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Development of a patient-centred medication management model for polymedicated home-dwelling older adults after hospital discharge: results of a mixed methods study

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ABSTRACT

Objective This study aimed to investigate medication management among polymedicated, home-dwelling older adults after discharge from a hospital centre in French-speaking Switzerland and then develop a model to optimise medication management and prevent adverse health outcomes associated with medication-related problems (MRPs).

Design Explanatory, sequential, mixed methods study based on detailed quantitative and qualitative findings reported previously.

Setting Hospital and community healthcare in the French-speaking part of Switzerland.

Participants The quantitative strand retrospectively examined 3 years of hospital electronic patient records (n=53 690 hospitalisations of inpatients aged 65 years or older) to identify the different profiles of those at risk of 30-day hospital readmission and unplanned nursing home admission. The qualitative strand explored the perspectives of older adults (n=28), their informal caregivers (n=17) and healthcare professionals (n=13) on medication management after hospital discharge.

Results Quantitative results from older adults' profiles, affected by similar patient-related, medication-related and environment-related factors, were enhanced and supported by qualitative findings. The combined findings enabled us to design an interprofessional, collaborative medication management model to prevent MRPs among home-dwelling older adults after hospital discharge. The model comprised four interactive fields of action: listening to polymedicated home-dwelling older adults and their informal caregivers; involving older adults and their informal caregivers in shared, medication-related decision-making; empowering older adults and their informal caregivers for safe medication self-management; optimising collaborative medication management practices.

Conclusion By linking the retrospective and prospective findings from our explanatory sequential study involving multiple stakeholders' perspectives, we created a deeper comprehension of the complexities and challenges of safe medication management among polymedicated, home-dwelling older adults after their discharge from hospital.

STRENGTHS AND LIMITATIONS OF THIS STUDY

⇒ The study used an innovative mixed methods approach combining retrospective and prospective findings.
⇒ Hospital register data were explained and complemented using multiple stakeholders' perspectives about medication management among polymedicated home-dwelling older adults after hospital discharge.
⇒ A causal analysis of the data was infeasible given its routinely collected retrospective nature.
⇒ The combined findings enabled the development of a collaborative, patient-centred model to optimise medication management after hospital discharge.
⇒ Measuring the effectiveness of the four interactive fields of action proposed by the study was beyond its scope and should be carried out in future research.

We subsequently designed an innovative, collaborative, patient-centred model for optimising medication management and preventing MRPs in this population.

INTRODUCTION

Older adult populations have a greater prevalence of multiple, chronic, non-communicable diseases, often resulting in complicated multidrug pharmacotherapies.[1] Taking five or more medications daily is usually referred to as polypharmacy.[2] Potential functional or cognitive decline, combined with pharmacokinetic and pharmacodynamic changes related to age,[3] mean that polypharmacy can be particularly problematical among older adults and is frequently associated with medication-related problems (MRPs).[4–6] According to the Pharmaceutical Care Network Europe, an MRP is 'an event or circumstance involving drug therapy that actually or potentially interferes with desired health outcomes'.[7] A recent systematic review

about MRPs among home-dwelling older adults reported an average of 4.16 MRPs per patient (95% CI: 1.37 to 10.00), including inappropriate prescription (51.41%), inappropriate dose (11.62%) and patient-related problems (10.70%) (such as non-adherence or inability to use the drug or form as prescribed).[8] MRPs lead to deviations from intended therapeutic benefits and make patients more susceptible to adverse health outcomes, including hospital admissions, prolonged hospital stays, reduced quality of life, nursing home admission, increased mortality and greater healthcare costs.[9–12]

Transitions of care—like a discharge home after hospitalisation—heighten the risk of MRPs.[1 6 10 13] An integrative review by Valente *et al* reported that the main MRPs among older adults during care transitions between hospital and home were related to the absence of medication reconciliation (40%), medication adherence (30%) and adverse drug events (30%).[14] Those MRPs were related to the greater number of medications prescribed during hospitalisation, modifications to the therapeutic regimen, incomplete, inaccurate or illegible prescriptions, and older adults' lack of knowledge about their prescribed medications. Older adults and informal caregivers often experience medication changes as disruptions to knowledge, routines and medication self-management.[15] Older adults may feel vulnerable, have difficulties understanding information and lack integrated community care.[16]

High occurrences of MRPs among older adults after hospital discharge could be reduced by improved care transitions based on discharge planning processes, combining hospital discharge medication-management plans and follow-up strategies at home.[17–19] Discharge planning is the in-hospital process of developing an individually tailored plan to facilitate a return home (or to a care facility) following an inpatient admission.[20] Comprehensive discharge planning for older inpatients effectively reduces unplanned readmissions (roughly three fewer readmissions per 100 patients).[20] Many existing discharge planning models include different hospital and community healthcare professionals, older adults and their informal caregivers. Tomlinson *et al*'s systematic review and meta-analysis suggested that interventions supporting safer transitions of care through better continuity in medication treatments should last for a minimum of 90 days after discharge.[21] Longer interventions were more likely to facilitate successful transitions than shorter ones focusing only on hospital admission or short periods after discharge. Aiding medication self-management, follow-up by telephone and medication reconciliation, were all interventions statistically associated with fewer hospital readmissions.[21] Strategies used to support safe medication management after hospital discharge also include checklists, offering advice and helping primary care professionals ensure that the correct medications are supplied at the correct time.[15] Comprehensive and safe medication management should involve interprofessional collaboration among the different providers of health and social care, with regular monitoring for potential MRPs and systematic medication reconciliation at transitions in care.[1 19]

Community healthcare centres across Switzerland support home-dwelling older adults who are unable to manage their medications independently or only when assisted by informal caregivers. The active role that community pharmacists play in primary care is also expanding.[22] The current trend in Switzerland's healthcare system is to attempt to reduce hospital lengths of stay as much as possible and promote outpatient treatment, but this may lead to the 'medication-intensive hospital discharge' of geriatric inpatients.[23] This is a major concern for public health that calls for a robust, integrated, multi-stakeholder model embedding medication management into the context of where and how older adults live, thus preventing the onset or progression of MRPs. A medication management model like this needs to be rigorously structured, using a care model process embracing development, implementation and sustainability milestones.[24]

Aim and objectives

The study aims were: (1) to explore how older adults', their informal caregivers' and healthcare professionals' perspectives on medication management at home after hospital discharge explained or complemented quantitative results about the health profiles of older adults presenting with greater risks of adverse health outcomes and (2) to develop a model to optimise medication management and prevent adverse health outcomes related to MRPs.

METHODS
Study design

We ran an explanatory, sequential, mixed methods study from February 2019 to January 2022.[25] The quantitative strand involved a retrospective analysis of 3 years of a local hospital's electronic patient records (n=105 243) to identify the profiles of polymedicated, home-dwelling older adults at risk of adverse health outcomes. These profiles were extracted from the hospital data and allowed us to take a purposive sample for the qualitative strand, focused on older adults' (n=28), informal caregivers' (n=17) and healthcare professionals' (n=13) perspectives on medication management at home after hospital discharge. Profile analysis allows researchers to identify whether research subjects or groups of subjects have significantly distinct profiles; it is based on an analysis of patterns in tests, subtests or scores. The present study explored the profiles of polymedicated, home-dwelling older adults at risk of adverse health outcomes based on their age, sex, polypharmacy and health status characteristics, and it used different statistical tests, clinical scores and cluster analysis.[26] The analysis of the results from the retrospective quantitative strand was integrated with the data collected from the prospective qualitative strand.

The rationale for this design was that previous studies had explored medication management from a quantitative or qualitative perspective, but rarely both. Furthermore, to the best of our knowledge, no study on medication management had attempted to connect data from hospital registers with qualitative data. Lastly, earlier qualitative medication management studies used either clinician-focused or patient-focused perspectives, yet safe medication management requires interprofessional, patient-centred approaches: using a single research focus could fail to provide a full description of the phenomenon. Therefore, our qualitative strand relied on a multiperspective description of older adults', their informal caregivers' and their healthcare professionals' perceptions of medication management after hospital discharge. Both strands led to different previously published articles that are used in the present paper.

