she has her snack. That's why we started this program, to make up for that (past severe hypoglycemic episode)”*.
>
> (HSCP in charge of Esther, CISSS3).

Yet, following the implementation of the strategy by the HSCP, more hypoglycemic episodes occurred. The HSCP doubted whether Esther took her evening snack as directed, and requested a

tailored telemonitoring report specifically on evening snack consumption: the report showed that Esther did not systematically eat her evening snack, as she claimed to do.

> *"So, what I did is that I asked (the research professional) to get the data out. We realized that it was more like three times out of four […] So, I know that three days out of four she takes it, then one day out of four she doesn't, so Mrs... I can see the discrepancy with what Mrs. tells me."*
>
> (HSCP in charge of Esther, CISSS3).

Table 2. Codes, definitions and verbatim extracts for Step 3: Risk assessment of ADL performance

Codes	Definitions	Context	Verbatim extracts
Sub-step 3.a. Care recipient's ADL performance is adequate	Most professionals deemed ADL performance to be adequate when the older adult performed activities adequately to meet his or her homecare needs (i.e., in terms of frequency, regularity, occurrence/ absence, etc.).	Serge lived at home with his wife, and both had neurocognitive deficits. When the professional in charge of their care initially joined the research project, Serge still had his car and would leave home in the middle of the night. Although he eventually stopped using his car, the professional wanted to know if he still went out at night. The telemonitoring report showed the user did not go out at night.	*"[…] when I made the request (to be part of the study), he still had his car. So, he was going out at night. […] There were nocturnal outings, too, that worried us when he was there. So, it was fun to see on the sensors that he wasn't going out, you know*" (Professional in charge of Serge, CISSS3)
Sub-step 3.b. Care recipient's ADL performance is inadequate	Most professionals deemed ADL performance to be inadequate when the older adult did not perform activities adequately to meet his or her homecare needs (i.e., in terms of frequency, regularity, occurrence/ absence, etc.)	Francine, an older woman recently diagnosed with neurocognitive deficits, had a tendency to minimize her difficulties. While she reported no sleep issues, her son reported she was agitated during the night, a concern not shared by her husband. The telemonitoring report shed light on the contradictory accounts of Francine's sleeping habits and showed that she did sometimes get up and become active at night.	*"We noticed that, at night, she tended to get up and sleep in blocks. So, it confirmed what the son had told us, that at night she doesn't necessarily sleep like everyone else. Let's say, she goes to bed and then gets up the next morning: there are also periods when she's more active, so it confirmed that aspect"* (Professional in charge of Francine, CISSS3).
3.c. To share information with other professionals	Some professionals shared the telemonitoring reports with other professionals	Bonnie had neurocognitive deficits, and had put her life in danger by leaving her home without a coat on, on two occasions in the past. Outings	*"It gave a lot of interesting information. It allows you to objectify what you think. You know, by deduction and then with the clinical discussions*

	involved in their client's homecare, whether their ADL performance was adequate or not.	were the main obstacle to her homecare. The professional in charge of her care was preoccupied because her surroundings (stairways, backyard) were very encumbered, and she lived close to a river. The telemonitoring reports showed Bonnie's outings were not for a prolonged duration.	*that you have as a team. But it allows you to objectify. That was really, really appreciated by our team"* (Professional in charge of Bonnie, CISSS3).
3.d. To share with their client's family to reassure them	Some professionals shared the telemonitoring reports with their client's family when the telemonitoring report showed that the older adult performed ADL adequately (e.g., regular, desirable activities), in order to reassure them about their homecare.	Marie lived alone with neurocognitive deficits and her daughter was very worried about the precarity of her homecare, especially in regards to her outings and eating habits. The telemonitoring reports showed that Marie's outings were minimal, of short duration and never at night, and that she was active in the kitchen even outside of CLSC service hours.	*"Actually, that's it, she was reassured. She worried that her mother would leave for longer periods of time or maybe a little more frequently eventually. Which is not the case. There was also, if I may add a little bit, concerning the meals, it allows us to see that the lady seems to eat even outside of CLSC service hours, at least to take snacks and all that. Which is reassuring for the daughter because she feared that Madame did not eat or barely did, you know"* (Professional in charge of Marie, CISSS3).
3.d. To share with their client's family to support relocation	Some professionals shared the telemonitoring reports with their client's family when the telemonitoring report showed that the older adult did not perform ADL adequately (e.g., prolonged, undesirable activi-ties), in order to support their decision to relocate their family member.	Living with severe cognitive difficulties, Maggie's homecare was known by the professional in charge of her care to be precarious, yet her daughter worried that relocation would deprive her of her quality of life. The telemonitoring reports showed that, while alone at home, Maggie spent on average close to 14.5 hours per day in bed.	*"It's mostly with sleep. Because, you know, she spends an average of 14 and a half hours a day in her room. In her bed. That's a lot of sleep. And during the day too. With little stimulation [...] sleep, in fact, it helped her to put on, well not weight, but to help her make the decision, for relocation, because, on the one hand, she (Maggie's daughter) was concerned about quality of life and taking something away from her by moving towards relocation, but on the other hand, if you look, well she sleeps.... She spent a lot of time in bed anyway,*

			and things like that, so we could still rely on that [...] so, you know, it also helped her to better understand reality" (Professional in charge of Maggie, CIUSSS1).

Step 4: Maintenance or modification of the intervention plan

After assessing the risks for their care recipients, professionals made decisions regarding their intervention plan (Step 4). Among HSCP, the most frequent decision reported in interviews was to maintain the actual intervention plan (43 occurrences recorded). The others decisions reported were to increase the number of intervention (2 occurrences), and to reduce the number of intervention (1 occurrence). See Table 3 for details per type of ADL. Step 4 sub-steps are detailed in Figures 4 and 5 and examples are given in Table 3.

