# Impact of a home-based remote patient monitoring system: a multicenter retrospective observational study in older adults with polypathology

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# *Table of Contents*

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## *Abstract*

**Background:** Every year, in France, 40% of people aged 80 and older are hospitalized, with an average length of hospital stay of 25 days and a readmission rate of 14 to 30% within the month following discharge. This situation is putting pressure on the healthcare system, encouraging the reinforcement of home care to reduce avoidable hospitalization.
EPOCA remote patient monitoring (RPM) system is a medical and social telehealth solution, specialized in remote patient monitoring, teleconsultation, tele-expertise and care coordination in emergency medicine and geriatrics. The platform provides long-term medical support at home (MSAH) with 24/7 telemonitoring of polypathological older adults. We hypothesized that entering the EPOCA RPM system long-term MSAH would be associated with a reduction of the rates and durations of hospitalizations or emergency department (ED) visits in older polypathological adults.

**Objective:** We aimed to compare the hospitalization and ED visits rates as well as the cumulated hospital stay duration before and after entering the EPOCA RPM system long-term MSAH globally and per participant. Then two subgroups of participants according to the severity of their disability were analyzed.

**Methods:** This retrospective observational study included polypathological (>2 affected systems) older (? 70 years) adults followed into two different types of long-term MSAH between February 2022 and October 2023. We compared the number of hospital admissions, including ED visits, the cumulated duration of hospital stays during the follow-up, and the average length of hospital stays between the period corresponding to the MSAH program (Y) compared to the year before entering the program (Y-1). Subgroup analysis were performed according to the severity of participant's disability.

**Results:** One hundred and twenty participants were included in MSAH, with a mean age of 86.8 years. Hospitalization and ED visits rate decreased (-48%) between Y-1 and Y periods as well as the total duration of hospital stays (-63%). A significant reduction of hospitalization number (from 1.3 to 0.7 per patient per year, P<.001) and ED visits (from 1.4 to 0.7 per patient per year, P<.001) was observed between Y-1 and Y follow-up periods. It corresponds to a significant reduction of 17 days spent at hospital per patient per year (P<.001). The decrease in hospitalization and ED visit rates and numbers was greater in participants with severe disabilities compared to those with no or moderate disabilities.

**Conclusions:** Among polypathological older adults, EPOCA RPM system is associated with reduction of hospitalization number, ED visits and duration of hospital stays. Facing the challenge of population aging, home telemonitoring embedded in the healthcare system offers potential benefits.

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# Original Manuscript

## Original Paper

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## Abstract

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**Conclusions:** Among polypathological older adults, EPOCA RPM system is associated with reduction of hospitalization number, ED visits and duration of hospital stays. Facing the challenge of population aging, home telemonitoring embedded in the healthcare system offers potential benefits.

**Keywords:** older adult; telemedicine; telemonitoring; tele-expertise; home-based medical care; hospital readmission; Patient Care Coordination; Hospitalization Reduction; polypathology; geriatric.

## Introduction

### The Challenge of Healthcare Pathway for Older Adults

The aging of the population is a global phenomenon challenging the healthcare system [1], [2]. Life expectancy at birth continues to rise worldwide, and in Europe, it stands around 85 years for women and 80 years for men [3]. For instance in France, on January 1st 2024, 28.0% (18.5 million people) of the French population was 60 years and older and 6.1% (4 million people) were 80 years or over [4]. Concomitantly, the proportion of older adults with disability is growing [5].

In this context, the healthcare system faces multiple challenges, as the medical offer does not increase proportionally to the demographic growth in the older population. Demand for medical services and specialized home care for older adults is particularly growing [6]. At the same time, the overall number of doctors is much lower in France than in the European Union's average (3.2 versus 4.1 doctors per 1 000 population in 2021, respectively). In particular, general practitioners (GPs) number has reduced over time by 8% between 2012 and 2022 [7]. Due to work overload, more and more GPs are adapting their practice toward refusing new and occasional patients or appointments at home [8], [9]. Thus, in 2021, approximately 6% of people aged 80 and over did not have an assigned GPs, and 10.6% of them were people with long-term illnesses [10].

Besides, hospitalization is often the quickest and commonest way to respond to the complexity of managing older adults with multiple pathologies [11], [12] causing organizational challenges, especially for emergency departments (EDs). While representing 6.1% of the French population, people aged 80 and over counted for 12.5% of persons hospitalized in 2018, and 40% of people aged 80 and over experienced at least one hospital stay during the year, with an average length of hospital stay per patient around 25 days [13], [14]. Furthermore, 13-40% of admissions to EDs and more than 30% of hospitalizations are believed to be avoidable [15].

Early readmission after a hospital stay is a frequent occurrence, involving between 14 and 30% of patients within the month following discharge [16], [17], [18]. Telemonitoring through the use of telemedicine is a way to optimize the care for older adults with multiple chronic diseases [19], [20], [21], and could lead to a significant reduction in hospital readmissions, and lower health costs [22], [23], [24]. Remote patient monitoring (RPM) is a telehealth activity to collect and analyze patient health indicators or medical data, with the objective of ensuring that patients are safety monitored, improving patient outcomes and reducing avoidable hospital admissions (for reviews: [25], [26], [27]).

