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Intervention Research

Effectiveness of a Technology-Enhanced Integrated Care Model for Frail Older People: A Stepped-Wedge Cluster Randomized Trial in Nursing Homes

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Abstract

Background and Objectives: The objective of this study was to evaluate the impact of an information and communication technologies (ICT)-enhanced, multidisciplinary integrated care model, called Systems for Person-centered Elder Care (SPEC), on frail older adults at nursing homes.

Research Design and Methods: SPEC was implemented at 10 nursing homes in South Korea in random order using a stepped-wedge design. Data were collected on all participating older residents in the homes before the first implementation and until 6 months after the last implementation. The 21-month SPEC intervention guided by the chronic care model (CCM) consists of 5 strategies: comprehensive geriatric assessment, care planning, optional interdisciplinary case conferences, care coordination, and a cloud-based ICT tool along with a free messaging app. The primary outcome was quality of care measured by a composite quality indicator (QI) from the interRAI assessment system. Usual care continued over the control periods. Nursing home staff were not blinded to the intervention.

Results: There were a total of 482 older nursing home residents included in the analysis. Overall quality of care measured by the composite QI was significantly improved (adjusted mean difference: −0.025 [95% CI: −0.037 to −0.014, $p < .0001$]). The intervention effect was consistent in the subgroup analysis by cognition and activities of daily living. There were no important adverse events or side effects.

Discussion and Implications: The SPEC, a CCM-guided, ICT-supported, multidisciplinary integrated care management intervention, can improve the quality of care measured by health and functional outcomes for frail older persons residing in nursing homes with limited health care provision.

Clinical Trials Registration Number: ISRCTN11972147

Keywords: Asia, Evaluation, Geriatric care model, Implementation science, Long-term care

Provision of quality care for older adults with complex care needs is critical for the sustainability and outcomes of health systems (Rowe et al., 2016; World Health Organization [WHO], 2015). Innovations in the delivery of health and care services are the main interest of policymakers in countries with aging populations. The chronic care model (CCM) has been widely accepted and used as a pragmatic, conceptual model for innovative disease management and geriatric care (Wagner et al., 1996, 2001). Several CCM-based interventions for older adults have improved quality of care, health outcomes, and/or satisfaction, but others have not (Davy et al., 2015). There are still evidence gaps in the literature on CCM-based care model development and implementation; most existing CCM-based studies target a single chronic disease (Coleman et al, 2009; Davy et al., 2015), but multimorbidity is prevalent among older people (WHO, 2015). In addition, studies guided by the CCM have mostly focused on primary care for community-dwelling people (Kadu & Stolee, 2015), and limited evidence exists on whether the CCM is a relevant model that can guide development and implementation of interventions for frail older people with complex conditions in institutional settings. The work of Boorsma et al. (2011) is the only published study we identified that has developed and tested a multidisciplinary integrated care model using comprehensive geriatric assessment (CGA); they reported an improvement in the quality of care in Dutch residential care facilities (RCFs). The study was conducted in Europe, and the linkage between the CCM and the components of the intervention developed was unclear.

To fill the gap in the evidence on the effectiveness of a CCM-guided intervention for older adults with complex chronic conditions, we developed the Systems for Person-centered Elder Care (SPEC), an integrated care management model guided by the CCM for older nursing home residents. The SPEC combines the elements of the CCM with evidence-based practice in improving quality of care, tailored to the long-term care (LTC) setting in South Korea. It uses an information and communication technologies (ICT) system to support nursing home staff in conducting a standardized CGA, developing an individualized care plan, and monitoring the care process for frail older people in nursing home settings, where limited evidence exists on the effects of ICT-based interventions. The SPEC is described in greater detail in the Method section (Kim et al., 2017). A relatively small number of studies on the quality of nursing home care in Asia have adopted a randomized controlled trial (RCT) design, widely known as a gold standard for evidence-building. The SPEC trial aimed to fill these gaps by evaluating the proposed CCM-based model at nursing homes in South Korea, an East Asian country where a formal LTC system was only recently developed (Kim, 2020).