ADL performed adequately, whether critical or non-critical (steps 4.a.1 and 4.a.2): When care recipients performed ADL adequately to meet their needs, most HSCP deemed it unnecessary to implement a new intervention or to modify their intervention plan (Table 3). In some cases, the telemonitoring reports also supported the reduction of interventions (Table 3).

Non-critical ADL performed inadequately (step 4.b.1): When the telemonitoring reports showed that the care recipients were performing non-critical ADL inadequately, most HSCP deemed it unnecessary to implement a new intervention or to modify it (Table 3).

Critical ADL performed inadequately ((steps 4.b.2-4.b.4)*:* Some HSCP faced with a critical homecare situation were not able to take action to address their care recipients' inadequate activities, such as in the case of Steve (Table 3). Indeed, the HSCP concluded that once Steve could no longer perform the "bare minimum", relocation would be the next step as their intervention plan was already maxed out. Some HSCP increased the number of interventions offered (Table 3). Lastly, when discrepancies between the telemonitoring reports and other sources of information about the care recipients' critical ADL performance arose, HSCP often opted to put their intervention plan "on hold", to further investigate. The term "on hold" was used when the HCSP and the research team required some time to investigate discrepancies between their observations and the telemonitoring data, in order to decide if a modification to the intervention plan was indeed warranted. As such, the actual plan was maintained but subject to future changes. The "on hold" cases were different from cases in which the intervention plan was maintained because ADL were performed adequately and/or were non-critical to the care recipient's homecare. This occurred when the reports showed that the care recipients scarcely performed desirable activities for which scheduled services were already in place (Table 3) or when they showed the care recipients performing desirable activities which were inconsistent with the HSCP's observations (Table 3). In Lois' and Louise's cases, discrepant telemonitoring data led the HSCP to enquire about sensor locations in the kitchen and bathroom, respectively. These enquiries with the research team led to improved sensor location, which in turn allowed for more accurate detection of the women's activities and for more accurate subsequent telemonitoring reports.

Timing of interventions (step 4.c.): Some HSCP used the telemonitoring reports to improve the timing of their interventions, notably by planning visits and follow-ups at the moments when the reports showed their care recipients to regularly be at home and active (Table 3).

Confirming the delivery of the intervention plan (step 4.d.): HSCP also used the

telemonitoring reports to confirm that their intervention plan was followed, notably by checking for increased activity in the care recipient's home during planned service hours delivered by health and social services assistants (Table 3).

Figure 4. Impact of telemonitoring report on risk assessment and service delivery