A meta-analysis of integrated care programmes using telemedicine in chronically ill patients (chronic

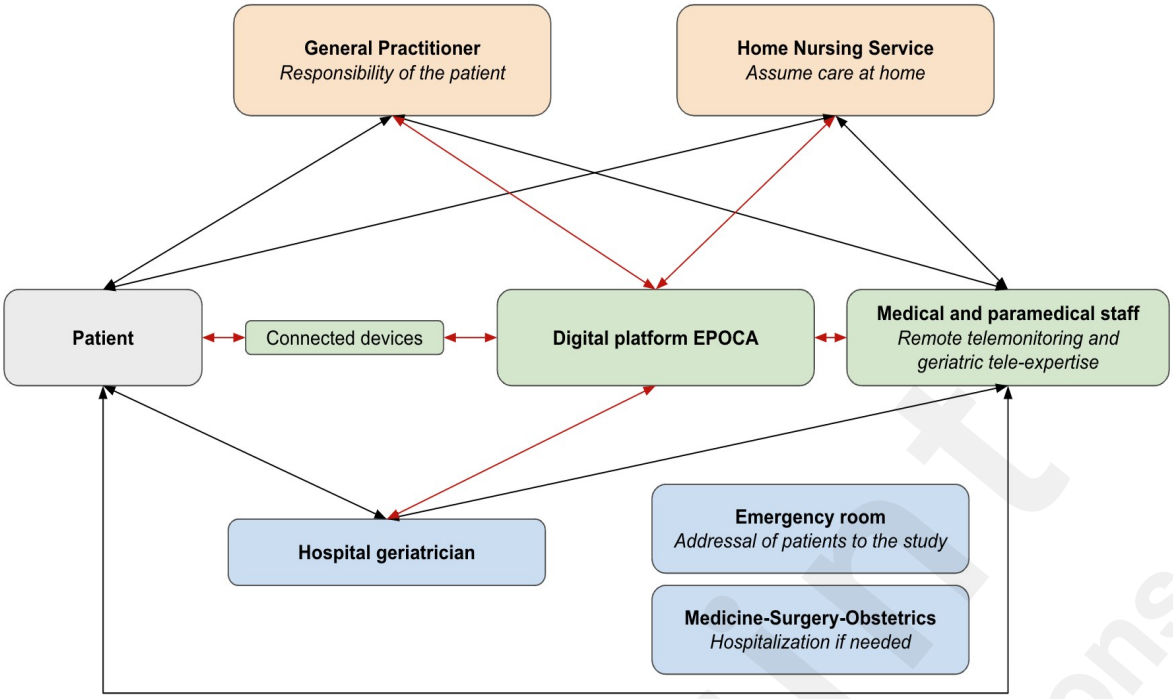
heart failure, DM, COPD and asthma) reported beneficial effects, including reduced use of healthcare resources (such as hospital admissions and readmissions) [21]. Most mentioned studies focused on one chronic condition whereas geriatric older adults are usually suffering from polypathology. More recently, another meta-analysis concluded that transitional care interventions with telemedicine were associated with a 40% reduction of hospital readmission in chronically ill older patients (≥ 65 years) with high risk of readmission (including polypharmacy or polypathology) [13]. The studies included in this meta-analysis reported telehealth assistance mostly performed by phone calls or visio conferencing. Moreover, the ED visits rate was not reduced suggesting a lack of coordination of community care services when health problems were detected. Results from a French multicenter observational study also evidenced the potential effectiveness of geriatric expertise phone hotlines in preventing unnecessary hospital admissions (36.3% decrease) in the ED or a geriatric acute care unit [28]. The eCOBAHLT randomized controlled trial assessed the impact of a home-based telesurveillance program on hospital readmissions in older patients (65 or more), with at least two comorbidities and discharged home after hospital care. The study found a significant reduction in readmissions for the intervention group (40.4%) compared to those receiving standard care (48.7%) during a 12-month follow-up [29]. However, as in previous studies, RPM generated more ED visits without hospitalizations. The impact of RPM on increasing ED visits may be an important issue. Integrating RPM in a program with important coordination of care between hospital and community services may help to reduce unnecessary ED visits and hospitalizations.

## The EPOCA RPM System Included in the Vigie-Age Project

The Vigie-Age project is a collaborative multidisciplinary hospital-community initiative starting in 2019 Hauts-de-Seine department (Paris area, France), that aims to ensure comprehensive and coordinated care for polypathological older adults, enhancing their quality of life and reducing avoidable hospitalizations. In this context the EPOCA RPM system collaborates with the geriatric departments of four hospitals, GPs and homecare services in the community. The EPOCA RPM system is a human and connected telemedicine solution that offers secure home support for complex patients. It consists in a 24/7 telemonitoring platform that enables continuous remote monitoring as well as human assistance for emergency and geriatric expertise, coordination between the community paramedical teams, the GP and the geriatrician in order to set up personalized care plans (Figure 1).
Basically, the EPOCA RPM system technology consists of two parts: (1) a remotely connected device (bracelet or medallion) for alert or health data transfer and (2) an RPM center with trained advisors (nurses and physicians) who contact patients and caregivers when necessary. Hospital geriatricians play a pivotal role, providing ongoing medical expertise through regular teleconsultations and tele-expertise, while being in constant contact with the other health professionals involved in patient care plans. Liberal nurses from community healthcare services conduct regular assessments and provide necessary home care.

This system is a medical device that meets the regulatory requirements for generic lines of remote medical telesurveillance operators. It also complies with General Data Protection Regulation (GDPR) and health data hosting (HDH) standards.

**Figure 1.** Collaboration between EPOCA RPM system and the healthcare professionals in the Vigie-Age project.




## Study Goals

The aim of this study was to investigate whether entering the EPOCA RPM system, as part of a hospital-community coordination of care program, is associated with the reduction of hospital admissions including ED visits, and shorter hospital stay duration.

