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Positive effect of the INTERCARE nurse-led model on reducing nursing home transfers: A nonrandomized stepped-wedge design

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Abstract

Background: Unplanned nursing home (NH) transfers are burdensome for residents and costly for health systems. Innovative nurse-led models of care focusing on improving in-house geriatric expertise are needed to decrease unplanned transfers. The aim was to test the clinical effectiveness of a comprehensive, contextually adapted geriatric nurse-led model of care (INTERCARE) in reducing unplanned transfers from NHs to hospitals.

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Methods: A multicenter nonrandomized stepped-wedge design within a hybrid type-2 effectiveness-implementation study was implemented in 11 NHs in German-speaking Switzerland. The first NH enrolled in June 2018 and the last in November 2019. The study lasted 18 months, with a baseline period of 3 months for each NH. Inclusion criteria were 60 or more long-term care beds and 0.8 or more hospitalizations per 1′000 resident care days. Nine hundred and forty two long-term NH residents were included between June 2018 and January 2020 with informed consent. Short-term residents were excluded. The primary outcome was unplanned hospitalizations. A fully anonymized dataset of overall transfers of all NH residents served as validation. Analysis was performed with segmented mixed regression modeling.

Results: Three hundred and three unplanned and 64 planned hospitalizations occurred. During the baseline period, unplanned transfers increased over time ($\beta_1 = 0.52$), after which the trend significantly changed by a similar but opposite amount ($\beta_2 = -0.52$; $p = 0.0001$), resulting in a flattening of the average transfer rate throughout the postimplementation period ($\beta_1 + \beta_2 \approx 0$). Controlling for age, gender, and cognitive performance did not affect these trends. The validation set showed a similar flattening trend.

Conclusion: A complex intervention with six evidence-based components demonstrated effectiveness in significantly reducing unplanned transfers of NH residents to hospitals. INTERCARE's success was driven by registered nurses in expanded roles and the use of tools for clinical decision-making.

KEYWORDS
implementation science, nurse-led models, nursing homes, stepped-wedge design, unplanned transfers

INTRODUCTION

Unplanned transfers from nursing homes (NHs) are burdensome, associated with adverse outcomes for residents such as falls, delirium, or nosocomial infections; and are costly for the health system.[1] Various interventions have been tested in NHs to reduce unplanned transfers and address the growing lack of geriatric expertise and healthcare resources.[2–6] Among these are new care models, implemented in NHs with multicomponent interventions at both staff and organizational levels to improve the way health services are delivered.[7] Care models that include improved access to medical providers such as geriatricians, specialist nurses, or registered nurses (RNs) with additional training—referred to as nurses in expanded roles—have shown effectiveness in reducing unplanned transfers from 6.1% to 11.7%.[8,9] Other care models have shown successful reductions in unplanned transfers by integrating advanced practice nurses (APNs) into NHs.[3,6,10,11] The Missouri Quality Initiative obtained a 30% reduction in all-cause hospital

Key points

- INTERCARE as a contextually tailored multicomponent intervention could reduce nursing homes unplanned transfers.
- It supports nurses trained in geriatrics if advanced practice nurses are not available.
- Implementation with tailored implementation strategies is crucial for clinical effectiveness.

Why does this paper matter?

This paper supports the clinical effectiveness of in-house registered nurses working in extended roles to reduce unplanned transfers from NHs. It also provides nursing homes and stakeholders with a comprehensive example of a combination of six evidence-based core components addressing unplanned transfers, and which can be successfully implemented in daily practice.

transfers[6] and included the use of evidence-based tools from the Interventions to Reduce Acute Care Transfers (INTERACT) program, which has proven effective in reducing hospital transfers.[12,13]

NHs face a shortage of trained nurses and general practitioners (GPs) and limited access to APNs to support staff and provide geriatric expertise. APN programs in Europe are recent and very few APN positions are available in NHs,[14–16] driving a need for nurse-led care models based on RNs in expanded roles.