The study was performed with close regard to the Good Reporting of A Mixed Methods Study guidelines.[27]

Phase I: retrospective quantitative strand

Using descriptive and multivariate regression analysis, the quantitative strand sought to identify profiles affected by similar patient-related, medication-related and environment-related factors among polymedicated, home-dwelling older adults at risk of hospital readmission[28] or unplanned nursing home admission (online supplemental file 1).[29] Patient-related factors included sociodemographic characteristics and the International Classification of Diseases 10th version (ICD-10) diagnostics (main diagnosis and comorbidities). Additional filters were added to discriminate 'polypharmacy' and 'home-dwelling'. Medication-related factors included their number and the Anatomical Therapeutic Chemical classification of the prescribed medication. Environment-related factors included the length of stay.

We derived our data from a substantial, longitudinal, electronic patient record dataset supplied by a public general hospital in a French-speaking region of Switzerland. The Valais Hospital register's electronic health records included all inpatients aged 18 years or more admitted or readmitted between 1 January 2015 and 31 December 2017 (n=105 243 hospitalisation records).

After approval by the Human Research Ethics Committee of the Canton of Vaud and our partnering hospital, a database containing the latter's electronic health records from 1 January 2015 to 31 December 2017 for all inpatients aged 18 years or more (n=1 05 243) was provided to the research team in early 2019. This database was used to explore the functional status of polymedicated older adult inpatients at discharge (n=53 690 hospitalisation records).[23] However, the hospital's data warehouse required more time to extract the database containing inpatients' medication lists, and an updated database was provided at the end of 2019. This database provided us not only with medication lists but also with the data from the year prior to our initial analysis (2018). As per our research protocol, the hospital's data warehouse had

added filters: inpatients had to be aged 65 years old or more, be polymedicated and normally living at home but be hospitalised in the canton of Valais' French-speaking region (n=20 422). Taushanov et al described the methods used to transform and synthesise the hospital patient registry dataset into an exploitable database for further investigation.[26]

To determine the risk of 30-day hospital readmission associated with patients' medical conditions and drug regimens, we considered 13 802 hospital stays, from 2015 to 2018, by polymedicated older adults who were discharged home and had no missing data.[28]

Furthermore, we included all the hospital stays, from 2015 to 2018, by polymedicated older adults with no missing data who had not died during hospitalisation (n=14 705) to investigate patient characteristics and the available health and drug data associated with their unplanned nursing home admission following an acute hospital admission or readmission.[29]

Finally, the profiles of polymedicated, home-dwelling older adults hospitalised and identified via multicluster analysis guided our qualitative strand and led to the purposive sampling of those presenting with the most risk factors.

A flowchart in online supplemental file 2 gives an overall view of the retrospective data analysis strategy used on the raw hospital register data.

Phase II: prospective qualitative strand

The qualitative strand consisted of a qualitative descriptive study of the medication practices and experiences of older adults presenting with the risk factors identified in the first strand (online supplemental file 1). This qualitative phase used purposive sampling from within our Swiss sample to better explain our retrospective quantitative findings. Besides the qualitative interview data collected from older adults, we also collected, analysed and cross-referenced the perspectives of their informal caregivers and healthcare professionals involved in medication management at home.

From October 2019 to November 2020, nurse research partners identified and recruited 28 home-dwelling older adults, using the following inclusion criteria: aged 65 years or older, managing at least five different medications daily, discharged from hospital in the 90 days prior to recruitment and estimated to retain a significant risk of adverse health outcomes (hospital readmission or unplanned nursing home admission). Nurse research partners described the study and asked older adults' permission for researchers to contact them. Between 7 and 90 days after their discharge, investigators contacted these older adults by telephone and requested their consent to participate in the study. If they agreed, an initial meeting was organised in the older adult's home in the next few days. Recruitment stopped once data saturation had been achieved.[30] The 90-day timeframe was defined based on Tomlinson et al's systematic review and meta-analysis, which regarded this period as the

most susceptible to MRPs.[21] For each older adult, an informal caregiver aged 18 years or above, if available, was also invited to participate in the investigation. Finally, a healthcare professional designated by each older adult and involved in their daily medication management at home was also integrated into the investigation.

Semistructured individual and joint interviews were conducted with each of these three populations. An interview guide was designed and tested for each of the four interviews using our retrospective quantitative strand and information from a literature review on medication management (online supplemental file 3).[31 32]

The initial semistructured interview collected older adults' perspectives about their latest transition from hospital to home, the treatment information given to them, possible modifications to that treatment and whether prescribers had considered their experiences and preferences when prescribing their medications. Each older adult was requested to maintain a medication journal for a week,[33 34] either independently or assisted by their informal or professional caregivers. This contained information about their daily medication routine, all medications taken (prescribed or self-medication) and their satisfaction with and views of their treatment. This provided information on the daily routines associated with the participant's medication and formed the basis of the second interview. The second interview was a walking interview allowing older adults to better explain their daily medication routines. A walking interview lies somewhere between observation and a standard interview.[35] We recorded the older adults' narratives about their medication self-management while observing their physical surroundings and objects and considering the care network assisting their medication practices at home and their lived experiences of all these interactions.

The third interview was a joint interview of about 1 hour organised with the older adult and their informal caregiver at the older adult's home one or 2 weeks after the walking interview.[33 36] These enabled investigators to observe interactions concerning medication management within each dyad.

A fourth semistructured interview, lasting about an hour, explored each healthcare professional's perspectives on the patient's postdischarge medication management. These interviews occurred in professionals' workplaces (medical practices, community healthcare centres or pharmacies) 1 or 2 weeks after the walking interview.

Participants' sociodemographic and health characteristics were summarised and analysed using descriptive statistics. Four investigators (including the two interviewers) shared out 53 audio recordings of the individual and joint interviews and fully transcribed them. They subsequently performed concurrent inductive codebook thematic analyses of each transcript to identify patterns shared across the full dataset.[37 38] Given our large qualitative dataset, using a codebook was appropriate for identifying patterns and relationships within the data.[39] Until the research team reached a consensus, they met regularly, under the principal investigator's supervision, to verify whether patterns of meaning across the entire dataset matched the coded extracts. Codes and themes were defined by giving detailed descriptions and restrictions of what could be included within a code and provided concrete examples of each code. This procedure enabled the qualitative data to be systematically organised and classified into distinct themes created using the similarities and differences in participants' narratives. The team then reviewed the entire body of interviews to validate the final thematic classification. The process of analysis ended when *patterns of shared meaning* in participants' accounts were agreed on in relation to our research objectives.[38] Initial qualitative results were subsequently discussed with the other authors. Lastly, each older adult's medication journal was analysed, and its contents were categorised using the same principles used for the interviews.

The qualitative strand's research team—consisting of researchers with backgrounds in gerontology, pharmacology, nursing, health psychology and social sciences—brought together a range of expertise and perspectives, and we collectively acknowledged our positionality and its potential impact on the research process and outcomes. Team members had specific personal experiences and knowledge of ageing, medication management and healthcare systems, and we recognised that these might shape our interpretations, biases and interactions with participants. For example, some team members had had personal experiences of ageing relatives managing polypharmacy at home, whereas others had worked directly with polymedicated older adults with multiple chronic conditions in clinical or community settings.

Our varied disciplinary perspectives may also have influenced how we framed research questions, selected data collection methods and interpreted findings; we remained conscious of the potential power dynamics between researchers and participants and of the potential for our presence or questions to have influenced participants' responses.

Throughout the qualitative prospective strand, we remained committed to reflexivity and critical self-reflection. We continuously examined our assumptions, biases and preconceptions, striving to minimise their influence on the research process. To do so, we engaged in regular team discussions to challenge and discuss our differing perspectives, fostering an environment of open dialogue and critical engagement.