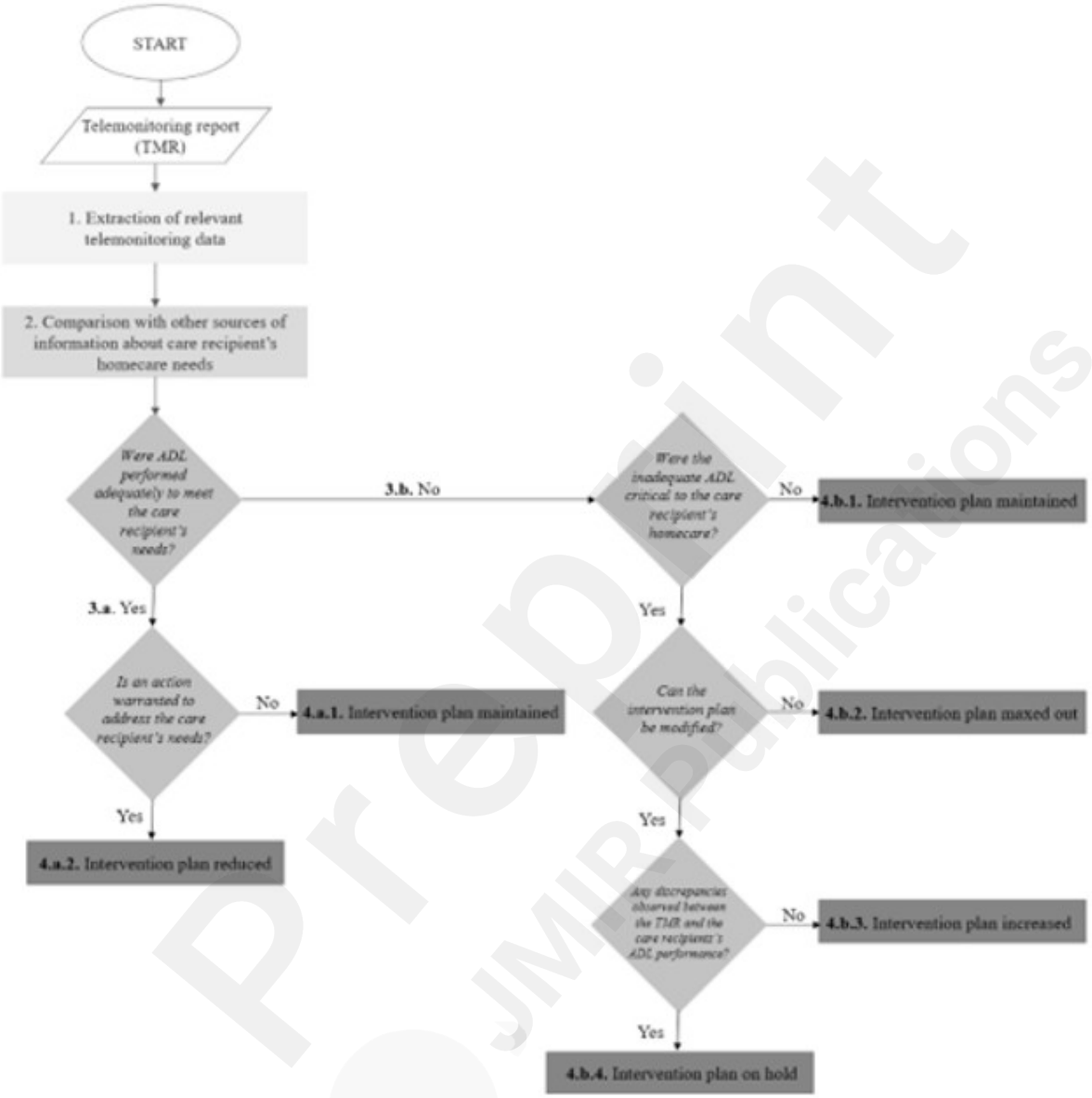


Table 3. Codes, definitions and verbatim extracts for Step 4: Maintenance or modification of the intervention plan

Codes	Definitions	Context	Verbatim extracts
Sub-step 4.a.1. Maintenance of the intervention plan	Most professionals deemed unnecessary to add an intervention when the telemonitoring report showed the older adult performed ADL adequately (e.g., he	In the case of Marge, an older woman living alone with neurocognitive difficulties, the professional was concerned about her safety after she had reported turning on the oven and leaving its door opened when she got cold. In a prior meal	*"And it also allowed me to, you know, in terms of stove use, I had doubts about the validity of my assessment in the sense that the wife had forgotten to turn it off […] So I was happy to see that the stove wasn't left on for*

	or she did not perform potentially dangerous or undesirable activities) Occurrences in care recipients: Meal prep:18, Sleep: 7, Hygiene: 8, Outings:9, Activity level:1.	preparation assessment with the professional, Marge had also forgotten to turn off the oven. Hence, adapting the oven for her safety was a potential intervention the professional was considering. Yet, when the telemonitoring report showed Marge did not use the oven for prolonged periods, its use was deemed safe by the professional and that intervention was not implemented.	*worrying lengths of time versus, in my assessment, she'd forgotten to turn it off […] Well, we didn't adapt the stove after all. The fact is, she was able to keep her habits, which was even better for her than upsetting her... she functions very much by automatism, so, like, I was afraid of introducing a new adaptation. So, we didn't have to upset her daily routine"* (Professional in charge of Marge, CISSS3)
Sub-step 4.a.2. Reduction of the intervention plan	Some professionals reduced an intervention when the telemonitoring report showed the older adult performed ADL adequately (e.g., he or she performed desirable activities regularly). Occurrences in care recipients: Meal prep:1, Sleep: 0, Hygiene: 0, Outings:0, Activity level:0.	Following their hospitalization, the user was under careful supervision by nurses (especially for medication). After some time back home following a hospitalization for a stroke, Thérèse wanted more autonomy, and while the professional in charge of her care believed too many services were now in place, her family remained greatly concerned. The telemonitoring report showed that Thérèse had good eating habits, and that she used the microwave mostly around lunchtime and the oven mostly in the evening. The telemonitoring report also showed that Thérèse was active in the kitchen at regular times, to prepare meals.	*"I think we've actually decreased a bit. We used to be present, and then we realized that everything was fine. Then we kind of, in terms of giving medication, I think there were things that were given that now are monitored like once a day or two, there. Then there are calls rather than visits. Then, during our checkups, everything is good […] Even diet. I think there's just... in the morning visit I think they check a bit that... in terms of taking meals. But the family continues to prepare meals. Madame organizes her lunch and with the data from the sensors, we were able to see that she is active at regular times for food. And that she uses the microwave more at lunchtime. That she cooks more in the evening. And that the sensor isn't on the oven's electricity. It's only on the door. But, hey, there's some activity going on"* (Professional in charge of Thérèse, CISSS3).
		Stan had Alzheimer's disease	*"In fact, it confirmed to us*

		and lived alone, with the help of his daughters. His eating habits had been problematic in the past and led to a worrisome weight loss. Stan's daughters had decided to hire an employee from *Chèque Emploi Service* (CES)[a]. Prior to receiving the telemonitoring report, the professional in charge of Stan's care had planned to ask the CES employee to implement a complete meal preparation occupational routine (i.e., when to eat, what to eat, in what quantity, etc.). The telemonitoring report showed that Stan already ate regularly, 3 times a day.	*that every day, he eats three times a day. So, we know we don't need to intervene, even when his daughters aren't there, we know we don't need to intervene on the habit of eating. We do not need to intervene on the whole "what to eat, in quantity and in quality"* (Professional in charge of Stan, CISSS3).
Sub-step 4.b.1. Maintenance of the intervention plan	Most professionals deemed unnecessary to add an intervention when the telemonitoring report showed the older adult performed ADL inadequately if this ADL was not at the core of his or her homecare challenges (e.g., he or she did not perform desirable activities as often as before). Occurrences in care recipients: Meal prep:2, Sleep: 3, Hygiene:1, Outings:3, Activity level:1.	In the past, Christine did not go out much, and the professional in charge of her care at the time was preoccupied. Now in charge of the older woman, the new professional remained vigilant of their predecessor's preoccupation. When the telemonitoring report showed a decrease in her outings, the new professional discussed the data with Christine.	*"Then, at some point, the outings - but I knew she was going out a little less - so I asked her about it [...] Then, I don't know if... maybe you weren't informed, but, basically, she was going out less because there's work going on right now in the block where she lives. In fact, they used to be able to go inside to the IGA (grocery store), but now they have to go outside. Ah, that's it. I know that for Madame, she mentioned to me that she found it more difficult"* (Professional in charge of Christine, CIUSSS1).
Sub-step 4.b.2. Intervention plan maxed out	Some professionals could not modify an already maxed out intervention plan	Long before his referral to the research project, Steve's homecare was very precarious. He lived alone with major	*"I'd say it (the data) didn't influence our intervention plan. Because, I mean, it would influence our*