Implementing science methodology supports the successful implementation and uptake of evidence-based interventions such as nurse-led care models, by tailoring interventions to NHs' needs and resources.[17] Methodological elements include a theory-driven contextual analysis and the use of implementation strategies. The former drives the development of contextually tailored interventions and implementation strategies, while the latter is key for the adoption, implementation, sustainment, and scale-up of a program.[18,19] Improving INTERprofessionalCARE for better resident outcomes (INTERCARE), is a nurse-led care model for Swiss NHs working with RNs in expanded roles. INTERCARE is a theory-based implementation science study using contextual analysis, continuous stakeholder involvement, evidence-based interventions and development of implementation strategies to reduce unplanned transfers from NHs. INTERCARE measures unplanned transfers, which has been recommended by Maslow and colleagues, due to the complexity of defining and measuring potentially avoidable hospitalizations.[20,21] INTERCARE used several adapted components from the INTERACT quality improvement intervention[22]: it adapted the "Stop and Watch Early Warning Tool", "the SBAR Form", and "the Quality Improvement Tool for Review of Acute Care Transfers". Furthermore, INTERCARE adapted the component of Advance Care Planning based on INTERACT and provided modified versions of the INTERACT "Care Paths" to interested INTERCARE NHs.[22]

OBJECTIVE

To assess the clinical effectiveness of the INTERCARE nurse-led care model on the reduction of unplanned transfers of long-term NH residents to hospitals.

METHODS

Trial design and procedures

We applied a nonrandomized stepped-wedge design (hybrid type 2, see clinicaltrials.gov Protocol Record NCT03590470) over 18 months, from June 2018 to February 2020, in a convenience sample of 11 Swiss German NHs (Figure 1).[23] Switzerland has around 1′550 NHs (45% are private, mean of 62 beds),[24] which provide dementia and palliative care, psychogeriatric, intermediate care, or assisted living. Medical care is often provided by GPs, 50% of NHs work with in-house physicians. In Switzerland, residents have free physician choice and NHs working with both in-house physician(s) and GPs is frequent.[25]

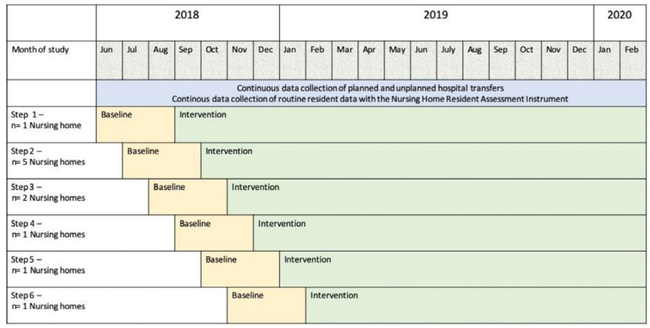

FIGURE 1 Nonrandomized stepped-wedge design. The first nursing home (NH) implemented the nurse-led model in September 2018; followed stepwise by five NHs in October 2018, two NHs in November 2018, one NH in December 2018, one NH in January 2019, and the last NH, in February 2019. The longest and shortest intervention periods, including the transitional period of 1 month, were 18 months and 13 months, respectively

The stepped-wedge design (Figure 1) included six steps, each step starting with a baseline observation period of 3 months after which INTERCARE was implemented. The roll-out period lasted six months with 1–2 NHs starting per step (September 2018 to February 2019), except for the second step with 5 NHs starting together. After the baseline period of 3 months, the NHs had a transitional period of 1-month to adjust to the requirements of INTERCARE and subsequently started with the INTERCARE model and continued until the end of the trial period, February 2020. Variability among NHs regarding the readiness for implementation at the NH management level and readiness of selected RNs to begin working in their new role as INTERCARE nurses precluded random assignment to the steps. Blinding of care staff, NH management, or residents to the intervention was not possible, nor was the blinding of data collectors, since all NHs received the intervention. INTERCARE received ethical clearance for the 11 participating NHs (EKNZ 2018–00501).

Participants and setting

Seventeen NHs in the German-speaking part of Switzerland were purposefully approached by the research group based on previous collaborations and stakeholder recommendations (Figure S1). The following criteria were applied for inclusion: (1) NHs had 60 or more long-term care beds, (2) had 0.8 or more hospitalizations per 1′000 resident care days over the year previous to recruitment based on their administrative data, and (3) were in the German-speaking part of Switzerland with the willingness to introduce INTERCARE and recruit RNs to work in an expanded role. Within each NH, all residents providing written informed consent were included except for short-term residents. If residents were unable to consent, their legal representatives were asked on their behalf.