## Methods

## Study Design

A retrospective observational multicenter cohort study was conducted on patients benefiting from EPOCA RPM system within the Vigie-Age project, to ensure a long-term care program, so-called Medical Support At Home (MSAH). The intensity of the intervention was adapted to the level of participant's disability.

The disability level was determined using the *Groupe Iso-Ressources* (GIR). The GIR is a French administrative score system that assesses basic activities of daily living (walking, feeding, dressing, washing, and urinary and faecal continence) and more complex activities (perception of time and place, managing medication, managing shopping and finances, and using a telephone). The GIR score can vary from 1 (bed-ridden or major physical and mental limitations requiring assistance in all daily living activities) to 6 (no disability [30]. Participants scoring GIR 4, 5 or 6 were considered as having no disability or moderately disabled, whereas participants scoring GIR 1, 2 or 3 were considered severely disabled.

The long-term MSAH started after the participant was discharged from one of the geriatric departments, emergency department involved in the program or by home nursing professionals. Multi-disciplinary re-evaluation were systematically proposed at D14, M1, M3 and then every three months. In case of acute event, the intervention could be reinforced during a short time period, so-called Acute Geriatrics at Home (AGH), to avoid hospitalization if possible. If hospitalization occurred in spite of this, the AGH could reduce the duration of the hospitalization by anticipating hospital discharge. Then the long-term MSAH program could continue after acute condition resolution.

## Inclusion and Exclusion Criteria

The criteria for admitting patients to MSAH follow-up were being aged 70 or older having polypathology (> 2 affected systems). The participants entered the EPOCA RPM system not simultaneously and so had very different durations of follow-up. All patients followed by the EPOCA RPM system in MSAH long-term care pathway for at least 5 months between February 2022 to October 2023, were included in the study. We choose to not include participants with shorter follow-up in order to obtain a median of follow-up close to one year, and then better approximate the annual hospitalization rate.

## Ethics

Participants received written information indicating that data collected in the EPOCA RPM system database regarding medical records and follow-up outcomes could be used retrospectively for research. They gave a written consent to the use of their data after anonymization when they entered the EPOCA RPM system. The research methodology and the minimum dataset were declared to the French authorities (CNIL, *Commission Nationale de l'Informatique et des Libertés*, declaration number 2234081).

## Data Collection and Data Storage

The medical and paramedical teams (internal or external to EPOCA RPM system) in charge of each patient collected data and compiled this data into the EPOCA RPM system database at baseline and during the follow-up.

Data corresponding to characteristics at the time of analysis were extracted and anonymized for each included patient from the EPOCA RPM system database. Data consisted in socio-demographic and environmental information (age, gender, social isolation, precarious social situation, presence of non-professional and professional caregivers, and being under legal protection, disability level according to GIR score, in activities of daily living (ADL) [31] and instrumental activities of daily living (IADL) [32], and cognitive status according to the mini-mental state examination (MMSE) [33]. Polypathology was assessed using the global Charlson comorbidity scale and the number of chronic conditions listed among the pathologies frequently observed in this population. The number and type of molecules in usual medication was also considered. Nutritional status was evaluated using body mass index (BMI), and history of recent weight loss.

## Primary Outcomes

A "before-after" pragmatic approach was used, to compare the primary outcomes. These outcomes were the total number of hospital admission including ED visits, hospitalization rate per participant, and the cumulated duration of hospital stays in days for the total population and per patient. The average length of hospital stays (i.e. the mean number of hospitalization days considering the overall cohort) was calculated by dividing the total number hospitalization days of all patients during the period by the total number of hospitalizations.
Given the retrospective nature of the study and the availability of data collected over varying lengths of time, a proration approach was used to adjust measures on an annual basis for the EPOCA RPM system period (Y period). Then the annualized rate of outcomes measured during the EPOCA RPM system were compared to the outcomes measured during the year before the entry into the program (Y-1 period). If participants ended the follow-up after 5 months for any reason including death, the primary outcomes were collected until the date the follow-up ended. The recovery of hospitalization data over the Y-1 period was carried out from patient medical records.

## Statistical Analysis

Sociodemographic and clinical data were expressed by mean with standard deviation (SD) for continuous variables and number and proportion for categorical variables. Data were described for the all population and compared according to the disability level using Student-T or Chi-square tests.

The absolute and relative variations of number of hospital stay and ED visits, cumulated length of hospital stay during the periods and the average length of hospital stay before and after the EPOCA RPM was performed after subtracting the values measured during the prior (Y-1) year to those of the EPOCA RPM follow-up (Y) year, adjusted on an annual basis. The number of hospitalizations, ED visits and the cumulated length of hospital stay per patient were compared between the two periods using the paired t-test.

Statistical significance was considered when $P<.05$. All statistical analyses were performed using Microsoft Visual Studio Code™ (VS Code), version 1.84.2 in Python language (version 3.11.5).