By acknowledging our positionality as a research team, we aimed to enhance the research process's transparency and trustworthiness. We recognised the importance of centring the medication practices and experiences of older adults presenting with the risk factors identified in the first strand, and we remained committed to representing their diverse perspectives in an accurate, respectful manner.
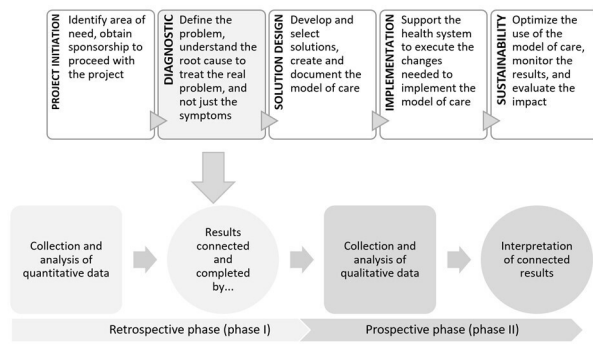
Figure 1 Methodological framework to develop our medication management model: mixed methods research with an explanatory sequential design.[24 40]

Phase III: integration of quantitative and qualitative results and development of a medication management model

As per Creswell and Clark[40] and Fetters et al,[41] the integration of the quantitative and qualitative results occurred at three distinct levels: (1) connecting level—data from the retrospective quantitative strand informed sampling for the qualitative prospective strand; (2) building level—data from the retrospective quantitative strand informed data collection for the qualitative prospective strand; (3) merging level—data from both strands were linked by the analysis. First, we collected accounts of the experiences of older adults presenting with the risk factors identified in the first strand (online supplemental file 1). Then, the interview guides for the qualitative strand were designed based on the retrospective quantitative findings (online supplemental file 3). Finally, once the qualitative strand was complete, we created a combined data display to link major quantitative and qualitative findings and thus identify points of convergence and divergence. This allowed us to integrate the two sets of connected results and develop integrated conclusions about how the qualitative findings explained and extended the quantitative findings.

Our connected results documented the 'diagnostic process' (phases I and II) and contributed to the 'solution design' (phase III) of our medication management model, which was guided by the Agency for Clinical Innovation (ACI) framework—a project management methodology comprising five stages for reviewing and developing models of care (figure 1).[24]

The solution design phase aimed to prioritise issues identified in the diagnostic phase and develop a range of solutions to optimise medication management and prevent adverse health outcomes related to MRPs. This phase involved the following four steps: reviewing the issues identified in the diagnostic phase; prioritising those issues; problem-solving; and selecting and prioritising solutions.

In step 1, the research team listed those issues evoked by participants during the diagnostic phase that could be improved, reinforced or maintained to optimise medication management and prevent adverse health outcomes related to MRPs. In step 2, we defined the priority issues—those most frequently raised by the participants.

In problem-solving step 3, we moved from an analytical to a creative perspective, generating a large number of potential solutions for the priority issues identified. New ideas were generated from the literature reviews of the best practices and from the potential solutions proposed by the participants themselves. Finally, in step 4, once a range of solutions had been identified, the research team clustered the solutions together, as several of them were closely related. At this point, we referred back to the study's aim and scope, together with the issues identified in the diagnostic phase, to verify whether the solutions proposed met the project's aims and solved the issues identified. Solutions were inspired by the quadruple-aim of enhancing the patient experience, improving population health, reducing costs and improving healthcare professionals' working lives.[42]

Patient and public involvement
None.

RESULTS
Overview of quantitative findings
The total dataset comprised 105 243 hospitalisation records, but our inclusion criteria required older adult inpatients aged 65 years or older, so our analysis covered 53 690 hospitalisations (51% of the dataset) from 2015 to 2017.[23] Mean age was 78.4 (SD=7.9), the median age was 78 (IQR 25–75=72–84) and potential participants ranged from 65 to 106 years old, with 28 018 (52.2%) female geriatric inpatients (online supplemental file 4).

The updated database covered 20 422 home-dwelling polymedicated older inpatients hospitalised in the canton of Valais' French-speaking region between 2015 and 2018. The 13 802 hospital stays by polymedicated older adults who were discharged home and had no missing data involved 8878 different individuals, with an average of 1.6 observations per person. The total sample's mean age was 77.8 years old (SD=7.5) and 57% were men. The average hospital length of stay was 8.4 days (SD=7.6). On average, 8.9 (SD=3.2) drugs were prescribed to each patient at hospital discharge.[28]

The 14 705 hospital stays by polymedicated older adults with no missing data who had not died during hospitalisation involved 9430 different individuals, with an average of 1.6 hospital stays per person.

Overall, 55% of the population sample were men, and the total sample's mean age was 78.2 years old (SD=7.6). The mean hospital length of stay was 8.6 days (SD=7.6). The mean number of drugs prescribed at hospital discharge was 9.1 (SD=3.3), with means of 10.9 (SD=3.9) drugs for patients discharged to a nursing home versus 8.9 (SD=3.2) for those discharged home.[29]

Overview of qualitative findings
A total of 28 older adults, 17 informal caregivers and 13 healthcare professionals participated in the study. Their sociodemographic characteristics are presented in online

supplemental file 5. The median number of ICD-10 diagnoses was 12 (range 3–27), and the median number of prescribed medications at hospital discharge was 8 (range 5–21). Not every older adult had an informal caregiver involved in their medication management. Only 13 of the informal caregivers interviewed lived with the older adult, although most (n=11) assisted them daily with multiple activities. Levels of independence in medication self-management were extremely varied: some organised and took their medications autonomously, whereas others needed health professionals and/or informal caregivers to prepare and administer them. Older adults designated nurses, pharmacists and general practitioners as the three types of healthcare professionals involved in their medication management.

Mixed methods findings

Detailed quantitative[23 28 29] and qualitative[43 44] findings have been published in previous papers. Therefore, this section connects and integrates both sets of findings (table 1) and draws conclusions on how the qualitative results help to explain and extend specific quantitative results.

Development of a medication management model

The solution design phase provided potential solutions to the issues identified in the diagnostic phase.

Four potential solutions—which we termed 'four interactive fields of action'—were developed as part of the solution design phase: listening to polymedicated home-dwelling older adults and their informal caregivers; involving older adults and their informal caregivers in shared, medication-related decision-making; empowering older adults and their informal caregivers for safe medication self-management; and optimising collaborative medication management practices.

DISCUSSION
Diagnostic step: defining the problem and understanding the root cause

This mixed methods study described the current state of polymedicated, home-dwelling older adults' medication management practices and experiences after discharge from the Valais hospital. Both the quantitative and qualitative phases reported on the complexity of their medication lists during hospital-to-home transitions. Quantitative results concerning profiles affected by similar patient-related, medication-related and environment-related factors among polymedicated, home-dwelling older adults were enhanced and supported by the qualitative findings. The qualitative strand conducted among a purposive sample of older adults provided a better understanding of the challenges and needs in their daily medication management that may be responsible for MRPs and adverse health outcomes.

Sociodemographic and hospitalisation data

Our quantitative findings revealed that a majority of geriatric inpatients were polymedicated at hospital discharge

and that their mean hospital lengths of stay were 5 days longer than their non-polymedicated peers. Previous research has associated prolonged lengths of stay with clinical complexity and geriatric inpatients' functional decline.[45–47] Despite longer lengths of stay, our qualitative findings showed that planning for discharge home was often considered unsatisfactory, unsuitable or non-existent, and discharges were experienced as rapid and sometimes too early. Even when polymedicated older adults had longer hospital stays, they did not feel sufficiently prepared for medication self-management at home. This is in line with the Knight et al[33] study that explored older adults' and informal caregivers' experiences of hospital discharge in relation to medication plans and management. Inadequate explanations about medications at discharge were commonly reported and led to medication omission, incorrect dosages, anxiety and confusion.[33]

From a statistical point of view, our quantitative findings confirmed the trend of older patients being prescribed more medications, in line with previous studies associating age and comorbidities with rates of polypharmacy among home-dwelling older adults.[46 48] However, statistically significant results do not necessarily equate to clinically relevant results.[49] Indeed, the median age of polymedicated inpatients was only 2 years older than that of non-polymedicated inpatients. Although the qualitative strand did not enable us to explain this result, the qualitative analysis provided information on older adults' daily attempts to self-manage their medication, despite their advanced age and the difficulties arising from continual changes to their prescriptions. Considering that advanced age and polypharmacy are the main risk factors for MRPs[50–52] and that MRPs have a major impact on functional outcomes,[53] the number of medications that geriatric inpatients have to manage after hospital discharge, more or less autonomously, deserves further attention from the healthcare professionals involved in discharge planning.