Sample size

The sample size for the primary outcome was estimated with a simulation of the proposed stepped-wedge design assuming an average of 0.8 unplanned transfers/1′000 resident days and a reduction of 25% in unplanned transfers in NHs after implementation of INTERCARE.[22,26] A sample size of 11 NHs allowed us to detect a 25% reduction of unplanned transfers with a power of 80% at a significance level of $\alpha = 5\%$.[23]

The INTERCARE model

The INTERCARE model comprises six evidence-based core components with minimal requirements for each of these and adaptable elements for local tailoring (Table S1). The core components were tailored to the Swiss context based on a contextual analysis of existing nurse-led care models in Swiss NHs and stakeholder involvement.[23] Stakeholders included NH leaders, NH associations, resident representatives, professional organizations, and health policy representatives.[27,28] Their input guided the development of both the intervention and the implementation strategies. The needs and wishes of residents and relatives concerning unplanned transfers to refine the core elements were assessed.[29]

In brief, the core components included 1) strengthening of interprofessional collaboration between physicians and NH staff through the development of internal structures; 2) an INTERCARE nurse specifically appointed in each NH[28]; 3) comprehensive geriatric assessment of residents initiated by INTERCARE nurses when a change in condition was observed; 4) the use of evidence-based tools from the INTERACT program, including STOP and WATCH, ISBAR, and a reflection tool to analyze reasons for unplanned transfers[26]; 5) advanced-care planning to help NHs initiate sensitive discussions and document residents' wishes; and 6) data-driven quality improvement to identify areas for improvement (e.g., unplanned transfers).

Implementation strategies

Implementation strategies were developed based on a contextual analysis, where we identified barriers and facilitators impacting the implementation of a nurse-led care model. We used the Consolidated Framework of Implementation Research (CFIR) to synthesize the factors to be addressed by the implementation strategies[30] (e.g., clinical competencies for INTERCARE nurses) to facilitate the introduction, uptake, and sustainment of INTERCARE (Table S2). Implementation strategies were categorized according to the Expert Recommendations for Implementing Change compilation (ERIC).[31] These strategies included the promotion for adaptability with peripheral components, ongoing training for INTERCARE nurses, providing NH continuous support, and audit and feedback to help NHs improve.

Outcomes

The primary effectiveness outcome of this study was unplanned transfers, defined as a transfer from the NH to a hospital (emergency department [ED], private clinic) without an appointment (e.g., transfer after a fall). Psychiatry referrals and visits to outpatient clinics were excluded because these are mostly planned transfers in Switzerland. Transfer rates were calculated as the number of transfers per 1′000 resident days over a given period. The INTERCARE nurses documented all unplanned transfers to a hospital within two weeks, collecting the date of transfer, type of transfer (planned–unplanned), and reason for transfer. The date of discharge from hospital and the hospital transfer outcome (back to NH, death, other) were documented within two weeks after discharge.

At the resident level, control variables were assessed for later adjustment for confounders, including age, gender, NH length of stay (day of NH admission until date of hospital admission), the activities of daily living long form scale (ADL-long form, ranging from 0 to 28 where higher values mean more dependence),[32] cognitive performance scale (CPS, score ranging from 1 = intact to 6 = very severely impaired)[33] and depression rating scale (DRS, score ranging from 0 = no mood symptoms to 14 = all mood symptoms almost daily in the last 7 days).[34]

Validation dataset

To validate the primary data collection, we used anonymous administrative routine data, for which no informed consent from residents was needed. The 11 participating NHs extracted from their administrative software fully anonymized data of each hospital transfer between January 2017 and December 2020, indicating the date of admission and the date of return to the NH. All planned and unplanned transfers of more than 1 day were included in this dataset (administrative software did not allow to assess stays outside of the NH of 1 day or less). NHs provided a summation of all care days for all long-term care residents for each month during the assessment period, used to calculate a monthly rate of transfers per 1′000 resident days.

Data collection

Local NH coordinators were responsible for resident recruitment. All long-term care residents present at baseline and all newly admitted residents throughout the study period fulfilling the inclusion criteria were asked to participate. Consenting residents were entered in a customized electronic Case Report Form (CASTOR EDC),[35] developed and managed by the INTERCARE research group.

Data about residents and hospital transfers for residents with informed consent came from two sources. First, hospital transfer data were entered by the INTERCARE nurses via secure online access into CASTOR EDC. Given that the validation set also contained admission and discharge dates of all transfers during the study period but from a different data source, we used it to validate the data entered by the INTERCARE nurses.

Second, resident data were extracted from routinely collected data using the Resident Assessment Instrument (RAI-NH)[33] every three months and transferred securely to the research team. For the validation dataset with the fully anonymized data, the responsible manager in each NH exported the overall transfer data quarterly from the administrative software, which included all residents in the participating NHs.