The SPEC study adopted a stepped-wedge cluster randomized controlled trial (SW-CRCT) design (Hemming, Haines, et al., 2015). The clustered design was needed, as the older people were nested in discrete nursing homes, which was the unit of care delivered and evaluated. The stepped-wedge design was relevant for the study, as this design allowed all participating homes to implement the newly developed intervention after a control period, which was often a condition in the recruitment stage for the homes to participate in this trial of a quality improvement program. This sequential roll-out of the implementation had practical benefits for the research team, as well, with our limited human and financial resources. We were also interested in estimating the intervention effects using both a between- and a within-cluster comparison.

The objective of the study was to examine whether the SPEC model (the intervention program), a theory-driven, technology-enhanced, integrated care management model, is effective for improving the quality of care for older residents in comparison to usual care reflecting current practice patterns in nursing homes in Korea. We hypothesized that a person-centered, integrated, multidisciplinary care model using an ICT system would improve the quality of care in nursing homes.

Method

Trial Design and Participants

The SPEC trial was a 21-month, multicenter, prospective, unidirectional crossover cluster RCT delivered to older residents in 10 nursing homes (the clusters) in South Korea from April 2015 to December 2016. It was an institution-level intervention. We adopted an incomplete stepped-wedge design (Hemming, Lilford, et al., 2015): The 10 clusters were randomly assigned to one of the five sequences, and the total number of periods was seven (Figure 1). The duration of time between each step was 3 months. The participants assessed in different periods were the same people, typically, and newly admitted residents were recruited when they met the study criteria. Using the incomplete SW-CRCT

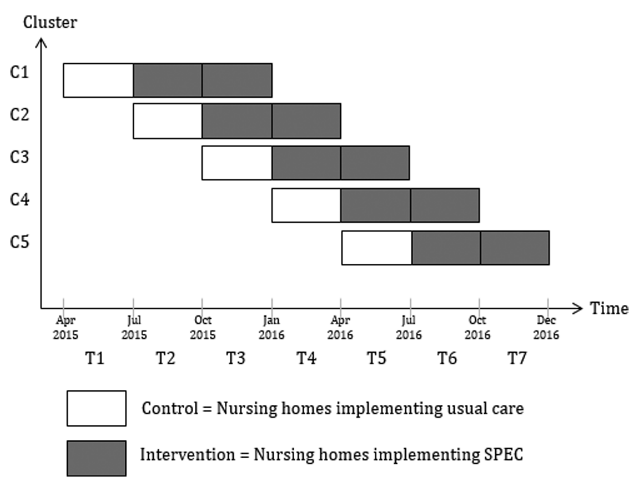

Figure 1. Design of the Systems for Person-centered Elder Care (SPEC) study.

design, two clusters (one group) in a sequence entered a 3-month control phase followed by a 6-month intervention phase. Four measures were made to compute three outcome scores at the end of each period: at the beginning and at the end of the control period, in the middle (after 3 months had elapsed; Period 1), and at the end (after 6 months had elapsed; Period 2) of the intervention period for each home. All eligible participants at each measurement point were assessed (Figure 2). No important changes were made to the methods after trial commencement.

Nursing homes were recruited through information sessions for the directors of the homes. All the homes were located in Seoul or the Gyeonggi province, and they were registered with and reimbursed by the public long-term care insurance (LTCI) for the older adults. Participants were nursing home residents aged 65 or older who had stayed at the participating homes for at least 1 week, were neither in a terminal condition nor comatose, and were capable of study participation. These older residents participated in the study only when each resident or his/her proxy signed a written consent form. The study was approved by the institution of the principal investigator of the study. Detailed study design, setting, and participant information were reported in the study protocol (Kim et al., 2017).