[a] Chèque Emploi Service (CES) is a governmental program which allocates a certain number of hours to eligible people with a loss of autonomy, during which they can benefit from the home care services they need to remain in their own homes (e.g., housework, meal preparation, personal assistance, etc.).

	even though the telemonitoring report showed the older adult did not perform ADL adequately to meet his or her needs (e.g., he or she did not perform desirable activities, or did so too rarely or for an insufficient duration). Occurrences in care recipients: Meal prep:1, Sleep: 0, Hygiene:2, Outings:0, Activity level:0.	cognitive difficulties. He received very few visits from his professional, as he distrusted most people and did not tolerate their intrusions in his private life. Steve's hygiene was particularly problematic, and his appearance showed signs of neglect. All of the professional's previous attempts to implement services to better support him at home were rejected by Steve. The telemonitoring report showed minimal movement in the bathroom and the shower.	*intervention plan, I don't want to be negative, but it would influence our intervention plan for his hygiene. I'd suggest he gets assistance again. But knowing that we're facing a refusal, I mean, I won't do it. Even if it's... we know there's a little movement. A little bit of... he's getting into the shower, all that, but that it would require a better, how can I put it, assistance from an auxiliary to give him a full shower, a full bath. But given the fact that we're... as I say, for this gentleman, it's categorical, it's a refusal. So, I'm not proposing a new intervention plan […] It'll be a relocation if we judge that, in the end, it's no longer relevant, it's become too dangerous"* (Professional in charge of Steve, CISSS3).
Sub-step 4.b.3. Addition to the intervention plan	Most professionals added an intervention to their intervention plan when the telemonitoring report showed the older adult did not perform ADL adequately to meet his or her needs (e.g., he or she did not perform desirable activities, or did so for an insufficient duration). Occurrences in care recipients: Meal prep:1, Sleep: 0, Hygiene:1, Outings:0, Activity level:0.	Patty lived alone with neurocognitive deficits, and her eating habits were problematic. While no services were in place yet, the professional wanted her to eat three meals a day. The telemonitoring report showed that Patty ate a simple meal in the morning and cooked once, in the late afternoon.	*"So, it says that she eats a simple meal between 11 a.m. and noon because she uses everything she needs, and then "seems to cook between 4:30 and 6 p.m.", so I have the impression that she eats just twice a day. So, yes, I'd have to see to it that she eats at least three times a day [...] But like, for her, I'm going to intervene, I'm going to see her, as I was saying, to take a look at her eating routine. So, I'm going to redecide with her, whereas if I hadn't had that information, I wouldn't have done it. And since we're in the prevention business, it's good to be able to help her."* (Professional in charge of Patty, CISSS3)

Sub-step 4.b.4. Intervention plan on hold	Some professionals put their intervention plan on hold when the telemonitoring report showed the older adult did not perform ADL adequately to meet his or her needs (e.g., he or she scarcely performed desirable activities to meet his or her needs), when the data was not compatible with the services their client received. Occurrences in care recipients: Meal prep:2, Sleep: 0, Hygiene:3, Outings:0, Activity level:0.	Lois' eating habits were considered problematic. The professional in charge of her care had observed unused food in the refrigerator and they frequently threw away unopened expired food. To support her homecare, Lois received three meals per week from Meals-on-Wheels. The professional was perplexed when the telemonitoring report showed she seldom used the microwave to reheat them.	*"In fact, we'd already received two reports... in all, we'd received two reports for the data. And in fact, the first report confirmed most of our information, with the exception of the food, but at that time, she was also often removing the microwave sensors. So, it was during the second report that (the research professional) made a modification so that the sensor would really remain in place at all times. And that's when we... at that time, we saw that she was using the microwave only three times, I think, on average per month"* (Professional in charge of Lois, CIUSSS1).
	Some professionals put their intervention plan on hold even though the telemonitoring report showed the older adult performed ADL adequately to meet his or her needs (e.g., he or she regularly performed desirable activities) when the data was not compatible with their observations of their client. Occurrences in care recipients: Meal prep:1, Sleep: 0, Hygiene:1, Outings:0, Activity level:0.	Louise lived alone, at home, with neurocognitive disorders. The habits she reported to her professional were unreliable, as she did not recognize her difficulties. The professional in charge of Louise's care had observed her neglected appearance and, as such, was surprised when the telemonitoring report showed she regularly showered.	*"Let's face it, in first report, there was a lot of activity in the bathroom. Which really surprised us. Because it was as if she got in and out of the shower regularly during the week. But for us, according to our observations, it didn't quite fit. To finally discuss with (the research professional), see how the sensors were installed and what was really recorded as activity [...] So, (the research professional) made another visit to move some sensors around, so that we could get better data [...] So, after that, he was able to produce a more accurate report"* (Professional in charge of Louise, CISSS3).
4.c. To improve the timing of interventions	Some professionals used the telemonitoring	Lisa had Alzheimer's disease, lived alone, and already received many homecare services.	*"Yes, actually, like you know, we see that the oven, she always uses it around noon.*