Medical conditions

The median number of comorbidities was two times as high among polymedicated than among non-polymedicated patients. Although it is understandable (but not always justifiable) that the more different medical diagnoses a patient has, the more medications they are likely to be prescribed, the opposite—the impact of the number of medications on the number of diagnoses—remains unclear.[54] Qualitative results showed us that polymedicated home-dwelling older adults were confronted with the burdens of not only their comorbidities but also complex medication self-management. Moreover, they had to juggle their loss of autonomy after hospital discharge and their efforts to maintain control of a complex medication regimen. Contradictions also emerged between prescriptions and older adults' and their informal caregivers' values and preferences. Medication changes were rarely discussed with patients and,

Table 1 Combined display of quantitative and qualitative findings regarding medication management

	Retrospective quantitative findings	Prospective qualitative findings
Sociodemographic and hospitalisation data		
Polypharmacy at hospital discharge	67.5% of geriatric inpatients were polymedicated at hospital discharge (n=36 266 (67.5%) vs n=17 424 (32.5%)).[23]	Older adults did not feel sufficiently listened to or involved in medication-related decisions. Discharge planning was often unsatisfactory or non-existent. Inconsistency between patients' prescriptions and their values and preferences and those of their informal caregivers.
Polypharmacy and length of stay	Median hospital lengths of stay were 6 days longer among polymedicated geriatric inpatients, (Med=10; IQR 25–75=5–17) vs (Med=4; IQR 25–75=1–11; p<0.001*).[23]	Discharge home was rapid and sometimes too early. Older adults and their informal caregivers felt they should be more involved in discharge planning.
Number of medications prescribed and age	The median age of polymedicated inpatients was 2 years older (Med=79; IQR 25–75=(72–84)) than for non-polymedicated inpatients (Med=77; IQR 25–75=(70–84); p<0.001†).[23]	Efforts to maintain control of medication management. Loss of autonomy: from revolt to resignation. Inconsistency between patients' prescriptions and their values and preferences and those of their informal caregivers. Older adults did not feel sufficiently listened to or involved in medication-related decisions.
Medical conditions		
Number of comorbidities (ICD-10 diagnoses)	Polymedicated patients had two times the median number of comorbidities (μ=5.7; SD=2.2; Med=6; IQR 25–75=(4–8)) than non-polymedicated patients (μ=4.4; SD=2.2; Med=3; IQR 25–75 = (3–6)).[23]	Efforts to maintain control of medication management. Inconsistency between patients' prescriptions and their values and preferences and those of their informal caregivers. 'Fighting' for older adults' medication preferences.
Physical impairments	Polymedicated inpatients suffered from proportionally more physical impairments to general mobility (43.2% vs 41.9% in non-polymedicated inpatients; p<0.001‡), gait (46.2% vs 43%; p<0.001†), fatigue (48.6% vs 43.4%; p<0.001†) and lower body care (49.7% vs 47.6%; p<0.001†).[23]	Loss of autonomy: from revolt to resignation. Trusting and letting go. Informal caregivers' felt they needed help in supporting and coordinating medication management.
Cognitive impairments	Older adults with severe cognitive impairments had fewer medications at hospital discharge (p<0.001‡) for all of the cognitive variables: alertness/consciousness disorders (n=591; 1.7% among polymedicated inpatients vs n=577; 12.0% among non-polymedicated ones); orientation space, time, people disorders (n=6686; 19.2% vs n=3463; 26.3%); concentration (n=3410; 9.8% vs n=2433; 18.5%); verbal expression (n=2392; 6.9% vs n=1980; 15.0%); ability and skills to respond to the demands of daily life (n=9294; 26.8% vs n=4010; 30.5%); ability to learn disorders (n=9675; 27.8% vs n=4149; 31.5%).[23]	Efforts to maintain control of medication management. Mobilising self-knowledge and past experiences every day. The stakeholders involved in medication management should receive help to ensure more effective communication between them.
Pain medication management	Acute pain at hospital discharge was reported by one-third of all geriatric inpatients (n=17 895; 33.3%). Proportionally more polymedicated inpatients reported acute pain than did non-polymedicated patients (n=13 189; 38% vs n=4706; 35.8%; p<0.001‡), whereas the reports of chronic pain were similar (n=4029; 11.6% vs n=1463; 11.1%; p=0.153‡). Older adults with analgesic prescriptions had a higher probability of unplanned nursing home admission (OR=1.244; 95% CI: 1.132 to 1.367). No association was found with 30-day hospital readmission.[23]	Inadequate pain management. Dysfunctional coordination between healthcare actors. Older adults did not feel sufficiently listened to or involved in medication-related decisions. Discharge planning was often unsatisfactory or non-existent.
Adverse health outcomes		

Table 1 Continued

	Retrospective quantitative findings	Prospective qualitative findings
30-day hospital readmission§	The overall 30-day hospital readmission rate was 7.8%. 30-day hospital readmission risks were associated with longer hospital length of stay (OR=1.014 per additional day; 95% CI: 1.006 to 1.021), impaired mobility (OR=1.218; 95% CI: 1.039 to 1.427), multimorbidity (OR=1.419 per additional ICD-10 condition; 95% CI: 1.282 to 1.572) and polypharmacy (OR=1.043 per additional medication prescribed; 95% CI: 1.028 to 1.058).[28]	Discharge home was rapid and sometimes too early. Discharge planning was often unsatisfactory or non-existent. Inconsistency between patients' prescriptions and their values and preferences and those of their informal caregivers. Older adults and their informal caregivers felt they should be more involved in discharge planning. Dysfunctional coordination between care actors. Defining shared medication management goals. Establishing personal routines to ensure safe medication.
Unplanned nursing home admission‡	The prevalence of unplanned nursing home admission after hospital discharge was 6.1%. The oldest adults (OR=1.07 for each additional year of age; 95% CI 1.05 to 1.08) presenting with impaired functional mobility (OR=3.22; 95% CI 2.67 to 3.87), dependency in the activities of daily living (OR=4.62; 95% CI 3.76 to 5.67), cognitive impairment (OR=3.75; 95% CI 3.06 to 4.59) and traumatic injuries had a higher probability of unplanned nursing home admission (OR=1.58; 95% CI 1.25 to 2.01). The number of ICD-10 diagnoses had no significant impact on institutionalisation, contrarily to the number of prescribed medications (OR=1.17; 95% CI 1.15 to 1.19).[29]	
Medication-related problems (medications statistically associated with 30-day hospital readmission and unplanned nursing home admission, controlled for other parameters)§	Adjusted multivariate analyses revealed an increased risk of hospital readmission for patients with polypharmacy (OR=1.043 per additional drug prescribed; 95% CI 1.028 to 1.058) and certain specific medications, including antiemetics and antinauseants (OR=3.216 per additional medication unit taken; 95% CI 1.842 to 5.617), antihypertensives (OR=1.771; 95% CI 1.287 to 2.438), medication for functional gastrointestinal disorders (OR=1.424; 95% CI 1.166 to 1.739), systemic hormonal preparations (OR=1.207; 95% CI 1.052 to 1.385) and vitamins (OR=1.201; 95% CI 1.049 to 1.374), as well as concurrent use of beta-blocking agents and medication for acid-related disorders (OR=1.367; 95% CI 1.046 to 1.788).[28] Antiemetics/antinauseants (OR=2.53; 95% CI 1.2 to 5.30), digestives (OR=1.78; 95% CI 1.09 to 2.90), psycholeptics (OR=1.76; 95% CI 1.60 to 1.93), antiepileptics (OR=1.49; 95% CI 1.25 to 1.79) and anti-Parkinson's medication (OR=1.40; 95% CI 1.12 to 1.75) were strongly linked to unplanned nursing home admission.[29]	The medication review of participants' medication lists showed that Beers and STOPP/START criteria were not often respected. The least frequently met criteria were STOPP-A1, STOPP-A2 and STOPP-A3: any drug prescribed without a clinical indication, any drug prescribed beyond the recommended duration and any dual prescriptions from the same drug class, respectively. For example, proton pump inhibitors prescribed for more than 8 weeks without indication (Beers and STOPP-F2); benzodiazepines for more than 4 weeks (Beers and STOPP-D5 and K1); non-selective beta-blockers with a history of asthma requiring treatment (STOPP-G4); a loop diuretic as first-line therapy for hypertension (STOPP-B6, B7); long-term aspirin at doses greater than 160 mg per day (STOPP-C1).