Intervention: The SPEC Model

The SPEC is a technology-enhanced, multidisciplinary, integrated care management model for frail older nursing home residents at risk of functional decline and common geriatric problems. It aims to improve the quality of care in nursing homes and thereby promote the health and well-being of older residents. We developed the SPEC intervention with Wagner's (1996) Chronic Care Model (CCM) as the conceptual model and referenced the CCM-inspired Multidisciplinary Integrated Care model (Boorsma et al., 2011) in the Netherlands. The multifaceted SPEC intervention consists of five components (Kim et al., 2017): CGA using the psychometrically tested interRAI Long-Term Care Facilities (interRAI LTCF: Kim, 2013); individualized need-based care planning (CP) using standardized care protocols and checklists developed from evidence in the existing literature and input from experts in academia and practice; optional interdisciplinary case conferences (ICCs); coordination of care (CC) with family members and external health professionals and institutions; and use of ICT including a cloud-based SPEC information system. This system was a prototype computerized care management software whose main outputs were an individualized need/risk profile report from the CGA and also a profile-based care plan and

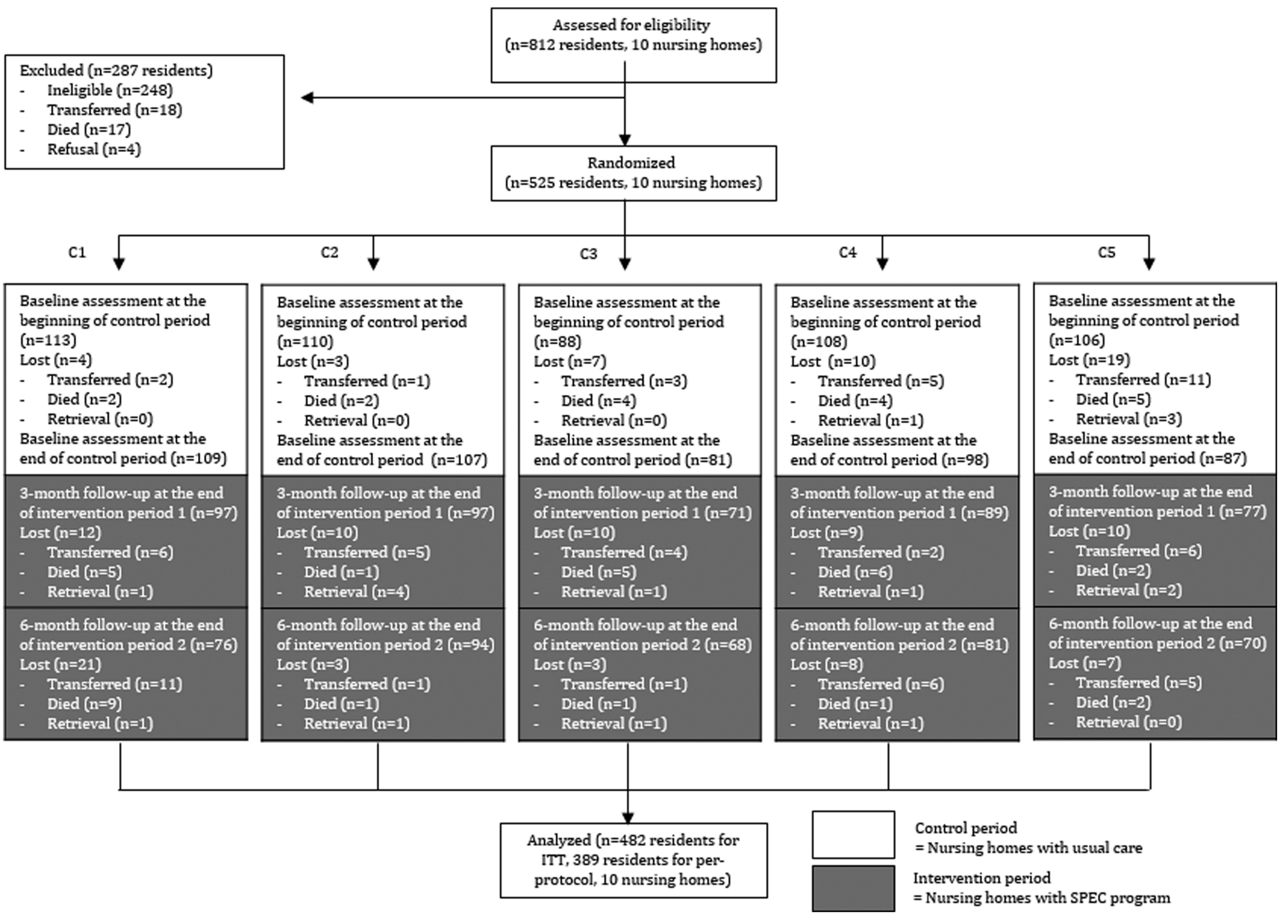

Figure 2. The flow of participants.

checklist for each patient from the CP and ICCs. Through the CP and/or ICCs, the care teams assessed and incorporated the priorities and preferences of older residents and/or their family members, if relevant. Their usual care reflected current nursing home practices in Korea and was provided during the control period; no home provided as part of usual care standardized CGA or implemented evidence-based CP in a systematic way (Park et al., 2015). The intervention was conducted by a care team led by onsite SPEC coordinators, typically a nurse–social worker pair, who were trained and coached by the SPEC consultant. The consultant, a nurse trained by the research team, was responsible for facilitating and monitoring the implementation process including educating the onsite coordinators to do CGA and CP; demonstrating how to use the SPEC information system; coaching the care team to do ICCs; and being a resource for inquiries about implementation, via onsite meetings and also a free messaging app. Details on the components of the intervention were reported in the study protocol (Kim et al., 2017).