	reports to plan their visits and follow-ups with their client, when the reports showed they performed activities regularly (e.g., he or she was active at regular times, he or she was absent at regular times).	The telemonitoring reports showed that she used her oven at mostly regular hours, and regularly went out between 9 and 10 am.	*So, for me, I make sure that I won't arrive at noon exactly, I'll arrive a little before to be sure that Madame is present to make her meal. Although for the exits, we did not see exactly when she left, but (the research professional) wrote to us "Generally, between 9 a.m. and 10 a.m., she opens the garage door". The fact that we know that between 9 a.m. and then 10 a.m., she goes for a walk, so we don't go there between those hours"* (Professional in charge of Lisa, CISSS3).
4.d. To confirm the delivery of the intervention plan	Some professionals used the telemonitoring reports to check for activity in their client's home during planned service hours (e.g., increased activity on the days services are provided to the older adult).	Peter had Alzheimer's disease and, as such, memory issues which made it difficult for him to reliably report whether he had eaten or not. In the past, weight loss had led the professional in charge of his care to implement a stimulation service three times a week, for three hours in the afternoon. Upon receiving the first telemonitoring report, the data showed increased activity in the kitchen, three times a week, in the afternoon.	*"Then also, we saw, because I can't remember how long it's been, but he has an employee who will spend time with him, three hours a day, to encourage him to eat, because at one point he had a weight loss, since he can't remember if he ate or not. Fact is that we put an employee in place. Then, your detectors picked up that yes, indeed, from such time to such time, on Tuesdays, Wednesdays, Thursdays, there is more movement in the house, so that also allows us to confirm that the employee is indeed there, as he says he is".* (Professional in charge of Peter, CIUSSS1)

Subsequent telemonitoring reports: assessment of ADL performance stability

With each subsequent telemonitoring report (see Table 4 for examples), HSCP went through the same clinical decision-making steps illustrated in Figure 3, with minor changes (identified with an "*"). However, most HSCP no longer felt the need to combine telemonitoring reports with other sources of information to validate their content. Instead, they compared the telemonitoring reports with *previous telemonitoring reports* (Step 2). As such, they assessed the risk of maintaining the care recipient at home (Step 3) by asking themselves: *in comparison to previous reports, was the care*

recipient's ADL routine stable (or not)? Hence, most HSCP deemed that a modification to their intervention plan was unnecessary if the care recipients' ADL performance had remained stable since the last telemonitoring report.

On the other hand, a modification to the intervention plan was warranted if the care recipients' ADL routine was unstable and thus reflected a deterioration of their routine (e.g., in comparison to the previous telemonitoring report, the care recipient now barely showers) or if undesirable activities had not improved or had worsened since then (e.g., in comparison to the previous telemonitoring report, the care recipient now regularly wanders at night).

Table 4. Codes, definitions and verbatim extracts for Subsequent telemonitoring reports: assessment of ADL performance stability

Codes	Definitions	Context	Verbatim extracts
Donna (CISSS3) **First report: Maintenance of the intervention plan**	Some professionals maintained their intervention plan when the telemonitoring report showed the older adult performed ADL adequately to meet his or her needs (e.g., he or she did not perform undesirable activities).	While Donna's cognitive difficulties made it difficult to explain her situation to the building managers, the first telemonitoring report showed that there was barely any activity at night, and that Donna remained in her bedroom, thus disproving the neighbor's claims. In doing so, it allowed the professional in charge of her care to provide the building managers with information before they began the eviction process with the *Quebec Regie du logement*, as they planned.	*"And when I told them (the building managers) that, well, Madame had sensors in her home and everything, that we could see what was going on at night and that what it showed us was that there wasn't really any activity going on. She's in her room most of the time, whereas the complaints were that she was in her bathroom and making a lot of noise in there […] Anyway, anyway! I explained everything and it seems that the situation is back to normal. They've offered her a new lease. You know, I don't have all the final, final details, but we'll be there. Madame, she's got a lease. She just signed a lease for a year"* (Professional in charge of Donna, CISSS3).
Subsequent report: Maintenance of the intervention plan	Some professionals maintained their intervention plan when the subsequent telemonitoring report still showed the older adult performed ADL adequately to meet his or her needs (e.g., he or she still did not perform undesirable activities).	Instead, Donna was offered a new lease to sign, and her relocation was no longer deemed necessary. The following telemonitoring report showed the stability of Donna's routine. The professional then used the following telemonitoring report to make the clinical decision that there still was no	*"I still get reports from (the research professional), and it's pretty stable. What I understand is that her routine is stable. She doesn't leave her apartment much, she doesn't have too many visitors, the door doesn't open that much [...]Despite everything she went through, she eats, she washes, she has a routine. You see, she goes to bed at relatively the same time, she*