## Sample Size Calculation

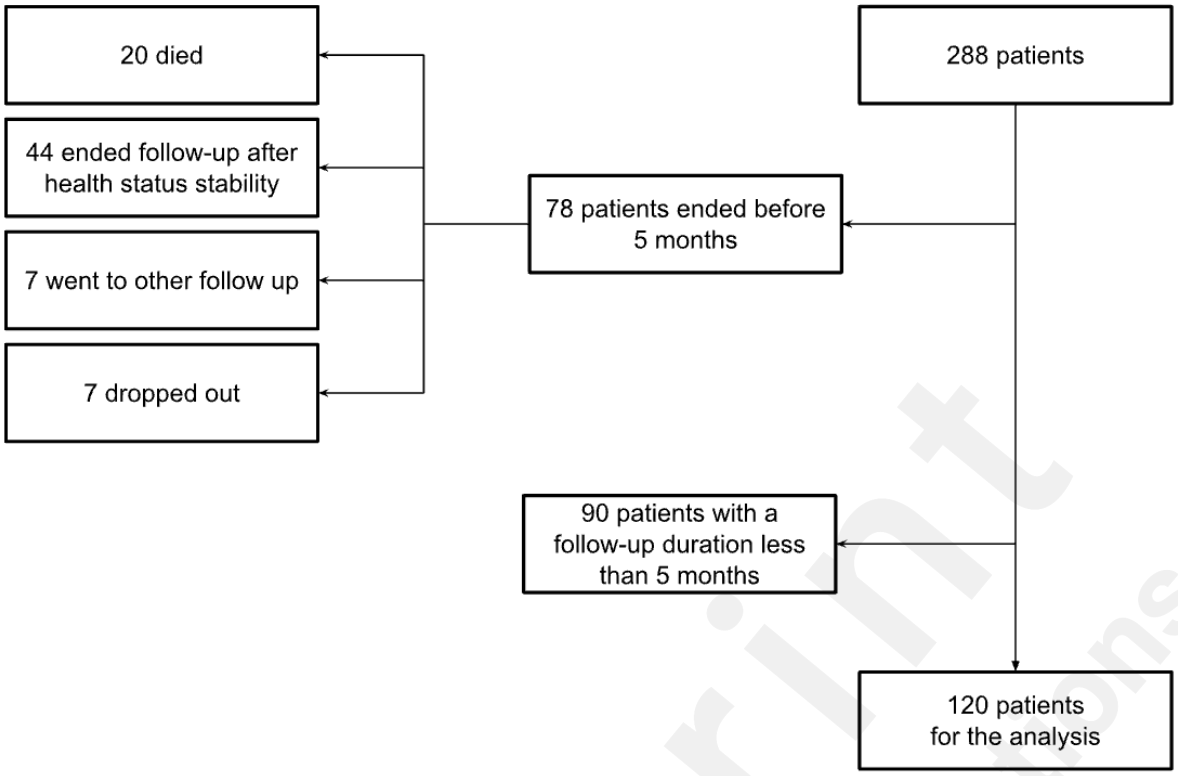
A sample size calculation was performed with an alpha risk of 1% and beta risk of 5%. An estimated yearly duration at hospital of 13 days, and an expected decrease of 30%. These data have been selected from a pilot study of MSAH patients with a mean follow-up duration of 5 months. A minimum of 111 patients is aimed.

## Results

## Participants Characteristics

Study included 120 participants (Figure 2) (59% were female, with a mean (SD) age of 86.8 (7.9) years), 69 (57.5%) were considered with no or moderate disability (GIR 4-6) and 51 (42.5%) severely disabled (GIR-1-3). Table 1 summarizes the characteristics of participants. Social isolation affected 48% of participants. People with higher level of disability had significantly higher number of external caregivers, were more frequently under legal guardianship, had lower MMSE scores and had a more frequent history of dementia. The mean (SD) number of chronic diseases was 6.1 (2.5) and the number of medications was 8.8 (3.4) without difference between disability level groups.

**Figure 2.** Flow chart of participant selection from the total number of patients included in the Vigie-Age project




## Overall Drop-Out Rate and Average Duration of Follow-Up

Among the 120 participants of the study, the duration of follow-up in EPOCA RPM system ranged from 161 to 597 days, with a median (first quartile ; third quartile) of 323 (225 ; 469) days. A total of 50 patients (42%) were followed for more than one year. A total of 34 (28.3%) patients ended the follow-up: 15 (12.5%) died, 15 (12.5%) ended follow-up after health status stability and reaching the expected follow-up duration, 3 (2.5%) dropped out and 1 (0.8%) went to another follow-up program.

**Table 1.** Characteristics of the participants.

| Variables | N of missing data | All (n=120) | Disability level | | |
|---|---|---|---|---|---|
| | | | No or moderate (n=69) | Severe (n=51) | *P value* |
| **Demographic data** | | | | | |
| Age (years), mean (SD) | 0 | 86.8 (7.9) | 86.7 (6.6) | 86.9 (9.4) | .90 |
| Gender (female), n (%) | 0 | 71 (59) | 45 (65) | 26 (51) | .17 |
| Social isolation, n (%) | 0 | 52 (48) | 33 (50) | 19 (45) | .77 |
| Presence of a non-professional caregiver, n (%) | 0 | 66 (55) | 32 (46) | 34 (67) | **.04** |
| Number of children, mean (SD) | 4 | 2.2 (1.8) | 1.8 (1.6) | 2.6 (2.2) | **.002** |
| Under legal guardianship, n (%) | 11 | 23 (21) | 8 (13) | 15 (33) | **.02** |
| **Professional caregiver** | | | | | |
| Number of external caregivers, mean (SD) | 0 | 2.4 (1.7) | 1.9 (1.5) | 3.1 (1.6) | **<.001** |
| Nurse, n (%) | 8 | 72 (64) | 34 (55) | 38 (76) | **.03** |
| Care assistant, n (%) | 14 | 67 (63) | 31 (53) | 36 (77) | **.02** |
| Physiotherapist, n (%) | 14 | 50 (47) | 26 (45) | 24 (50) | .74 |
| Home nursing services, n (%) | 22 | 39 (40) | 14 (25) | 25 (59) | **.0012** |