Statistical methods

Analyses were performed using SAS 9.4 (SAS Institute, Cary, NC) and R 3.5.2 (Eggshell Igloo),[36] with packages dplyr[37] and tidyverse.[38]

Descriptive statistics were calculated for resident and transfer characteristics and reported as means, standard deviations (SDs), median, and interquartile range (IQR) for continuous, or frequencies and percentages for nominal variables. Mixed-effect logistic regression analysis was used to assess differences between groups of residents transferred for at least one unplanned transfer compared to those with none, and to compare hospital transfer characteristics between unplanned and planned transfers to give a clear overview of the sample of included residents.

Clinical effectiveness of the intervention was tested by a segmented mixed-effect logistic regression, predicting unplanned transfer status of individual residents assessed daily (yes/no).[39] NHs were entered as random intercepts and generalized estimating equations were additionally applied to correctly estimate serial correlations of individual observations nested within the NHs over time. The variables 'time since baseline' plus the 'time since intervention start' were entered as fixed variables to allow evaluating whether the intervention altered the trajectory of unplanned transfers over time, that is, if the existing trend of unplanned transfers (=time since baseline with estimated slope β_1) changed direction after deployment of the intervention (=time since intervention with estimated slope β_2). Thus, the parameter β_2 represented the relative slope alteration postimplementation relative to the preintervention trend β_1. Hence, the slope of the regression line post-implementation could be obtained in this second segment of the analysis as $\beta_1 + \beta_2$. We additionally checked if resident-level variables age, sex, and cognitive status confounded the relationships of β_1 and β_2 to the outcome variable.

For the validation set, no daily resident-level unplanned transfer data were available. Instead, the number of monthly transfers per 1′000 resident days were retrieved, which could—as a logarithmically transformed outcome variable—be modeled by linear mixed regression analysis. As for the main analysis, clustering within NHs was taken into consideration by random intercepts and serial correlations determined empirically. The two covariates time since baseline (β_1) and time since intervention (β_2) served as predictor variables in the same segmented manner as explained above.

RESULTS

Eleven NHs agreed to participate. Reasons for non-participation were ongoing projects or restructuring processes. Eight of the 11 NHs are situated in urban neighborhoods and 9 out of 11 are privately funded, with a median size of 120 long-term care beds. Four NHs worked with external physicians responsible for more

TABLE 1 Consenting resident characteristics

Characteristics	INTERCARE consenting residents: Overall participating residents with informed consent	Subgroup of residents never transferred for an unplanned reason during the study	Subgroup of residents transferred at least once for an unplanned reason during the study	p value[a]
Number of residents (%)	942 (100)	717 (76.1)	225 (23.9)	-
Age, median (IQR)	85.5 (80–90)	85.0 (80.0–90.0)	86.0 (79.0–91.0)	0.368
Gender, Female, *n* (%)	650 (69.0)	497 (69.3)	153 (68.0)	0.589
Length of stay in NH, years, median (IQR)	2.8 (1.7–4.7)	2.8 (1.4–4.8)	2.8 (1.7–4.5)	0.736
Intervention time, years, mean (SD)	1.1 (0.4)	-	-	-
Activities of daily living (0–28) (ADL)[a] *n* (%)				0.109
Not–mildly impaired (0–4)	203 (22.1)	145 (20.7)	58 (26.9)	
Moderately impaired (5–23)	699 (76.1)	543 (77.3)	156 (72.2)	
Severely impaired (24–28)	16 (1.8)	14 (2.0)	2 (0.9)	
Cognitive performance scale (0–6) (CPS)[b], *n* (%)				0.004
Intact to mild impairment (0–2)	380 (41.4)	266 (37.9)	114 (52.8)	
Moderate to moderately severe (3, 4)	388 (42.3)	306 (43.6)	82 (38.0)	
Severe to very severely (5, 6)	150 (16.3)	130 (18.5)	20 (9.2)	
Depression rating scale (0–14)[b] (DRS) (mean (SD))	1.1 (1.5)	1.1 (1.5)	1.2 (1.6)	0.330

Abbreviations: IQR, interquartile range; NH, nursing home; SD, standard deviation.
[a]Group differences by random-intercepts logistic regression (t-value approximation).
[b]For ADLS, CPS, and DRS scores, data were unavailable for 24 residents.

than 80% of residents, three with on-site physician(s) responsible for more than 80% of residents and the rest had mixed models. A median of one INTERCARE nurse worked per NH (Table S3). A total of 942 residents with informed consent were included (females 69%) with a median age of 85.5 years (IQR 80–90) (Table 1), representing an overall consent rate of 68% across the 11 NHs (Figure S1). Residents were exposed to the intervention for a mean duration of 1.1 years (SD 0.41). In the validation set, an observation period of 327 months across all NHs, resulted in 949 hospitalizations (planned or unplanned) and a summed length of stay of 7330 days.