		need for an intervention (or relocation) to address Donna's homecare situation.	*gets up at the same time..."* (Professional in charge of Donna, CISSS3).
Rose (CISSS3) **First report: Intervention plan on hold**	Some professionals put their intervention plan on hold when the telemonitoring report showed the older adult did not perform ADL adequately to meet his or her needs (e.g., he or she frequently performed undesirable activities), which the family doubted was accurate.	Rose lived alone in a basement apartment, located in her daughter's home. Upon receiving the first telemonitoring report, questions arose for both Rose's daughter and the professional: it showed that Rose frequently woke up during the night and went upstairs. The professional in charge of Rose's care initially put their intervention plan "on hold", to assess the possibility with the research team that the sensors were in fact detecting the family dog, not Rose.	*"So, the daughter doesn't think that her mother goes upstairs to her apartment in the middle of the night. She says: "She sleeps well". But she says: "The dog, it's more likely that it was the dog that had gone upstairs". So, it would be a matter of validating it. Because I know he was very careful, (the research professional), to put them (the sensors) on, precisely so that it wouldn't detect the dog"* (Professional in charge of Rose, CISSS3).
Subsequent report: Addition to the intervention plan	Some professionals then added an intervention to their intervention plan when the subsequent report still showed the older adult did not perform ADL adequately to meet his or her needs (e.g., he or she still frequently performed undesirable activities).	When the professional received the following telemonitoring report – which still showed Rose going upstairs during the night – follow-ups were made with her daughter to better secure her medication, which was kept upstairs.	*"In what way did it influence… well basically it allowed… well, because of her comings and goings, and we could see that she was going upstairs. Above all, it influenced the follow-up with her daughter, to put in place safer measures for her medication"* (Professional in charge of Rose, CISSS3).

Quantitative indicators of the impact of ADL telemonitoring reports on the intervention plan

The quantitative data complements the qualitative information obtained from HSCP describing how they maintain or modify their intervention plan according to the ADL telemonitoring report, i.e., Step 4 and subsequent telemonitoring report usages. We initially conducted a visual analysis of graphed data for each case to discern specific trends in services provided in correlation with NEARS-SAPA reports. Initial examination of the overall data suggests a gradual increase in the monthly sum of homecare services received over time prior to the introduction of NEARS-SAPA (Figure 6), with a deceleration in added services following its implementation. However, Tau-U analyses revealed no significant changes in trends from pre- to post-intervention. Yet, scrutinizing individual participant curves revealed two distinct patterns, which obscured outcomes when merged together. When solely

considering the period before the introduction of NEARS-SAPA, two separate baseline trends emerged (see Figure 7): 1) those in which the number of services provided remained stable or decreased before the intervention (Group-; Tau ≤ 0, n=12); and 2) those in which the number of services provided increased prior to the intervention (Group+; Tau > 0, n=13). Subsequent analyses were conducted separately for these two groups to avoid conflicting trends from overlapping in the same analysis. Both groups were comparable in terms of age (t=-1.56, p>.05), sex (t=-0.10, p>.05) and Iso-SMAF profiles (t=-0.87, p>.05).

Figure 5. Monthly sum of homecare services received over time prior to the introduction of NEARS-SAPA

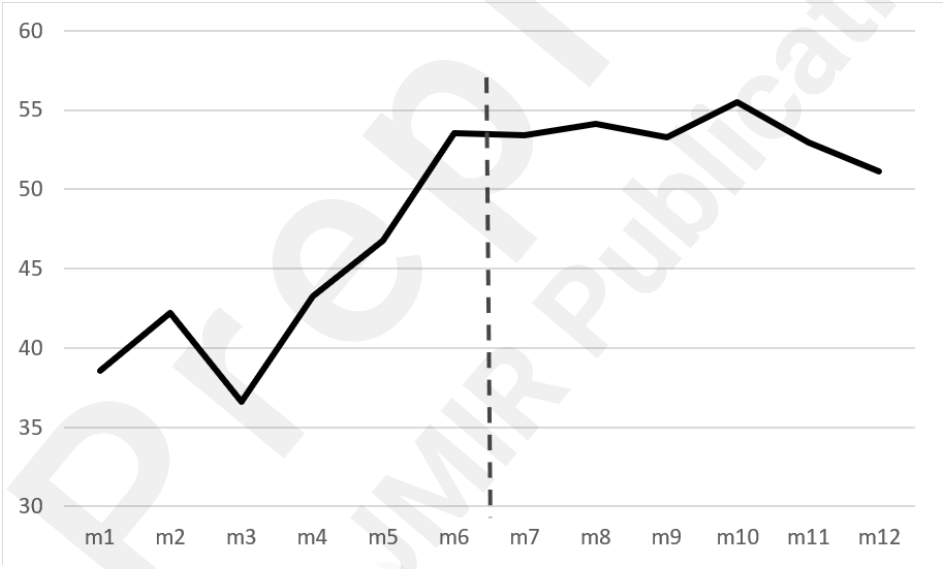
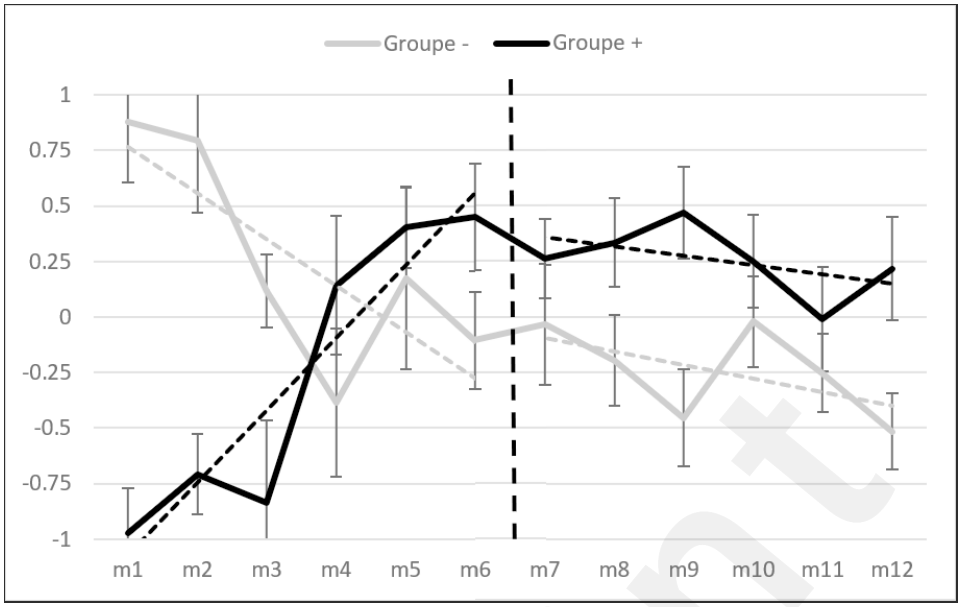