Outcomes

The primary outcome variable was quality of care, which was reported via a composite score of quality indicators (QIs) using the interRAI LTCF (Boorsma et al., 2011; Frijiters et al., 2013). The composite QI score was calculated using the number of QIs with value 1 (triggered vs. 0: not triggered) divided by the number of observed QIs in the sample. A set of individual QIs were secondary outcome variables. Prevalence-based QIs included behavior problems (high risk and low risk), bladder–bowel incontinence (high risk and low risk), a low body mass index, inadequate pain management, little or no activity, and physical restraint use. Incidence-based QIs were as follows: activities of daily living (ADL) late-loss worsening, locomotion worsening, cognitive decline, communication decline, delirium new or persistent, behavior problem worsening, bowel continence worsening, bladder continence worsening, and pain worsening. All the QIs represent care problems; these QIs were expected to be less likely to occur or to be reduced given good quality care. Trained external assessors with clinical nursing experience rated the participants four times at 3-month intervals and calculated each QI's value three times.

Sample Size

The sample size for a cluster (nursing home) was calculated using the formula of Hemming, Haines, et al. (2015) for incomplete SW-CRCT designs. The expected intervention effect on the primary outcome, the composite score of QIs, was set at $\delta = 0.067$ (control: 0.182, intervention: 0.115) based on an intervention study similar to ours (Boorsma et al., 2011). We took account of both within-cluster and within-resident correlations by adding cluster-specific and resident-specific random effects to the outcome models. The intracluster correlation coefficient (ICC) was assumed to be 0.01 based on Boorsma et al.'s study (2011). The correlation coefficient of repeated measurements was set at 0.25 based on the ratio between the ICC and the correlation coefficient used in the study of Muntinga et al. (2012). Both the ICC and the correlation coefficient were assumed to be fixed across time. Finally, we took account of the fact that the 10 clusters were divided into five groups with two clusters each, and that the groups were randomized in a sequential manner. The calculation was conducted in R software, version 3.2.4. The minimum cluster size required to detect the expected intervention effect with 80% power at the 5% significance level was $n = 45$.