During the 3 month-baseline and 18 month-intervention study periods, 367 hospital transfers occurred, of which 303 transfers (82.6%) were unplanned (primary outcome) and 64 transfers (17.4%) planned (Table 2). The major reason for unplanned transfers was fall-related injuries (40.6%). At the resident level (Table 1), 225 residents (23.9%) were transferred to a hospital at least once for an unplanned reason. Residents with higher cognitive impairment were less often transferred for unplanned reasons (transferred: intact–mild cognitive impairment 52.8% versus severe cognitive impairment 9.3%; not transferred: intact–mild cognitive impairment 37.9% versus severe cognitive impairment 18.5%).

Effectiveness of INTERCARE model

Raw rates for unplanned transfers per 1′000 resident days were 0.41 for the three baseline months and subsequently 0.84 (intervention start = T1), 0.85 (3 months after T1), 0.64 (6 months after T1), 0.79 (9 months after T1), and 0.42 (12 months after T1) unplanned transfers/1′000 resident days per quarterly period after baseline.

During the baseline period, unplanned transfers increased over time ($\beta_1 = 0.52$, Table 3), after which the trend significantly changed by a similar but opposite amount ($\beta_2 = -0.52$; p = 0.0001, Table 3), resulting in a flattening of the average unplanned transfer rate throughout the postimplementation period ($\beta_1 + \beta_2 \approx 0$). The trajectory postimplementation has a logodds of $0.524 + -0.521 = 0.004$, or an odds ratio of exp

TABLE 2 Hospital transfer characteristics that occurred during the INTERCARE project from baseline until the end of the intervention

Hospital transfer characteristics	All	Unplanned	Planned	p value[a]
Number of transfers, *n* (%)	367 (100)	303 (82.6)	64 (17.4)	
Length of stay in hospital in days, median (IQR)	4 (1–8)	4 (1–7)	4 (1–9)	0.235
Hospital transfer outcome, *n* (%)				0.235
Discharged back to NH	344 (95.0)	282 (94.0)	62 (100)	
Death in hospital	17 (4.7)	17 (5.7)	0 (0)	
Discharged elsewhere	1 (0.3)	1 (0.3)	0 (0)	
Missing	5	3	2	
Reason for hospital transfer *n* (%)				-
Injury	128 (34.9)	123 (40.6)	5 (7.8)	
Gastro-intestinal disorder	38 (10.4)	33 (10.9)	5 (7.8)	
Infection[b]	34 (9.3)	31(10.2)	3 (4.8)	
Cardiovascular disorder	43 (11.7)	32 (10.6)	11 (17.2)	
Respiratory disorder	31 (8.4)	30 (9.9)	1 (1.6)	
Urinary disorder	20 (5.4)	16 (5.3)	4 (6.3)	
Other[c]	34 (9.3)	16 (5.3)	18 (28.1)	
Dermatology disorder	20 (5.4)	12 (4.0)	8 (12.5)	
Ear Nose Throat disorder	7 (1.9)	7 (2.3)	0 (0)	
General deterioration	9 (2.5)	7 (2.3)	2 (3.1)	
Neurological disorder	8 (2.2)	7 (2.3)	1 (1.2)	
Problem with medical device	11 (3.0)	6 (2.0)	5 (7.8)	
Metabolic disorder	6 (1.6)	6 (2.0)	0 (0)	
Renal disorder	5 (1.4)	5 (1.7)	0 (0)	
Gynecology disorder	4 (1.1)	2 (0.7)	2 (3.1)	
Psychiatry disorder	3 (0.8)	1 (0.3)	2 (3.1)	
Number residents with hospital transfers ($n = 224$ residents)				0.367
Number of residents with single hospital transfers, *n* (%)	166 (67.2)	146 (69.9)	20 (52.6)	
Number of residents with rehospital transfers, *n* (%)	58 (23.5)	43 (20.6)	15 (39.5)	
Subgroup: number of residents with three or more hospital transfers, *n* (%)	23 (9.3)	20 (9.6)	3 (7.9)	

Abbreviations: IQR, interquartile range; SD, standard deviation.
[a]Group differences by random-intercepts logistic regression (t-value approximation).
[b]Infection can be concomitant to other conditions, for instance, a resident could be transferred for a respiratory disorder with infection.
[c]Other includes a mix of signs and symptoms not attributable to a specific condition (i.e., hemorrhage).