Figure 6. Visual analysis of subcases showing two distinct profiles, i.e. Group- and Group+



In the case of Group+, Tau-U analyses showed a significant change of medium effect size in trend following the introduction of NEARS-SAPA, Tau-U = -0.25, $p < 0.01$. This finding aligns with the outcomes of repeated ANOVAs: a significant Intervention X Months interaction, $F(1, 12) = 7.34$, $p < 0.01$, $eta^2 = 0.38$ revealed notable differences in trends before and after the introduction of NEARS-SAPA. Prior to the introduction of NEARS-SAPA, there was a substantial increase in services provided over time, Tau-U = 0.52, $p < 0.01$. However, following the introduction of NEARS-SAPA, there was no significant increase in services during subsequent months, Tau-U = -0.01, $p = 0.94$. In essence, this indicates a stabilization in monthly services following the implementation of NEARS-SAPA.

The Tau-U analysis conducted for Group- also exhibited a noteworthy change in trend subsequent to the introduction of NEARS-SAPA, as evidenced by a medium effect size, Tau-U = -0.27, $p < 0.01$. Upon closer examination, we noted a moderate decrease in services provided before the introduction of NEARS-SAPA, Tau-U = -0.31, $p < 0.01$, whereas this reduction was no longer significant after the introduction of NEARS-SAPA, Tau-U = -0.12, $p = 0.25$. However, this finding did not hold under repeated ANOVAs, as the differences in service decreases before and after were not statistically significant.

Overall, results suggest a stabilization in monthly services received following the introduction of NEARS-SAPA when compared to the 6 months prior. This effect is more significant in cases where services were increasing before its implementation.

Discussion

Principal Results

We conducted an ADR project to co-develop and implement NEARS-SAPA, an ADL telemonitoring system aiming to support homecare services of care recipients with cognitive deficits. As part of this larger ADR project, the objectives of the present study were more specifically to describe: 1) how the ADL telemonitoring data was used by HSCP in the process of maintaining care recipients with cognitive deficits at home, as well as 2) the impact of ADL telemonitoring on service delivery. For objective 2, we hypothesized that ADL telemonitoring would contribute to service optimization, in that it would enable HSCP to better identify which type of services their care recipient needs throughout the evolution of their condition.

To our knowledge, this is the first study to report on the usage of ADL telemonitoring into

real, healthcare services and, in particular, into the decision-making process of HSCP [12]. With regard to objective 1, the HSCP reported their usages in the form of a series of steps aiming to assess the suitability of the existing intervention plan. More specifically, once the telemonitoring data were extracted and compared with other relevant sources of information, HSCP conducted a risk assessment of the care recipient's ADL performance to remain at home and then acted on their intervention plan. With regard to objective 2, HSCP reported that their intervention could be maintained, reduced, increased or put on hold. Care recipients' clinical meta-data showed a stabilization in services received following the introduction of NEARS-SAPA, especially in cases where services were increasing prior to its implementation. This is consistent with qualitative data indicating that, in light of the telemonitoring data, most HSCP decided to maintain the current intervention plan rather than increasing or reducing services. Consequently, we observed fewer significant changes in homecare services after telemonitoring introduction. Still, interpretation must remain prudent as the distribution of services is influenced by multiple factors and results needs to be replicated with a larger sample size and a control group. Overall, the qualitative results confirm our hypothesis that ADL telemonitoring contributed to service optimization on a case-to-case basis. These preliminary quantitative results suggest that ADL telemonitoring has the potential to influence service delivery on a larger scale, in particular when questions remain as to the relevance of services. ADL telemonitoring seems to have the potential to play an important role in reassuring HSCP about their risk management and the appropriateness of services delivery. NEARS-SAPA enables the clinicians to obtain information that was not available from other sources, contradictory or only partially available.

For homecare workers, risk management is central to their practice, particularly for the homecare of care recipients with cognitive deficits. Professionals and caregivers who care for them define this risk management as fluid and highly context-dependent [37], thus encompassing subjective aspects[38]. In a study conducted among homecare staff in Sweden, Sandberg et al. [39] reported that these workers implement a reasoning process aimed at tracking, identifying, and acting on this risk. Tracking and identifying risks were considered challenging by the participants, requiring close and longitudinal monitoring as needs evolve with the progression of cognitive impairments. Participants in the Sandberg et al.[39] study described how they were constantly on the lookout for signs of risk during home visits, which can occur several times a day. In our current study, healthcare providers reported that ADL telemonitoring has the potential to reduce certain subjective aspects related to risk management, facilitate longitudinal monitoring, and, in some contexts, reduce the need to travel to confirm certain information.