| | | | | | |
|---|---|---|---|---|---|
| Home care helper, n (%) | 21 | 38 (38) | 11 (21) | 27 (59) | **<.001** |
| Housekeeper, n (%) | 84 | 16 (44) | 10 (50) | 6 (37) | .68 |
| Meal delivery, n (%) | 9 | 15 (14) | 9 (14) | 6 (12) | 1.0 |
| GP declared, n (%) | 0 | 9 (7.5) | 4 (5.8) | 5 (9.8) | .63 |
| **Functional and cognitive assessment** | | | | | |
| GIR, mean (SD) | 0 | 3.4 (1.3) | 4.2 (0.98) | 2.3 (0.87) | **<.001** |
| ADL - Katz index, mean (SD) | 10 | 3.6 (1.9) | 4.4 (1.5) | 2.4 (1.7) | **<.001** |
| IADL - Lawton index, mean (SD) | 12 | 2.8 (2.3) | 4.0 (2.3) | 1.2 (0.8) | **<.001** |
| MMSE, mean (SD) | 57 | 21.8 (5.7) | 23.6 (4.1) | 18.9 (6.8) | **.002** |
| **Nutritional assessment** | | | | | |
| BMI, mean (SD) | 5 | 25.4 (5.8) | 25.3 (5.2) | 25.5 (6.7) | .88 |
| Abnormal weight loss, n (%) | 0 | 21 (18) | 9 (13) | 12 (24) | .21 |
| **Comorbidities** | | | | | |
| Charlson, mean (SD) | 0 | 7.4 (2.4) | 7.4 (2.3) | 7.3 (2.5) | .84 |
| Number of chronic diseases, mean (SD) | 0 | 6.1 (2.5) | 6.0 (2.5) | 6.3 (2.6) | .42 |
| Essential hypertension, n (%) | 0 | 89 (74) | 50 (72) | 30 (76) | .78 |
| Heart failure, n (%) | 0 | 50 (42) | 31 (45) | 19 (37) | .51 |
| Atrial fibrillation and flutter, n (%) | 0 | 43 (36) | 26 (38) | 17 (33) | .76 |
| Coronary artery disease, n (%) | 0 | 21 (18) | 15 (22) | 6 (12) | .24 |
| Dementia, n (%) | 0 | 43 (36) | 18 (26) | 25 (49) | **.02** |
| Gait disorders, n (%) | 0 | 42 (35) | 29 (42) | 13 (25) | .09 |
| Depression, n (%) | 0 | 28 (23) | 15 (22) | 13 (25) | .79 |
| Cerebrovascular accident, n (%) | 0 | 23 (19) | 9 (13) | 14 (27) | .08 |
| Diabetes mellitus, n (%) | 0 | 20 (17) | 10 (14) | 10 (20) | .62 |
| Chronic obstructive Pulmonary Disease, n (%) | 0 | 19 (16) | 13 (19) | 6 (12) | .43 |
| Anemia, n (%) | 0 | 28 (23) | 12 (17) | 16 (31) | .12 |
| **Medications, n (%)** | | | | | |
| Number of medications, mean (SD) | 0 | 8.8 (3.4) | 8.8 (3.6) | 9.0 (3.1) | .74 |
| Antihypertensive drugs | 0 | 91 (76) | 54 (78) | 37 (73) | .61 |
| Anticoagulant drugs | 0 | 55 (46) | 33 (48) | 22 (43) | .69 |
| Antiaggregants | 0 | 31 (26) | 19 (28) | 12 (24) | .78 |
| Diuretic drug | 0 | 49 (41) | 33 (48) | 16 (31) | .10 |
| Benzodiazepine | 0 | 47 (39) | 22 (32) | 25 (49) | .09 |
| Antidepressants | 0 | 35 (29) | 17 (25) | 18 (35) | .29 |

## Hospitalization and Emergency Department Admission Rate and Hospital Stay Duration

Table 2, Table 3 and Figure 3 present outcomes variation between Y and Y-1 follow-up periods.
In the total study population, all the indicators decreased between Y-1 and Y follow-up periods including the total hospitalization duration (-63%), the number of hospitalizations (-48%), the number of ED visits (-48%) and the average length of hospital stays (-18%). The decrease concerns the two subgroups according to the level of participant's disability and even greater in the more severely disabled participant group (Table 2).

**Table 2.** Total hospitalization duration, number of hospitalizations, emergency department visits and average length of stay in all populations on Y and Y-1 follow-up periods.

| | **Y-1 period** | **Y period** | **Change Y versus Y-1 (%)** |
|---|---|---|---|