Based on our earlier national nursing home survey study (Kim et al., 2015) and also publicly available data on the characteristics of LTC residents (Korean National Health Insurance Service [KNHIS], 2016), we assumed and accounted for a 15% dropout rate among the recruited residents. We allowed new enrollments when an older adult was newly admitted to a participating nursing home and met our trial criteria. The new enrollment was not only for recruitment purposes but also for a practical purpose: to help participating homes assess and provide care management for their newly admitted residents.

Randomization, Implementation, and Blinding

All 10 nursing homes were randomly assigned to one of the five sequences using a SAS program-generated list of random numbers before patient recruitment started for the first group. The nursing home was the unit of randomization, and simple randomization was performed. The data team director did the randomization independently, and the randomization results were delivered to each home via the SPEC consultant assigned. In this incomplete SW-CRCT study, participating homes were informed of the results of the randomization (the order of allocation) only 1 month before the start of their respective sequence, that is, when the study actually started with patient recruitment, according to the prestratified schedule. The SPEC study was a facility-level intervention, so eligible older residents in the homes were recruited by the research team with the help of the care teams in the homes through flyers and verbal explanations of the study shared with the residents and/or their families. The residents who agreed to participate in the study with written consent, either by themselves or their proxies, were registered in the study by the SPEC consultant, after she confirmed with help from the participating homes that the individuals met the study criteria.

To keep the blinding, the identities of the participating institutions and individuals were registered anonymously in the research database by the data team director. The external assessors were blinded to the study design (e.g., the allocation sequence and the switch from control to intervention period), and the data analysts were blinded to the identifications and the randomization results until the data collection and analyses were done. Neither the identifications nor the randomization results were revealed to the funding agencies. The principal investigator and the SPEC consultant could not be blinded.

Statistical Methods

We did the main analysis based on the intention-to-treat (ITT) principle, which is a conservative approach to examining intervention effects, and include all participants who are randomized regardless of whether or not they comply with the study protocol. This approach can minimize potential bias due to drop out or attrition. As sensitivity analyses, per-protocol analyses were conducted with only participants who completed the study, and these analyses confirmed the results of intervention effects based on the ITT analyses.

The intervention effect on the primary outcome was estimated using a multilevel linear mixed-effects model to account for the hierarchical structure. The intervention effect on each of the secondary outcomes was estimated using a generalized linear mixed-effects model (McCulloch & Neuhaus, 2005). We also performed subgroup analyses by ADL and cognition level to explore subgroup-specific effects of the intervention on the primary outcome. In the fitted analytic models of the primary outcome, the coefficient estimates were equivalent to the absolute change in the QI scores. As for the secondary outcomes, the coefficient estimates were equivalent to the logarithm of odds ratios (ORs). We also computed the percentage change in the composite QI score by dividing the coefficient estimate by the average composite QI score in the control phase (baseline). For individual QIs, we also calculated the percentage change in the number of patients who were triggered (value = 1) for the corresponding QI using the equation provided in the study of Zhang and Kai (1998).

Three random effects at the group, nursing home, and resident levels were applied in all analyses. The group-level random effect was used to adjust for any secular trend effect on the outcome. Both unadjusted and confounder-adjusted analyses were performed. Confounders included age, sex, logarithm of length of stay, cognition measured by the Cognitive Performance Scale (Morris et al., 1994), and physical function measured by the ADL Hierarchy Scale (Morris et al., 1999) of the participants in both the control and intervention periods. The ICC of the outcome was reported based on the confounder-adjusted analyses. We used two-sided p values with a 5% significance level.

The model equations are presented in Supplementary Appendix A, and additional analyses were conducted (Supplementary Appendices B–I). We evaluated time-specific intervention effects at 3 months and 6 months after the beginning of the intervention as well as the time duration effect of the intervention. Sensitivity analyses were also conducted via comparison of the main analysis with both per-protocol analysis and ITT open cohort analysis, the latter including residents who entered after the trial began. If the results show similar trends in all three data sets, we can conclude that the analyses are insensitive to attrition or drop out of the residents.