However, ADL telemonitoring only provides a few pieces of the puzzle. There are several factors contributing to the risks at home and the maintenance of the individual in their living environment, factors that cannot be assessed through telemonitoring, such as each HSCP's comfort level with risk, ethical dilemmas related to the protection of the individual versus their expressed needs and wishes, caregiver level of burden, the older adult's socio-economic status, complex medication management, etc. [23, 39, 40]. The decision to add a service or recommend a change in living environments to avoid excessive risks thus relies on a multitude of factors, and it is possible that ADL telemonitoring does not have a direct effect on the services received. This is why quantitative data in the present study may not, at this stage at least, show significant direct changes in all contexts. Future larger-scale studies with control groups may be able to identify more specific effects of ADL telemonitoring on service delivery and associated costs.

Results of the present study also suggest that the NEARS-SAPA system may be considered as a form of clinical decision support system. According to Sutton et al.[41], "a clinical decision support system (CDSS) is intended to improve healthcare delivery by enhancing medical decisions with targeted clinical knowledge, patient information, and other health information" (p.1). However, NEARS-SAPA does not issue recommendations on decisions and actions to be taken, and therefore does not perfectly fit with the classical notion of CDSS[41]. Lyell et al.[42] suggest to use the term

“assistive technology” for clinical decision making to refer to these types of systems where part of the data extraction and analysis is done by algorithms but where the clinicians provide the decision on the task and need to confirm or approve the device information. This distinction is important when one seeks to compare the results of our study with those of other types of telemonitoring systems. The use of the data in both these situations is not the same: in one case, the clinicians use a recommendation indicating changes in the health situation that needs a follow-up (e.g. oxygen saturation and/or heart rate indicate deterioration from previous day or from hospital discharge), whereas in the case of NEARS-SAPA, HSCP used uninterpreted evaluation results (e.g. care recipient showers once a week).

That said, despite the distinction between the two types of systems, there is no substantial data on how clinicians use CDSS systems or assistive technologies in their clinical reasoning, particularly in real clinical practice contexts [42]. Barken et al.[43] is one of the few studies, to our knowledge, that has examined how the telemonitoring of parameters related to chronic diseases is integrated into the clinical decision-making of nurses dedicated to this task. This study showed that nurses combine various pieces of information, including telemonitoring, to get an overall view of the patient's condition and clarify their current health status. Similar to the HSCP in the present study, the nurses in the Barken et al.[43] study use telemonitoring as a complementary source of information. They use it to initiate their clinical reasoning, i.e., to identify health problems and then prioritize by themselves the patients' follow-up needs. In our study's context, the information was specifically used to address questions about potential risks in a setting where clinical reasoning had already begun and where the HSCP was interested in obtaining additional or supplementary information. It would be interesting to study in the future whether the framework that emerged from our study could apply to the use of other types of telemonitoring, such as those related to chronic diseases, as well as in another clinical contexts; for example, when clinical reasoning is in its infancy, such as for new care recipients. Understanding the clinical reasoning of professionals using telemonitoring is crucial to help field teams prepare for the deployment of such systems and implement them harmoniously with existing practices [44]. This careful planning of implementation can significantly impact the adoption and sustainable maintenance of the technology, knowing that many technology deployment projects in healthcare have failed worldwide [44]. Understanding how technology can truly be useful to healthcare workers is an important consideration.

Limitations

The work presented here is a first step in this direction, but we are aware that our work still has limited scope. This limitation is partly due to the COVID context, which forced us to use manually created PDF reports to present the data and help HSCP understand its significance. This made the process laborious and difficult to scale up. Future studies will focus particularly on ensuring automated and clear data presentation so that the system can be more easily used on a larger scale while continuing to effectively support clinical reasoning. The limited scope of our study is also related to the absence of a control group, which particularly impacted the analysis of quantitative results. Additionally, the scope is limited by the fact that the older adults followed in our study were mostly already known to homecare services and were already receiving services. Thus, we do not know how ADL telemonitoring could be used in the context of an initial contact with a user for a first needs assessment. The use of ADL telemonitoring data could be different at this stage and have more cost savings related to the time saved in obtaining the initial clinical information required to develop an intervention plan. Also, we did not document the cost impacts related to service delivery and the benefits for the healthcare system in a more holistic manner. Lastly, another important point to address in the future is the ethical issues that can arise during the implementation of a system like NEARS-SAPA. These ethical aspects should be explored in greater depth with all stakeholders, to ensure that all potential ethical issues are considered a-priori and during the course of the study.

Future larger-scale studies will allow us to analyse both cost and ethical aspects.

One of the great strengths of our study is however the fact that it relied on mixed, longitudinal data and a large number of interviews, enabling a rigorous and innovative investigation of the use of ADL telemonitoring data in a real clinical setting.

Conclusions

To our knowledge, this is the first demonstration of the integration of ADL telemonitoring data in a real clinical practice setting. It is also the first description of the real potential impact of this technology on the delivery of home support services. These results will help future studies and healthcare managers to better target the role of new technologies in homecare clinical practice. Future studies may further explore the benefits of ADL telemonitoring (qualitative and quantitative) for public healthcare systems, with larger-scale implementation studies.

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Conflicts of Interest

A transfer of NEARS-SAPA IP was completed in 2023 to a solidarity cooperative. Some co-authors are involved in it and may receive dividends in the future. However, they do not control it as it is a solidarity cooperative

Abbreviations

ADL: activities of daily living
ADR: action design research
CDSS: clinical decision support system
CISSS: *Centre intégré de santé et de services sociaux*
CIUSSS : *Centre intégré universitaire de santé et de services sociaux*
CLSC : *Centres locaux de services communautaires*
HSCP: health and social care professionals
MMSE: Mini-Mental State Examination)
MoCA: Montreal Cognitive Assessment)
NEARS: iNnovative Easy Assistance System
SAPA: *soutien à l'autonomie des personnes âgées*

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