*Wilcoxon-Mann-Whitney.
†Kruskal-Wallis.
‡Chi-square test.
§Logistic regression.
ICD-10, International Classification of Diseases 10th version.

therefore, were not always well accepted and integrated into their daily lives. Even if older adults had multiple conditions, they were not always in favour of extending their treatment list and often found it necessary to fight for their medication preferences and medication self-management.

Polymedicated inpatients had proportionally more physical impairments—general mobility, gait and fatigue problems—than did non-polymedicated inpatients. Previous studies had positively associated physical impairments with polypharmacy.[48] In our qualitative phase, these conditions were reflected in patients' inability to perform

some medication management tasks independently, as they had done before hospitalisation. Their reactions to this loss of autonomy after hospital discharge ranged from resistance to resignation. Indeed, some older adults revealed their daily efforts to self-manage their medication despite their advanced age, physical impairments and continual changes to their prescriptions. Establishing an individual routine was one of the strategies used to ensure safe medication self-management. However, some older adults with more functional impairments felt less involved in medication management and had withdrawn from certain tasks and responsibilities that they had previously

endeavoured to control. We noted that older adults who 'let go' of medication self-management reported greater difficulties understanding their medication regimens and comprehending changes. This agreed with Diedrich *et al*,[55] who reported that home care clients who had reached their physical, psychological and social limits felt relieved when a community healthcare centre took over the coordination of medication management, and they no longer perceived themselves as active partners in maintaining medication safety. In line with Mortelmans *et al*,[56] our research showed that regardless of their functional impairments or level of involvement in medication management, polymedicated older adults experienced a variety of struggles during the process of medication self-management after hospital discharge. These included finding the physical strength to take medication, a lack of medication knowledge, non-adherence and/or disrupted continuity of medication self-management.

Our quantitative data showed that geriatric inpatients diagnosed with severe cognitive impairments actually had fewer medications at hospital discharge. This could be explained by clinicians' worries about potentially inappropriate prescribing and deprescribing practices with this particular geriatric population or about the risks of non-adherence resulting from omitted or repeated medication intake.[57 58] It may also be that current recommendations on deprescribing medications for older adults with a limited life expectancy have shifted clinicians' focus away from disease prevention and towards maximising the patient's quality of life.[59] Indeed, the medication management tasks highlighted in our qualitative phase revealed the complexity that polymedicated home-dwelling older adults face in their daily lives and the impracticability of safe, effective management by individuals with severe cognitive impairments—at least without the presence of a robust social network. A prerequisite for older adults managing their own polypharmacy at home was the ability to use their knowledge and past experiences daily and make efforts towards more effective coordination within their healthcare network. Our interviews showed that the more cognitively impaired a polymedicated older adult was, the more they required highly coordinated family and professional support to manage their medication. This was in line with previous findings revealing that cognitive impairment was associated with non-compliance and medication management difficulties, thus increasing the risk of MRPs.[60]

In our retrospective quantitative phase, although reports of chronic pain were similar, acute pain was reported by a statistically significant greater proportion of polymedicated inpatients than non-polymedicated inpatients. Although pain assessments were carried out, the medications prescribed did not seem to entirely address pain outcomes.

Although we found no statistically significant associations between the prescription of analgesics at discharge and hospital readmission,[28] discharge-day pain scores have previously been associated with 30-day hospital readmissions.[61] Indeed, our logistic regression analysis revealed that older adults with analgesic prescriptions had a higher probability of unplanned nursing home admission (adjusted for age, sex, number of comorbidities and functional status).[29] Four participants and their informal caregivers described inadequate pain management during our qualitative phase, which might be explained by poor discharge planning and older adults' complaints of not feeling sufficiently listened to or involved in medication-related decisions. In addition, the dysfunctional coordination between healthcare actors, disclosed by all three groups of participants, may contribute to and exacerbate inadequate pain management in the critical hospital discharge period. Deficient pain medication management is of significant concern considering the well-known functional and psychological impacts of pain on older adults, not to mention the great healthcare costs.[62]

Adverse health outcomes

In our retrospective quantitative phase, 30-day hospital readmission risks were associated with longer hospital length of stay, impaired mobility, multimorbidity and polypharmacy. Regarding unplanned nursing home admission after hospital discharge, the oldest adults presenting with impaired functional mobility, dependency in the activities of daily living, cognitive impairment, traumatic injuries and polypharmacy had a higher probability of nursing home admission. In addition, adjusted multivariate analyses revealed an increased risk of hospital readmission and unplanned nursing home admission for patients prescribed certain specific drugs. This might be explained by potentially inappropriate medications, particularly among geriatric inpatients. Indeed, the medication prescription reviews for our qualitative phase participants showed that the Beers and STOPP criteria[63 64] were rarely fulfilled. Potentially inappropriate medications have been associated with MRPs and adverse health outcomes, such as hospital readmission and mortality.[65] According to our qualitative findings, these adverse health outcomes and inappropriate prescriptions might have been the result of dysfunctional discharge planning: many older adults and informal caregivers considered that discharges home had occurred too rapidly, with no time to organise a care network to support the older adult's medication management. In addition, several older adults and informal caregivers revealed not feeling sufficiently listened to or involved in medication-related decisions during hospital discharge, despite them being the most important stakeholders in the decision-making process. Thus, they described contradictions between prescriptions and their medication preferences. Research into older adults' experiences of post-discharge medication management, by Tomlinson *et al*[15] and Parekh *et al*,[16] documented similar findings. Participants felt vulnerable, evoking their difficulties understanding information, pressures surrounding the circumstances of their discharge and a lack of integrated community care.

Our qualitative phase revealed that not being involved in medication-related decisions led three of our participants to deliberate non-adherence. Losi et al[66] suggested that medication adherence was influenced by multiple factors, including polypharmacy, psychological and social issues, and a patient's motivation and health literacy. Given that medication adherence is closely associated with MRPs and that polymedicated older adults are particularly vulnerable to these, medication adherence and continuity require an evaluation of patient preferences and adequate patient education.[66]

The lack of patient centredness revealed in our study was exacerbated by dysfunctional coordination between healthcare actors, which affected the quality of care and medication management. Older adults and informal caregivers described perceiving weak communication between healthcare professionals and having few opportunities to discuss new prescriptions with staff in hospital settings. Our results were in line with the cross-sectional studies by Mabire et al[67] and Meyer-Massetti et al,[68] which revealed wide gaps in discharge planning processes for geriatric inpatients, and the qualitative findings of Holmqvist et al[69] describing home-dwelling older adults' eagerness to be actively involved in their own medication evaluations. In addition, the healthcare professionals involved in our qualitative phase considered that the long delay between being tasked to intervene in a care transition after hospital discharge and receiving the paperwork was potentially harmful. Communication failures between hospitals and community healthcare professionals have been described in previous studies.[33] Tomlinson et al[21] demonstrated that successful care transitions implied not only medication reconciliation and review but also patient education, collaboration within the care team, timely cross-sector communication (between hospital and community healthcare or between other healthcare services) and a patient-centred discharge document. Concerning discharge documentation, our qualitative research revealed no standardised, systematic interprofessional collaborative interfaces—such as software or other tools—that might help to optimise collaborative medication management.

Solution design step: development of the medication management model

Our combined findings helped us design an interprofessional, collaborative medication management model to prevent MRPs among home-dwelling older adults after hospital discharge. It is composed of four interacting fields of action (figure 2).