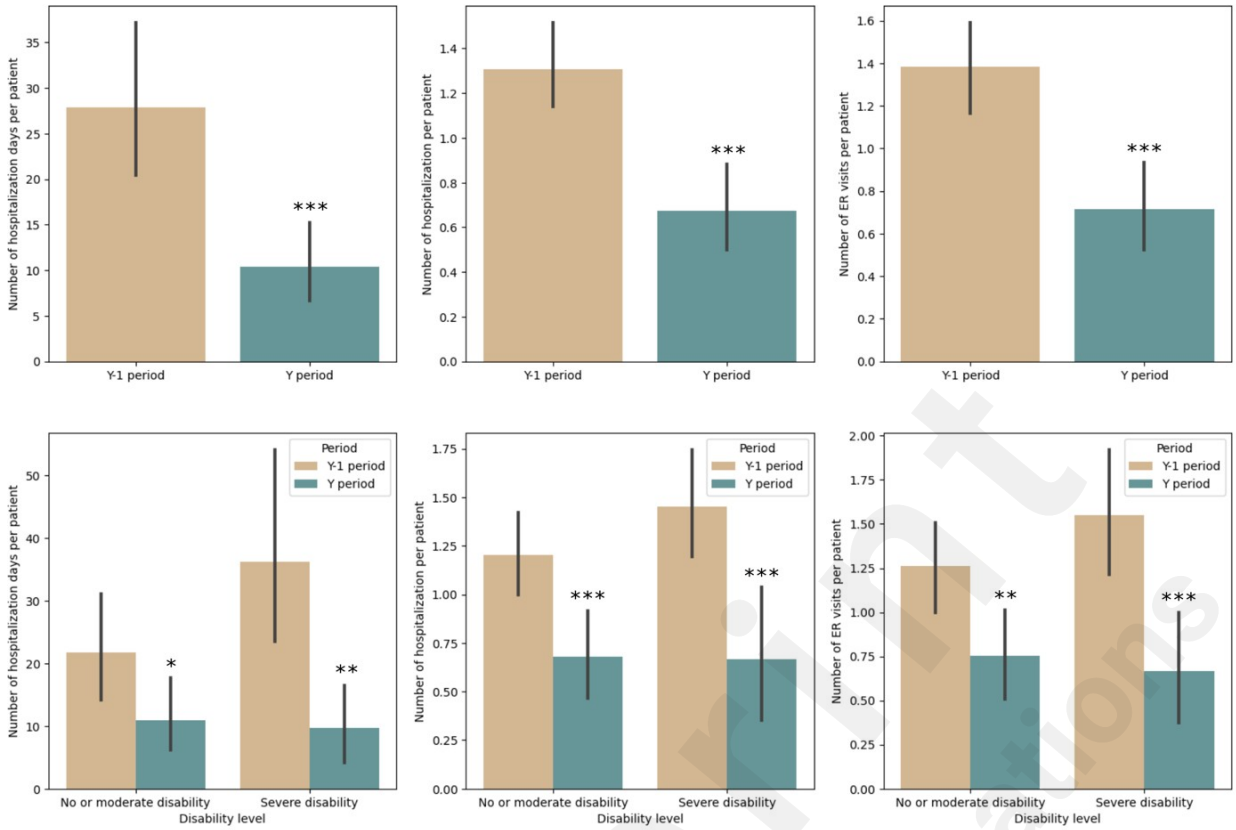
| | | | |
|---|---|---|---|
| **All (n=120)** | | | |
| Total hospitalization duration (days) | 3345 | 1248 | - 63 |
| Number of hospitalizations | 157 | 81 | - 48 |
| Number of emergency department visits | 166 | 86 | - 48 |
| Average length of hospital stays (days) | 21.3 | 15.4 | -28 |
| **No or moderate disability (n=69)** | | | |
| Total hospitalization duration (days) | 1500 | 753 | - 50 |
| Number of hospitalizations | 83 | 47 | - 43 |
| Number of emergency department visits | 87 | 52 | - 40 |
| Average length of hospital stays (days) | 18.1 | 16.0 | -12 |
| **Severe disability (n=51)** | | | |
| Total hospitalization duration (days) | 1845 | 495 | - 73 |
| Number of hospitalizations | 74 | 34 | - 54 |
| Number of emergency department visits | 79 | 34 | - 57 |
| Average length of hospital stays (days) | 24.9 | 14.6 | -41 |

During the Y-1 period, 104 (87%) participants had been hospitalized at least once. This number dropped to 45 (37%) after starting the EPOCA RPM system (Y period). As shown in Table 3, the total hospitalization duration per patient, as well as the number of hospitalizations and ED visits per patient decreased significantly between the Y-1 and Y follow-up periods. It corresponds to a mean reduction of 17 days spent at hospital per patient per year. Hospitalization and ED visits rates per patient per year were almost divided by two between the two periods. The decrease of indicators concerned the two groups of participants, and was greater in most disabled participants (Figure 3).

**Table 3.** Hospitalization duration, number of hospitalizations and emergency department visits per patient on Y and Y-1 follow-up periods.

| Variables | Y-1 period | | | Y period | | | P value | | |
|---|---|---|---|---|---|---|---|---|---|
| | All (n=120) | No or moderate disability (n=69) | Severe disability (n=51) | All (n=120) | No or moderate disability (n=69) | Severe disability (n=51) | All (n=120) | No or moderate disability (n=69) | Severe disability (n=51) |
| | Mean (SD) | Mean (SD) | Mean (SD) | Mean (SD) | Mean (SD) | Mean (SD) | | | |
| **Total hospitalization duration (days)** | 28 (46) | 22 (37) | 36 (55) | 10 (24) | 11 (25) | 9.7 (22) | ***<.001*** | ***.04*** | ***.002*** |
| **Number of hospitalizations** | 1.3 (1.0) | 1.2 (0.96) | 1.5 (1.0) | 0.7 (1.1) | 0.7 (0.95) | 0.7 (1.3) | ***<.001*** | ***<.001*** | ***<.001*** |
| **Number of emergency department visits** | 1.4 (1.2) | 1.3 (1.1) | 1.5 (1.3) | 0.7 (1.2) | 0.8 (1.1) | 0.7 (1.2) | ***<.001*** | ***.004*** | ***<.001*** |