(0.004) = 1.004, implying that the odds of unplanned transfer postimplementation only went up by 0.4% per month on average.

Figure 2 shows these trends, as expressed in probabilities of unplanned transfer over the entire study follow-up. Controlling for depression and functional status did not have an effect on the model; therefore, they were not retained in the final model. Nor did age, gender, and cognitive performance affect these trends (Table S4).

Validation dataset with overall hospitalization data

An analysis of the validation dataset over an extended time window from 10 months before until 20 months after the study started, confirmed the trend discontinuation after intervention started, compared to the initial hospitalization rate trajectory (Figure S2).

TABLE 3 Effect estimation of the INTERCARE nurse-led model on unplanned transfers using mixed-effect logistic regression model adjusted by NH as random effects

Parameter	Estimate (logodds)	Standard Error	t-value (df)	p-value	Odds ratio
Intercept (α)	−6.943 (−7.877 to −6.008)	0.4195	−16.55 (10)	<0.0001	
Months preimplementation (β_1)	0.524 (0.262 to 0.787)	0.1338	3.92 (41E4)	<0.0001	1.69 (1.30 to 2.20)
Months postimplementation (β_2)	−0.521 (−0.783 to −0.258)	0.1339	−3.89 (41E4)	0.0001	0.59 (0.46 to 0.77)

df, degrees of freedom.