Listening to polymedicated home-dwelling older adults and their informal caregivers

Our findings suggested that hospital and community healthcare professionals should explore older adults' values and preferences—and those of their informal caregivers involved in medication management—before and after hospital discharge. Although this is a common

concern in research,[66 70] our results showed that it is still not sufficiently implemented in the Valais hospital and local community clinical settings. Previous studies have argued for regular reassessments of their values and preferences and for integrating them into each change in treatment.[71 72] Our findings also suggested the need to ensure more adequate responses to pain assessments. Not only should older adults' and informal caregivers' needs be considered and addressed, but collaborative pain management plans should be developed in conjunction with them and the healthcare professionals involved in their medication management.[73] Our study evidenced the misaligned perspectives between older adults, informal caregivers and their healthcare professionals; they may also have revealed a misalignment between their medication management goals and values. Moreover, they suggested healthcare institutions' failure to be patient centred. Collaborative medication management could be strengthened by fully sharing stakeholders' goals and creating a well-defined project about the older adult's health and quality-of-life trajectory.[71] Healthcare professionals should verify that medication management goals are up to date (corresponding to the current reality) and ensure that all the partners in the care network have been informed and that information has been duly documented and can be consulted.[74]

Involving older adults and their informal caregivers in shared medication-related decisions

Regardless of older adults' age, comorbidities or functional impairment, they wished to be involved in decision-making concerning them, such as medication changes or discharge planning. The meta-analysis by Hunt-O'Connor et al[75] noted a reduced risk of readmission among older adults who had benefitted from discharge planning (RR=0.78; 95% CI: 0.72 to 0.84; p<0.001). Older adults should benefit from being given better, more appropriate, personalised information and being allowed to participate more actively in medication-related decisions at a technical or clinical level adapted to their preferences and capabilities.[76–78] In approaches using shared medication-related decision-making, patients should be considered proactive partners and codecision-makers in a manner adapted to their values, preferences and capabilities.[70 78] When they are not, the risks of non-adherence to treatment or medication errors are higher, as supported by our qualitative findings and previous studies.[71 79] Therefore, it is important to support and encourage older adults' remaining autonomy in medication management.[71]

Empowering older adults and their informal caregivers for safe medication self-management

Because our participants often reported misunderstanding the changes in their medication that took place in hospital and their difficulties in dealing with them at home, our findings emphasised that older adults' safety should benefit from a more empowering approach. This might
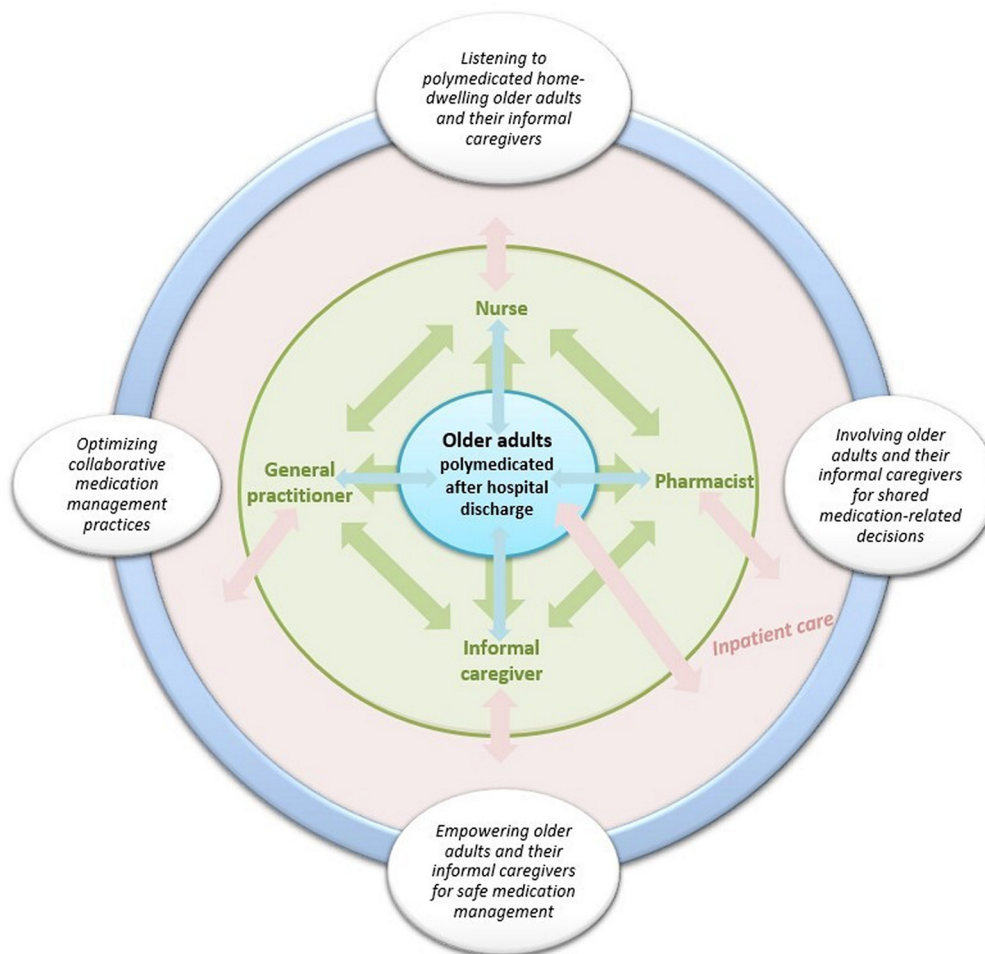
Figure 2 A collaborative, patient-centred, medication management model for polymedicated home-dwelling older adults after hospital discharge, based on mixed methods research using an explanatory sequential design.

comprise healthcare professionals sharing information on best practices in medication management with older adults and their informal caregivers and agreeing on the division of responsibilities relating to it.[69] A patient-centred medication empowerment plan, based on older adults' and informal caregivers' needs in terms of medication knowledge and skills, should be initiated in the hospital and followed up by community healthcare professionals. Healthcare professionals should be able to determine the extent to which an older adult and their informal caregivers have understood the changes in their medication that took place in hospital[80]; they should give them the means, tools and tips to optimise day-to-day medication self-management[81 82]; and they should monitor each older adult's level of medication adherence and any potential barriers to this.[83 84] Facilitating medication empowerment for older adults and their informal caregivers helps healthcare professionals promote shared-decision making; this may encourage them to take greater control over this important aspect of their own health, resulting in safer medication management and better patient outcomes.[85]

Optimising collaborative medication management practices

Our findings suggested that the different actors involved in older adult care considered collaborative practices a key part of safe medication management, particularly transitions of care. However, they also showed that, in some situations, effective communication was clearly lacking, putting the effectiveness of medication management at risk and, thus, the safety and quality of older adult care. Interventions that foster communication and collaboration between multiple stakeholders, particularly during the care transitions between hospital and home, have been shown to best meet older adults' needs, prevent MRPs, reduce the worsening of chronic conditions and cut the significant costs of hospital readmission.[21 74 86] Proper communication channels should be established to facilitate medication information-sharing among the multiple stakeholders. For example, adopting a validated interprofessional collaborative tool able to detect and identify the physiological, clinical, psychosocial and pharmacological risk factors for MRPs could improve interprofessional teamwork and promote safe medication management.[87 88] In addition, each stakeholder's independent, joint and overlapping responsibilities regarding medication management should be clearly defined so that they can better contribute to the different stages of the medication administration process.[80] Each older adult at significant risk of MRPs should be assigned

Table 2 Summary of the main results and recommendations for healthcare professionals' interventions to optimise medication management for polymedicated home-dwelling older adults discharged home

Listening to polymedicated home-dwelling older adults and their informal caregivers	Involving older adults and their informal caregivers in shared medication-related decision-making	Empowering older adults and their informal caregivers for safe medication self-management	Optimising collaborative medication management practices
► Explore older adults' and informal caregivers' values and preferences before and after hospital discharge. ► Regularly reassess those values and preferences and integrate them into each change in treatment. ► Develop collaborative patient-centred pain management plans. ► Verify that medication management goals are up to date, that all the partners have been informed and that information has been duly documented and can be consulted.	Allow the older adult to participate more actively in medication-related decision-making in a manner adapted to their values, preferences and capabilities.	► Determine the extent to which older adults and their informal caregivers have understood the changes in their medication. ► Give them the means, tools and tips to optimise day-to-day medication self-management. ► Monitor older adults' medication adherence and any potential barriers to this. ► Develop patient-centred medication-empowerment plans based on older adults' and informal caregivers' needs for medication knowledge and skills.	► Establish communication channels to facilitate medication information sharing among the multiple stakeholders. ► Clearly define each stakeholder's responsibilities regarding medication management. ► Assign a patient-centred nurse manager for older adults at a high risk of medication-related problems.

a *patient-centred geriatric care manager* from their nearest community healthcare centre, a professional with the overall responsibility of fulfilling the patient's care needs and ensuring their safety.[89–91] These managers could contribute significantly to preventing hospital admissions, rehospitalisations, institutionalisations and early death, as well as limiting the economic impact on the healthcare system.[92] They could ensure that medication reconciliations are performed whenever there is a change in health status or a care transition, ask an older adult's general practitioner or pharmacist to perform a medication review whenever there is a new prescription, as well as document and date all medication reconciliations or reviews and distribute that information to the care network.[93]

Table 2 summarises the interventions that hospital and community healthcare professionals should implement to prevent MRPs and adverse health outcomes.