**Figure 3**. Hospitalization outcomes during the year before telemonitoring and the year of follow-up. P-values between (Y) and (Y-1) follow-up periods are indicated by stars: *p<0.05, **p<0.01, ***p<0.001




## Discussion

### The EPOCA-RPM Associated with Hospitalization and ED Visits Reductions

In this retrospective, real-life study based on the results of 120 patients monitored for a minimum period of 5 months (median duration of follow-up 323 days), we found that using a RPM in the context of a coordinated hospital-community program was associated with an important reduction of hospitalizations number and duration as well as ED visits. Similar to our findings, previous studies have shown that telemedicine was associated with improved patient outcomes [13], [21], [28], [34]. However, when compared to previously published promising results about hospital or ED admissions, improvement in outcome measures obtained in our study were more pronounced than those reported in other studies [28], [29], [34]. The eCOBAHLT randomized controlled trial published in 2023 was the study that comes closest to our study in terms of population and RPM system [29]. However, we observed a greater reduction of hospitalization rate and while Tchalla and colleagues found an increase in ED visits in the intervention group, the ED visits were also reduced in our study. This potential positive effect on ED visits may result in a better coordination of care as the EPOCA-RPM was included in a more global hospital-community program. It is known that RPM may increase ED visit by increasing alerts generated by the monitoring of biometric parameters. However, in the eCOBAHLT randomized trial, the increase of ED visits was not associated with an increase of hospitalization, suggesting that most of these ED visits may be related to health problems manageable with GPs and appropriate community care services. As part of the Vigie-Age project the EPOCA-RPM system ensures better monitoring of health parameters but also a coordinated, rapid response, limiting hospitalization whenever possible. In case of an acute event, the intervention could

be reinforced during a short time period, so-called Acute Geriatrics at Home (AGH), to avoid hospitalization if possible. If hospitalization occurred in spite of this, the AGH could reduce the duration of the hospitalization by anticipating hospital discharge. Thus, our study also found that the EPOCA RPM system was associated with a 6-days reduction of average duration of incident hospitalizations. Long duration of hospital stay in poly pathological older adults is an important issue for the patients and healthcare system increasing the risk of hospital-acquired complications, loss of independence and costs. As hospitalization is linked to functional decline in older adults [35], a decrease of hospitalization admission may help in maintaining functional abilities. Although we did not measure the participants' quality of life, telemonitoring has been associated with improved quality of life in older adults, especially in the physical domain of the SF-12 score [36]. Moreover, Batlle et al. found that implementing a RPM in polypathological older adults was cost-effective [36]. A specific study of the cost benefits with the use of EPOCA RPM system is ongoing with the access of the French administrative health care database. This study will analyze all health-cost of participants, years before inclusion in the program and during EPOCA RPM system cares.

### Positive Effect Was Greater in More Complex Participants

The study population of the eCOBAHLT trial is close to our study population in terms of age and comorbidities, except for the proportion of participants with dementia that concern less than 2% in this previous study (compared to 36% in our study). Cognitive disorders limited the participation in randomized control trials due to ethical reasons. It is however mandatory to evaluate the impact of RPM systems in populations with dementia since they are among the people most likely to benefit from them, but also to have less acceptance of the intervention. Interestingly, the stronger reduction of hospitalizations and ED visits was observed in the more complex participants according to their higher level of disability and cognitive decline. It suggests that RPM may be used beneficially for people with cognitive disorders with the support of home care services. It is important to consider the RPM as a monitoring and coordination tool that does not replace homecare workers. In the more severe disabled participants, personal home care services were frequently set up before the start of the RPM. Our results suggest a good coordination between the EPOCA RPM staff and the personal home care services. Indeed, the EPOCA RPM system facilitates interactions between patients, their personal caregivers and the healthcare system, minimizing the burden on patients while maximizing the effectiveness of remote monitoring. The multi-disciplinary operational team not only adapts treatment, but it also deals with social issues and coordinates care alongside primary care professionals. This multidimensional approach contributes significantly to the positive results observed in our study, even in the most disabled participants.

## Patient and Caregivers Acceptance

Patient and caregivers’ acceptance of any healthcare intervention is a key factor for initial and long-term success. The implementation of an RPM can be perceived as an additional constraint that can worsen the burdens of patients and their caregivers. Our data suggest a very good acceptability, as evidenced by the low drop-out rate (2.5% of patients from the study and 3.5% of the entire cohort of patients), with only 1.8% before 150 days (about 5 months) of follow-up.

## Study Limitations

There are some intrinsic limitations of our study that should be considered when interpreting results. First, the study was based on retrospective data and therefore had limitations of an observational

study design. The study did not explicitly consider temporal variations in the use of EPOCA RPM system. Over time, external factors, medical developments, introduction of additional interventions, and continuous improvement of the system may have had an influence on the results. As a retrospective study, the data might not be completely comprehensive. However, we believe that any underestimation regarding primary outcomes is more likely to impact the Y-1 year.

Second, the effect of prorating the data over one year, which also represents itself a study limitation, is clearly attenuated by the average duration of patient follow-up, close to one year (median 323 days). However, for certain patients, only a specific period of the year was studied and prorated, such as the summer (or winter) period, which could have induced a bias towards the avoidance of winter respiratory diseases and distort the analysis of variations in days of hospitalization (and reciprocally). Observation over a more extended period could strengthen the hypothesis that MSAH monitoring offers a sustainable alternative to staying at home.

Third, the size of the patient sample was small, and short-durations follow-up (<5 months) have been excluded from the analysis which may imply a bias. Although sample size allowed to show statistically significant differences in the outcome measures.