For each analysis, a statistical test was first conducted to select either a two-level (group and resident levels) or three-level (group, nursing home, and resident levels) mixed-effects model for the analysis. The reported effect estimates are based on the selected models: If the latter (more complicated model) was significant, we reported that one; if not, we reported the simpler former one. All analyses were carried out using R software, version 3.2.4.

Results

Participants and Recruitment

Figure 2 is an overview of the participant flow. A total of 904 participants were recruited in the 10 nursing homes; 92 older residents declined to participate in the study; and 812 were assessed for eligibility, among which 287 residents were excluded due to ineligibility (n = 248) or other reasons such as transfer (n = 39). For the control period, 482 out of 525 cases with an initial measure to compute the incidence-based QIs completed the baseline assessment at the end of the period and joined the intervention; these were valid cases for the ITT analysis. A total of 431 cases had a 3-month follow-up, and 389 completed a 6-month follow-up during the intervention period. The latter became valid cases for per-protocol analyses.

Institutional recruitment proceeded from January to March 2015, and the random assignment of institutions to groups was completed immediately after completion of the recruitment. After we screened for eligible patients in the institutions assigned to the first group, the patients were registered through participation agreement. The first sequence began for the first group in April 2015, and each successive sequence up to the fifth (and final) one started approximately every 3 months thereafter. The control period for the first sequence was somewhat delayed due to a Middle East respiratory syndrome (MERS) epidemic, but it was the control period, so we adjusted for the delay statistically. No other event occurred that affected the scheduled implementation. The baseline characteristics of the participants are summarized in Table 1. The basic characteristics of the participants during the control and intervention periods were similar.

Outcomes and Estimation

Results of the main analysis are given in Table 2. The composite QI score significantly changed in the unadjusted model from 0.230 to 0.211 (a decrease of 8.1%, p < .001). This change is consistent with the change in

Table 1. Basic Characteristics of the SPEC Study

Number of residents	Control period (*n* = 482)	Intervention period (*n* = 431)
Age (mean ± *SD*)	82.7 ± 7.3	83.1 ± 7.5
Female	80.3%	80.9%
ADL[a] (mean ± *SD*)	3.1 ± 1.9	3.2 ± 1.9
Cognition[b] (mean ± *SD*)	2.2 ± 1.3	2.3 ± 1.2

Note: ADL = activities of daily living; SPEC = Systems for Person-centered Elder Care.
[a]ADL was measured by ADL Hierarchy Scale ranging from 0 (independent) to 6 (totally dependent; Kim et al., 2015).
[b]Cognition was measured by Cognitive Performance Scale ranging from 0 (independent) to 6 (totally dependent; Kim et al., 2015).

the confounder-adjusted model, which was from 0.230 to 0.205 (a decrease of 11.1%, $p < .001$). This implies a significant decrease in quality issues. In each analysis, the variance component of the group-specific random effect was insignificant, implying no secular trend effect. The ICC and correlation coefficient estimates based on confounder-adjusted analyses were 0.080 and 0.469, respectively.

As for the secondary outcome analyses, the intervention significantly decreased ADL late-loss worsening (OR = 0.655, 95% confidence interval [CI] = 0.450–0.955), cognitive decline (OR = 0.641, 95% CI = 0.442–0.927), communication decline (OR = 0.538, 95% CI = 0.396–0.731), delirium new or persistent (OR = 0.501, 95% CI = 0.306–0.820), and behavior problem worsening (OR = 0.634, 95% CI = 0.434–0.926). The percent decrease in people with those quality issues was between −31.1% and −44.7%. The intervention effect on bladder–bowel incontinence, a prevalence QI, was positive in the unadjusted model, but the effect became insignificant after covariate adjustments. In each analysis, the variance component of the group-specific random effect was insignificant ($p > .05$), implying no secular trend effect on secondary outcomes.

The 3-month (Period 1) and 6-month (Period 2) time-specific intervention effects were both significant in all analyses and had a similar value to the main intervention effect (Supplementary Appendices B and C). The time duration effect of the intervention was nonsignificant for all of the QIs except the prevalence of behavior problems among the high-risk group (Supplementary Appendix D); this result implies that the intervention effect did not weaken as time passed.