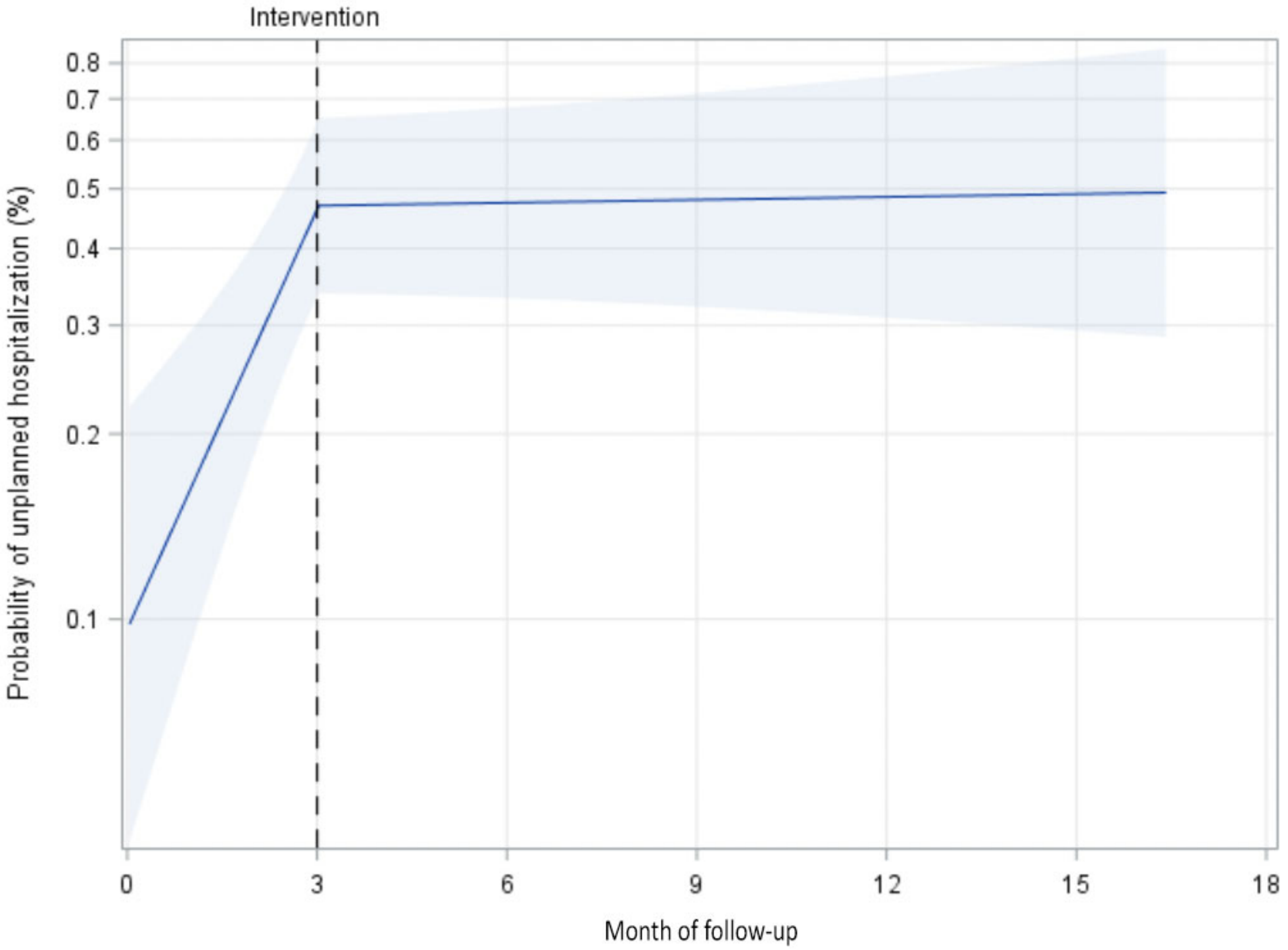

FIGURE 2 Predicted trajectory of unplanned transfers from baseline until end of intervention (+95% confidence intervals). Probabilities are derived from the logodds shown in Table 3 and can be calculated as exp(logodds)/(1 + exp(logodds)). For example, solving the regression equation of Table 3 gives a logodds of unplanned transfer at three months of −6.943 + 3*0.524 + 0*−0.521 = −5.37, which can be algebraically transformed into a probability of 0.46% by substituting the formulas above [exp(−5.37)/(1 + exp(−5.37))] = 0.0046

A descriptive presentation of monthly total hospitalization rates for both data sets (residents with informed consent and all residents) shows that routine data differed from study data, in that the number of registered unplanned transfers is slightly higher for the routine data, and that the baseline increasing trajectory is less steep (Table S5 and Figure S3).

DISCUSSION

INTERCARE's implementation significantly changed the trend in unplanned transfers from NHs to EDs and hospitals. This change in trend was visible in both the dataset assessing unplanned transfers controlled for age, gender, and cognitive performance and in the validation data set with overall hospitalizations. The primary outcome of unplanned transfers chosen in this study is distinct from the more commonly used outcome of potentially avoidable hospitalizations based on International Classification of Diseases, 10th Revision (ICD-10) codes. Swiss NHs do not have access to ICD-10 codes that are used to identify Ambulatory Care Sensitive Conditions for which timely primary care can reduce the risk for an avoidable hospitalization. The alternative approach using the unplanned transfer as the primary outcome was seen as a better fit for Swiss NHs.

INTERCARE is a pragmatic and contextually adapted multicomponent intervention developed with NHs and stakeholders' input. Specifically developed implementation strategies to support the uptake of the intervention (e.g., a targeted curriculum for geriatric conditions to train the INTERCARE nurse) were used. INTERCARE's core elements build on the evidence of former successful care models to reduce unplanned hospitalizations. All 11 NHs adopted and implemented the core components but tailored the peripheral elements to their needs. Leadership engagement to both the study and the organizational change could be maintained and all NHs had an INTERCARE nurse in place throughout the study period, supporting an effective outcome.

INTERCARE used similar components to both the Missouri Quality Improvement (MOQI) study[6] and the OPTIMISTIC program,[12] which, respectively, showed reductions in all-cause transfers or in the risk for these. Both models were supported by an operations team or by nurse practitioners.[40,41] INTERCARE did not integrate APNs in NHs but rather built a model with in-house workforce and chose to further educate NH RNs. Our results show that this is a viable solution for settings that do not have access to APNs or where NHs cannot afford to integrate other professionals such as social workers.[6] Both OPTIMISTIC and MOQI models report interfacility variation depending on the use of the program, facility leadership stability, and engagement in and resource commitment to the project.[40,41] All INTERCARE nurses' remained in their positions during the project. Turnover in APNs results in serious disruption of the intervention as reported elsewhere.[40] INTERCARE was developed as an implementation science study and we thoroughly assessed, which implementation strategies could enhance and sustain implementation through the identification of barriers and facilitators. The additional tailored training and education provided to the INTERCARE nurses as an implementation strategy helped enhance geriatric expertise in the NHs. The INTERCARE nurses were integrated into the NHs' teams and were involved in day-to-day care and clinical decisions, as opposed to external expertise brought into the NHs, for example, in the form of nurse practitioners working with GPs. Extensive cost analysis of these different models is needed to be able to compare how cost-effective these models are with one another.