Strengths and limitations

This study contributes to the growing body of knowledge and multiple perspectives on the barriers, challenges and opportunities for improving the safe medication management of polymedicated older adults at home after hospital discharge. We used an innovative mixed methods approach involving an explanatory sequential design that connected retrospective and prospective findings, including the many perspectives of the study's participants. Older adults', informal caregivers' and healthcare professionals' perspectives on medication management at home after hospital discharge helped explain and complete quantitative results describing the health profiles of older adults presenting with greater risks of adverse health outcomes related to MRPs. Our connected findings enabled us to develop a collaborative, patient-centred model to optimise medication management and prevent adverse health outcomes related to MRPs among polymedicated home-dwelling older adults after hospital discharge. The model proposes four interacting fields of action with tangible, collaborative recommendations.

The study, nevertheless, had some limitations. Regarding its retrospective quantitative strand, our dataset was based on routinely collected data, and we were unable to control for their quality or any potential assessment errors made by the hospital's healthcare staff at discharge. In addition, data on patients' medication at admission and during hospitalisation often contained gaps or were unknown, which meant that we were unable to explore changes in the number of prescriptions during hospitalisation. It would be interesting to explore whether hospitalisation tends to increase or decrease the number of medications prescribed to geriatric inpatients. Additionally, although the study considered statistical associations between medications and adverse health outcomes, it did not consider clinically diagnosed drug–drug interactions. This would have involved inputting the multiple possible interactions or analysing the prescriptions of a sample of the 105 243 hospitalisation records. Regarding the study's prospective qualitative strand, one limitation was the problem of maintaining older adults and their informal caregivers' interviews focused tightly on the topic of medication

management instead of on other instrumental activities of daily living and on the most recent care transition rather than on previous hospitalisations. Another limitation was the interruption of data collection at the beginning of March 2020 due to the COVID-19 pandemic restrictions. Because the study was longitudinal, follow-up data for four of the participating older adults were lost. Using a different qualitative methodology and collecting data using an online platform seemed unfeasible, since our older adult population was mostly unused to working with information and communication technologies. Despite our best efforts at methodological rigour, we cannot exclude that our study participants displayed a social desirability bias. It is possible, therefore, that older adults' medication management was actually less effective and collaborative than they reported in their interviews.

Although it had no impact on the methodological rigour of this mixed methods research, the qualitative phase started a few months before the end of the quantitative phase in order to meet planned project deadlines. Consequently, some of the results obtained in the retrospective phase (not presented in this paper) could have been explored further if the two phases had been conducted in a perfectly sequential manner. Concretely, the interview guides could have targeted some of the quantitative phase's results more deeply to explain or complete them. Nevertheless, this remains challenging when adopting an explanatory sequential design in a study that involves conciliating different data sources, field partners, research subteams and time constraints. Given that our findings frequently pointed toward the need for better communication and coordination between healthcare professionals, including those involved in discharge planning into the study could have contributed to disentangling existing dysfunctions. Future research, including those hospital professionals, could help to develop recommendations that align the needs of older adults, informal and professional caregivers, with the capacities of healthcare systems in order to prevent MRPs.

Finally, the study's research perspective was 'with' the public and not 'for' the public. It would have been interesting to involve polymedicated home-dwelling older adults, their informal caregivers and their healthcare professionals in the development of the model as research partners. Although it had initially been planned to involve associations of patients, caregivers and healthcare professionals, this could not be done due to the COVID-19-related restrictions in place when the model was being developed.

Conclusion

Exploring polymedicated home-dwelling older adults' medication management after hospital discharge, using mixed methods research, pointed us toward several opportunities for enhancing its safety and effectiveness and for preventing adverse health outcomes associated with MRPs. Healthcare professionals should consider not only the individual barriers to older adults' involvement in medication management, triggered by their advanced age, multimorbidity and physical impairments, but also older adults' and informal caregivers' preferences and values regarding their involvement in medication decision-making. More effective bidirectional communication and coordination between patients and healthcare professionals, between healthcare professionals and informal caregivers, and among healthcare professionals themselves, should be broadly promoted. Our collaborative, patient-centred medication management model is innovative and could prove a tangible strategy for improving medication management safety in the canton of Valais and Switzerland. Future studies should be conducted to explore the effectiveness of combining these fields.

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terminology, drug names and drug dosages), and is not responsible for any error and/or omissions arising from translation and adaptation or otherwise.

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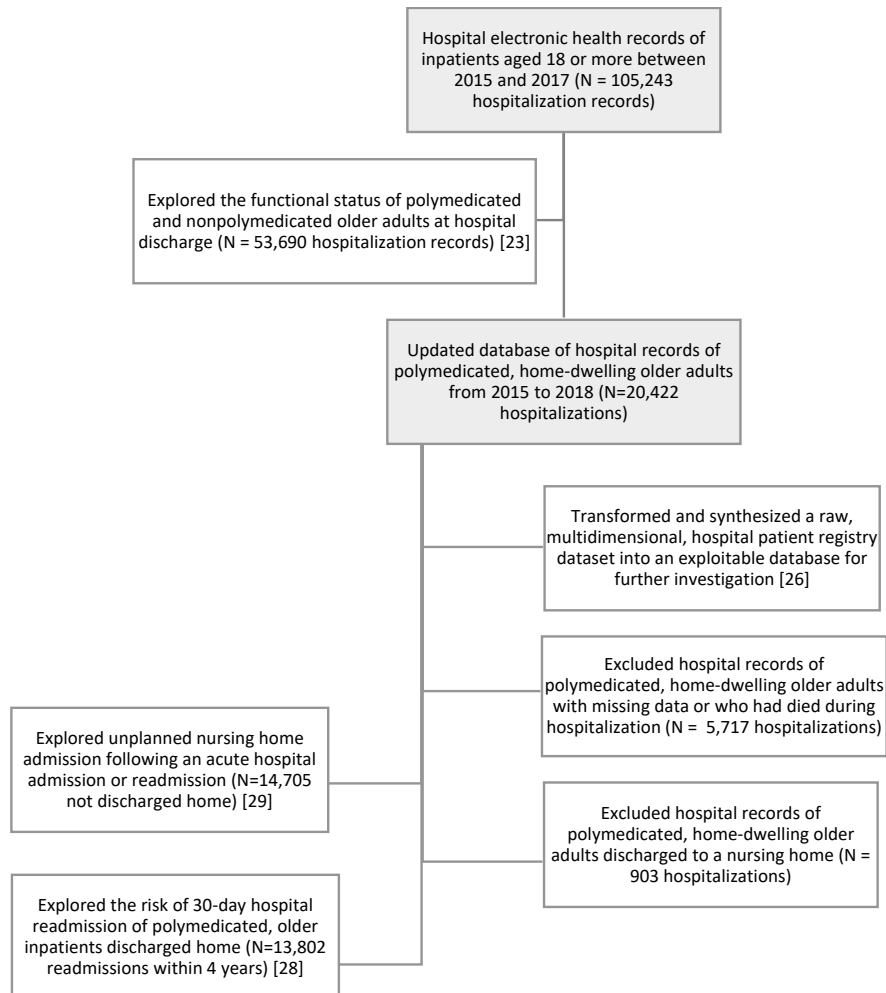
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Supplementary File 1: Profiles of polymedicated, home-dwelling older adults at risk of adverse health outcomes (30-day readmissions and unplanned nursing home admission)

Patient-related factors
- age (OR = 1.07 for each additional year of age; 95% CI 1.05–1.08) [29];
- multimorbidity (OR = 1.419 per additional ICD-10 condition; 95% CI 1.282–1.572) [28];
- impaired mobility (OR = 1.218; 95% CI: 1.039–1.427) [28]; (OR = 3.22; 95% CI 2.67–3.87) [29];
- dependency in the activities of daily living (OR = 4.62; 95% CI 3.76–5.67) [29];
- cognitive impairment (OR = 3.75; 95% CI 3.06–4.59) [29];
- traumatic injuries (OR = 1.58; 95% CI 1.25–2.01) [29].
Medication-related factors
- number of prescribed medications (OR = 1.043 per additional medication prescribed; 95% CI: 1.028–1.058) [28]; (OR = 1.17; 95% CI 1.15–1.19) [29].
Environment-related factors
- longer hospital length of stay (OR = 1.014 per additional day; 95% CI: 1.006–1.021) [28].