Sensitivity and Subgroup Analyses

Results of the subgroup analyses are given in Table 3. The intervention effect on the composite QI was significant in the subgroups with both moderate (baseline score = 0.293; percent change = −11.3%; $p = .043$) and severe (baseline score = 0.331; percent change = −20.0%; $p = .001$) cognitive impairment as well as the subgroup with severe ADL limitations (baseline score = 0.276; percent change = −10.4%; $p = .006$). The effect size was larger as function was more impaired. The time duration effect of the intervention was nonsignificant in all cases (Supplementary Appendix E).

We assessed the sensitivity of the main analysis via comparison with per-protocol analysis (Supplementary Appendix F) and ITT open cohort analysis (Supplementary Appendix G). Results were consistent in all three data sets, giving evidence that the main analysis was insensitive to attrition and drop out of residents. We also found similar robustness in the results of the sensitivity subgroup analyses (Supplementary Appendices H and I).

Discussion

This study aimed to evaluate the effectiveness of the SPEC, a multidisciplinary, ICT-enhanced integrated care management model, for frail older adults at nursing homes in South Korea. In our theory-based, stepped-wedge randomized clinical trial, we found significant effects of the SPEC on the overall quality of care for older nursing home residents using composite QIs measuring health and functional outcomes, and the results were consistent in subgroup analyses by ADL and cognition level and in the additional analyses in the supplementary appendices as well. The SPEC also had significant effects on several individual QIs, the secondary measures; while adjusting for confounding factors, the intervention prevented ADL late-loss worsening, cognitive decline, communication decline, delirium new or persistent, and behavior problem decline. The results were also quite consistent in various sensitivity analyses.

Although the effects of the SPEC on the primary endpoint was not large, the effects in the first 3 months, when the research team was actively engaged, did not diminish during the next 3 months, when the multidisciplinary team in each home was more likely to take the lead in implementing the SPEC program in their daily practice. While the SPEC intervention did not improve all the various health and functional aspects, it did prevent worsening of several important functional aspects of older residents, such as ADL late-loss worsening, communication decline, and behavior problem decline; these are critical for the well-being of residents as well as meaningful indicators of care quality in the homes. Moreover, the intervention effect was larger among the residents with moderate or severe cognitive and ADL limitations than their counterparts. This is because the former group is more likely to be a challenging group to

Table 2. Main Effect Analysis Using ITT Data Set

Primary outcome	*n*	Baseline score[b]	Unadjusted effect: Estimate[c]	*p* Value	Change (%)[d]	Confounder-adjusted effect[a]: Estimate[c]	*p* Value	Change (%)[d]
Composite QI	482	0.230	−0.019	<.001	−8.05	−0.025	<.001	−11.05