Finally, there was no control group as the model of usual care, allowing concomitant comparison of the results.

## Conclusions

This retrospective observational study showed that home-based remote patient telemonitoring (RPM) could help to reduce the total length of hospital stay, the total number of hospital admissions and the number of emergency department visits. These results are similar to those of several previous studies evaluating the impact of telemedicine in patients who are mostly monopathological or less complex. Our study added to these previous reports by suggesting the similar effectiveness of telemedicine in highly complex polypathological patients. In this specific population, the effectiveness of RPM relies not only on the monitoring of health indicators, but also on a high level of responsiveness and coordination between multidisciplinary teams providing 24/7 human assistance, general practitioners, hospital geriatricians and homecare services. The costs of this enhanced system appear to be largely compensated by the significant reduction in hospitalization rates and emergency room visits but need to be confirmed by a cost-effectiveness study. Integrating EPOCA RPM into the healthcare system therefore seems to offer more benefits than risks for polypathological older adults, and should help reduce healthcare costs.

## Acknowledgements

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## Conflicts of Interest

None declared

## Abbreviations

ADL: Activities of daily living
BMI: Body mass index

COPD: Chronic obstructive pulmonary disease
ED: Emergency department
GDPR: General Data Protection Regulation
GIR: Groupe Iso-Ressources *(Iso-Ressources Group)*
GP: General practitioner
HDH: Health Data Hosting
IADL: Instrumental activities of daily living
MSAH: Medical support at home (Accompagnement médicalisé à domicile)
MMSE: Mini-mental state examination
RPM: Remote patient monitoring
SD: Standard deviation

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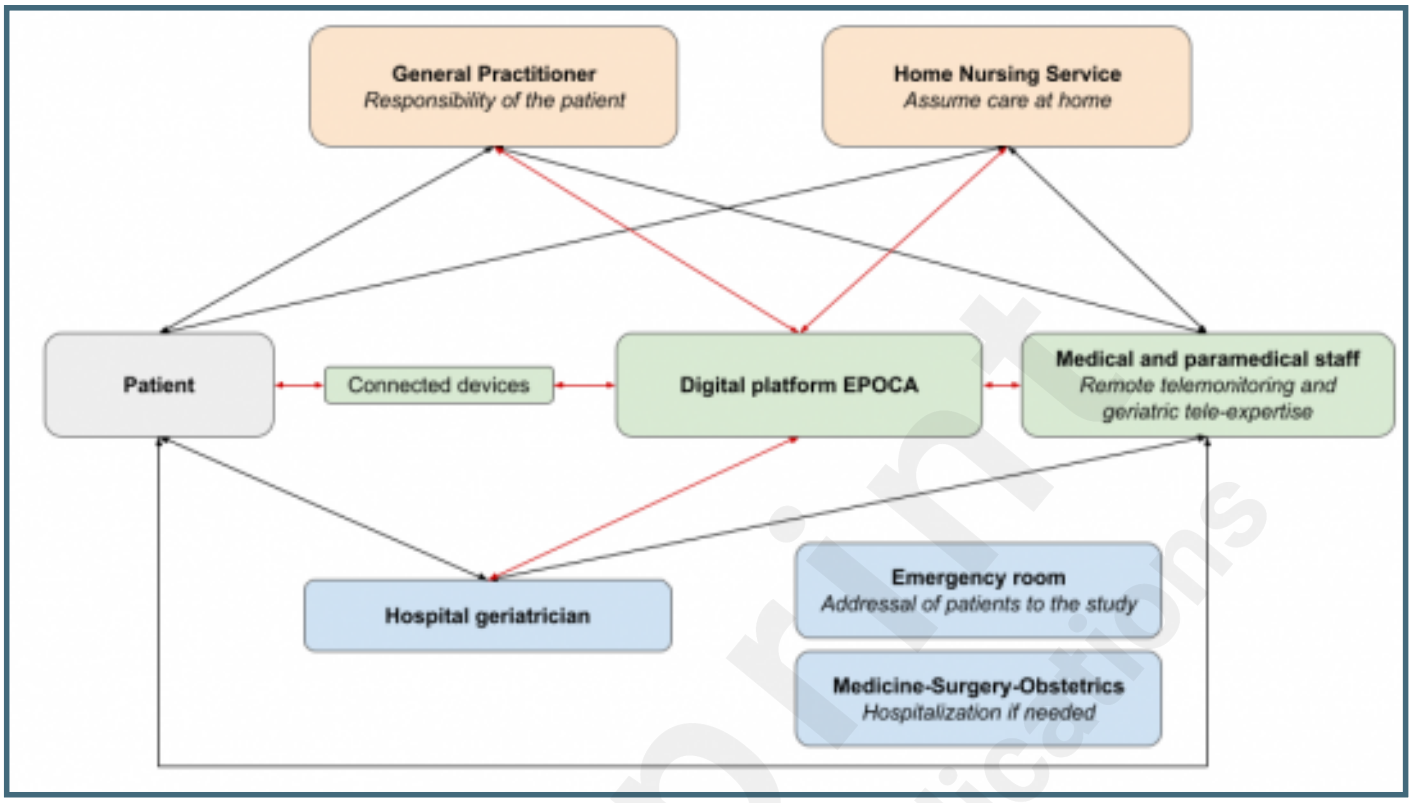
# Supplementary Files

# Figures

Collaboration between EPOCA RPM system and the healthcare professionals in the Vigie-Age project.



Flow chart of participant selection from the total number of patients included in the Vigie Age project.