1

Supplementary File 2: Overall view of the retrospective data analysis strategy for the raw hospital register data.

Hospital electronic health records of inpatients aged 18 or more between 2015 and 2017 (N = 105,243 hospitalization records)

Explored the functional status of polymedicated and nonpolymedicated older adults at hospital discharge (N = 53,690 hospitalization records) [23]

Updated database of hospital records of polymedicated, home-dwelling older adults from 2015 to 2018 (N=20,422 hospitalizations)

Transformed and synthesized a raw, multidimensional, hospital patient registry dataset into an exploitable database for further investigation [26]

Excluded hospital records of polymedicated, home-dwelling older adults with missing data or who had died during hospitalization (N = 5,717 hospitalizations)

Explored unplanned nursing home admission following an acute hospital admission or readmission (N=14,705 not discharged home) [29]

Excluded hospital records of polymedicated, home-dwelling older adults discharged to a nursing home (N = 903 hospitalizations)

Explored the risk of 30-day hospital readmission of polymedicated, older inpatients discharged home (N=13,802 readmissions within 4 years) [28]

Supplementary File 3. Interview guides.

The interview guides were inspired by our literature review and tested in a preliminary study [32]. The original French versions were approved by the Human Research Ethics Committee of the Canton of Vaud on 5 July 2017 (2017-01025) and on 1 February 2019 (2018-02196), as well as by the institutional review board of our study's field partners. The guides have been translated into English for publication.

Interview 1: Older adult

Topics	Items
1) Presentation	Presentation of the study Presentation of the interview's objectives Details of the ethics measures taken
2) Experience of hospitalization and hospital discharge	General experience of the hospital stay Experience with medication received in hospital: - Changes to usual treatment in hospital - Information received in hospital about medication changes - People involved - Tools received in hospital to help manage medication at home
3) Experience of the return home	General experience and process of return home Experience with medication since returning home: - Management of medicines (and any changes made in hospital) since return home - People involved in medication management at home - Perceptions/experiences of taking several medications per day - Methods put in place to avoid forgetting to take medication, keep to the right schedule, and avoid taking the wrong medication - Taking other health or wellness products
5) Socio-demographic data	
6) End of the interview	Reminder of the ethical requirements for using the data collected in the interview

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Interview 2 (follow up interview): Older adult

Topics	Items
1) Presentation	Presentation of the interview's objectives Reminder of the details of the ethics measures taken
2) Daily medication management	Description of daily medication management: - Medication management locations (taking, storing) - Schedules - Routines
4) Support at home for medication management	People involved in the day-to-day management of medicines: - Who (people involved) - Frequency of assistance - Type of assistance
3) Experiences with medication	Medication habits and changes: - Time of onset of medication (before, during and after hospitalization) Knowledge about medications: - Indication for each medication - Effects of each medication - Possible precautions - Most important medication Satisfaction with information received about each medication Wish to ask questions about a particular medication
4) End of the interview	Reminder of the ethical requirements for using the data collected in the interview

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Interview 3: Joint interview with the older adult and their informal caregiver

Topics	Items
1) Presentation	Presentation of the study Presentation of the interview's objectives Details of the ethics measures taken
2) Older adult–informal caregiver relationship	The relationship between them Assistance provided in ADL and IADL
3) Experience of the return home	Process of hospital discharge and return home: - Experience with medication changes - Information received - Experience with medication since returning home - Support for medication management -
4) Involvement in medication management	Activities where the informal caregiver is involved in medication management How it happens Example
5) Sociodemographic data	
6) End of the interview	Reminder of the ethical requirements for using the data collected in the interview

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Interview 4: Professional caregiver involved in medication management

Topics	Items
1) Presentation	Presentation of the study Presentation of the interview's objectives Details of the ethics measures taken
2) Experience with the older adult in relation to medication management	Since when has Mr./Mrs. X been followed Type of intervention(s) for medication management (prescription, preparation, administration, monitoring, etc.) Frequency of intervention Process of hospital discharge and the return home: - Information received before the first visit after hospitalization - Possible changes in usual medication Progress of the medication adjustment Any difficulties encountered with Mr./Mrs. X regarding medication management
3) Sociodemographic and professional data	
4) End of the interview	Reminder of the ethical requirements for using the data collected in the interview

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Supplementary File 4. Sociodemographic characteristics of older adults from the quantitative strand

(n = 53,690) [23]

Variables	Older adults aged 65 or more (n = 53,690)			
	Total n (%) 53,690	Polymedicated 36,266 (67.5)	Non-polymedicated 17,424 (32.5)	P–value
Sex				
Male	25,672 (47.8)	17,357 (67.6)	8,315 (32.4)	0.763[a]
Female	28,018 (52.2)	18,909 (67.5)	9,109 (32.5)	
Age (years)				< 0.001[b]
Mean (SD)	78.37 (7.9)	78.75 (7.7)	77.58 (8.3)	
Min–Max	65–106	65–106	65–106	
Med [IQR-75]	78.00 [72–84]	79.00 [72–84]	77.00 [70–84]	< 0.001[a]
65–74	18,882 (35.2)	11,753 (62.2)	7,129 (37.8)	< 0.001[a]
75–84	21,818 (40.6)	15,485 (71.0)	6,333 (29.0)	< 0.001[a]
85 or more	12,990 (24.2)	9,028 (69.5)	3,962 (30.5)	
Admitted from				
Home	38,324 (71.4)	24,740 (64.6)	13,584 (35.4)	< 0.001[a]
Hospitals and nursing homes	15,366 (28.6)	11,526 (75.0)	3,840 (25.0)	< 0.001[a]
Discharged to				
Home	33,771 (62.9)	23,747 (70.3)	10,024 (29.7)	
Hospitals and nursing homes	17,273 (32.2)	12,302 (71.2)	4,971 (28.8)	< 0.001[a]
Died in hospital	2,646 (4.9)	217 (8.2)	2,429 (91.8)	
Length of stay (days)				
Mean (SD)				
Min–Max	12.1 (14.5)	13.8 (15.1)	8.6 (12.4)	< 0.001[c]
Med [IQR-75]	1–197	1–197	1–192	
65–74	8 [4–15]	10 [5–17]	4 [1–11]	
Mean (SD)				
Min–Max	10.3 (14.7)	12.4 (16.0)	6.8 (11.4)	< 0.001[b]
Med [IQR-75]	1–197	1–197	1–192	
75–84	6 [13]	8 [4–15]	3 [1–7]	
Mean (SD)				
Min–Max	12.4 (14.0)	13.9 (14.4)	8.8 (12.2)	< 0.001[b]
Med [IQR-75]	1-194	1-194	1-189	
85 or more	9 [13]	10 [1]	5 [10]	
Mean (SD)				
Min–Max	14.3 (14.6)	15.5 (14.8)	11.6 (13.9)	< 0.001[b]
Med [IQR-75]	1–192	1–192	1–170	
	11 [14]	12 [18]	8 [15]	

Note. [a] Chi-square test; [b] ANOVA; [c] Wilcoxon–Mann–Whitney

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Supplementary File 5. Sociodemographic and professional characteristics of participants from the

qualitative strand

Sociodemographic and professional characteristics	Older adults (n = 28)	Informal caregivers (n = 17)	Healthcare professionals (n = 13)
Sex (number)			
Female	11	15	10
Male	17	2	3
Age (years)			
Mean	81	68	44
Range	66–94	48–86	28–58
Relationship with the older adult			
Spouse/partner		10	
Child		6	
Daughter-in-law		1	
Profession (number)			
Retired	28	9	-
Employed	0	7	13
Unemployed	0	1	-
Nurse			5
Pharmacist/Pharmacy Assistant			4
General Practitioner/Specialist			4

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