Neither the sampling of NHs nor the assigning of steps in the stepped-wedge design were random. Although nonrandomization can lead to misleading estimates of effect, nonrandom sampling and step assignment allowed NH leadership to prepare for the implementation and fit it into their strategic goals and contexts, supporting successful implementation.[19] The study results are not generalizable to Swiss NHs overall as NHs participating were highly motivated to implement a complex intervention requiring organizational and leadership engagement. The comparison of the baseline trend with the intervention period trend in unplanned transfers does not allow us to definitely attribute a direct effect to INTERCARE since we lack a true comparison group. We observed low transfer rates in the baseline period, which we cannot explain since recruitment of residents was finalized at the beginning of baseline and the INTERCARE nurses knew how to enter data correctly at the start of the study. We also saw fluctuating rates during the intervention phase; with a slight rise 9 months after the implementation start (0.79). Factors such as staff turnover could explain this. Temporal trends such as seasonal fluctuations were checked on both the study data and the larger validation data set and showed no differences. Interestingly, the validation data set showed a similar trend, adding weight to our findings and those of other pre–post studies.[26,40,41] In addition, we found that the proportion of days of planned transfers remained stable over the study period, whereas unplanned transfers showed a declining trend (Figure S4). Due to the sample size of 11 NHs, investigating physician coverage on the impact of unplanned transfers was not possible; although this would have been interesting to measure and could be addressed in future research.

CONCLUSION

This study supports the clinical effectiveness of in-house nurses working in extended roles to reduce unplanned transfers. Policymakers should consider expanding the scope of practice of RNs to help NHs acquire better geriatric expertise if APNs are not available. Clinicians can tailor the core elements to develop a similar model with in-house resources. Further in-depth analysis of implementation outcomes (e.g., fidelity), strategies, and barriers and facilitators, described elsewhere[42] will examine the contribution of each intervention element to better understand what supports the successful implementation of nurse-led care models in NHs.

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CONFLICT OF INTEREST

All authors have completed the *Unified Competing Interest form* and declare: Franziska Zúñiga, Sabina De Geest, Dunja Nicca, Reto W Kressig, Andreas Zeller, Nathalie I H Wellens, Carlo De Pietro, Mario Desmedt, Michael Simon had financial support from the Swiss National Science Foundation and the Nursing Science Foundation Switzerland for the submitted work; none of the authors had financial relationships with any organizations that might have an interest in the submitted work; no other relationships or activities that could appear to have influenced the submitted work.

AUTHOR CONTRIBUTIONS

Franziska Zúñiga, Michael Simon conceived, designed, supervised, and obtained the funding for the study. Franziska Zúñiga, Raphaëlle-Ashley Guerbaai, Michael Simon, Kris Denhaerynck collected, analyzed, and interpreted the data and are responsible for the overall content as guarantors. Franziska Zúñiga and Raphaëlle-Ashley Guerbaai drafted the manuscript. Sabina De Geest, Lori L Popejoy, Jana Bartakova, Kornelia Basinska, Reto W Kressig, Andreas Zeller, Nathalie I H Wellens, Carlo De Pietro, Mario Desmedt, Christine Serdaly, Dunja Nicca critically revised the manuscript for important intellectual content. Kris Denhaerynck, Diana Trutschel, and Raphaëlle-Ashley Guerbaai did the statistical analysis. The corresponding author attests that all listed authors meet authorship criteria and that others not meeting the criteria have been omitted. The corresponding author had full access to all the data in the study and had final responsibility for the decision to submit it for publication.

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SUPPORTING INFORMATION

Additional supporting information may be found in the online version of the article at the publisher's website.

Table S1. Core and peripheral elements of the INTERCARE model.
Table S2. Implementation strategies used to promote the up-take of INTERCARE.
Table S3. Nursing home characteristics.
Table S4. Effect estimation of the INTERCARE nurse-led model on unplanned transfers (controlled) using linear mixed regression model adjusted by NH as random effects.
Table S5. Effect of the INTERCARE nurse-led model on all transfers (10 months prior to intervention start until 20 months post-implementation start).
Figure S1. Nursing home and resident recruitment flowchart.
Figure S2. Predicted total transfers per 1000 resident care days (+ 95% confidence intervals) calculated from validation routine data.
Figure S3. Hospital transfer rates across the routine validation dataset compared to the CASTOR EDC dataset. Note: Same-day unplanned transfers from the CASTOR EDC data from residents with informed consent are omitted, to be comparable to the validation data; Lines fitted using penalized B-spline smoothing.
Figure S4. Planned and unplanned transfer rates post implementation of INTERCARE.

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