Secondary outcomes	*n*[e]	Baseline score	Unadjusted effect: Odds ratio	95% CI	Change (%)[f]	Confounder-adjusted effect: Odds ratio	95% CI	Change (%)[f]
Prevalence QIs								
Behavior problem	482	0.259	0.818	0.482–1.387	−14.15	0.766	0.431–1.359	−18.45
High risk	372	0.313	0.816	0.456–1.461	−13.42	0.765	0.409–1.429	−17.43
Low risk	153	0.129	0.683	0.214–2.179	−28.78	0.748	0.204–2.738	−22.68
Bladder–bowel incontinence	474	0.577	2.214	1.208–4.057	30.21	1.329	0.661–2.673	11.7
High risk	251	0.883	3.352	1.173–9.577	8.93	2.187	0.653–7.327	6.77
Low risk	250	0.278	1.520	0.658–3.511	32.77	1.018	0.423–2.447	1.29
Low BMI	478	0.264	1.400	0.754–2.599	26.64	1.19	0.594–2.385	13.32
Inadequate pain management	482	0.268	0.820	0.559–1.200	−13.85	0.887	0.585–1.347	−8.53
Little–no activity	479	0.404	0.912	0.600–1.388	−5.44	1.042	0.664–1.637	2.46
Physical restraints use	482	0.073	0.545	0.197–1.507	−43.62	0.52	0.182–1.487	−46.11
Incidence QIs								
ADL late-loss worsening	461	0.143	0.730	0.513–1.039	−24.06	0.655	0.45–0.955	−31.1
Locomotion worsening	335	0.161	0.808	0.540–1.209	−16.62	0.888	0.542–1.455	−9.57
Cognitive decline	471	0.14	0.716	0.506–1.013	−25.44	0.641	0.442–0.927	−32.51
Communication decline	472	0.244	0.580	0.435–0.774	−35.38	0.538	0.396–0.731	−39.36
Delirium new or persistent	472	0.188	0.571	0.360–0.904	−37.89	0.501	0.306–0.82	−44.72
Behavior problem worsening	479	0.133	0.625	0.434–0.901	−34.22	0.634	0.434–0.926	−33.36
Bowel incontinence worsening	316	0.141	0.926	0.605–1.417	−6.42	0.814	0.509–1.303	−16.4
Bladder incontinence worsening	310	0.205	0.707	0.479–1.045	−24.79	0.777	0.51–1.183	−18.58
Pain worsening	482	0.144	0.860	0.620–1.193	−12.23	0.853	0.61–1.191	−12.85

Note: ADL = activities of daily living; BMI = body mass index; CI = confidence interval; ITT = intention-to-treat; QI = quality indicator.
[a]Confounders include age, sex, Cognitive Performance Scale (range 0–6), ADL (range 0–6), and logarithm of length of stay.
[b]The baseline score refers to the population average score of the composite QI in the control period. The value 0.230 means the average ratio of the number of triggered QIs (value = 1) to the number of observed QIs is 0.230 (range: 0–1).
[c]The estimate is equivalent to the absolute change in the composite QI score in our linear model (Supplementary Appendix A). Thus, the composite QI score after the intervention can be computed using the baseline score and the absolute change statistic. For example, the after-intervention composite score in the covariate-adjusted model was 0.205, which can be calculated by 0.230 (baseline score) minus 0.025 (absolute change statistic).
[d]The percent change is the estimate divided by the baseline score in percentage.
[e]We did continuous QI measurements for all eligible cases across all three periods. The reason the valid number of cases varies across individual QIs is because each indicator had different inclusion and exclusion criteria to select relevant cases in computing that indicator (Frijters et al., 2013).
[f]For the individual QIs, the new column represents the estimated percentage change in the number of patients who had value 1 for the corresponding QI, following the approach of Zhang and Kai (1998).

treat effectively during usual care; with limited human and training resources, it can be more difficult for nursing home staff to provide quality care to these residents with complex conditions, which often require more staff time and energy.

To the best of our knowledge, this is the first registered RCT at LTC settings in Korea. Few studies have tested the CCM for people with serious disabilities residing in noncommunity settings, where the roles and competency of care teams are critical for improving the health and well-being of residents through the collaborative implementation of a care model assuring care quality. The results of this study were consistent with Boorsma et al.'s (2011) study of a standardized CGA-based care management program in the Dutch RCFs; the study was a two-arm clustered RCT and also reported significant improvement in participants. However, several differences exist between our and Boorsma's studies. First, compared to the RCF in the Netherlands, the people in our study were likely to be more frail with a higher level of impairment, as the population coverage for the public LTCI in Korea is much lower than that in the Netherlands, and the eligibility for nursing home care reimbursed by the public LTCI was more likely to be

Table 3. Subgroup Analysis of the Main Effect[a]

Outcome	Composite QI *n*	Baseline score	Estimate	*p* Value	Change (%)
Cognition subgroups					
0–2: Intact/mild impairment	350	0.203	−0.009	.190	−4.30
3–4: Moderate impairment	86	0.293	−0.033	.043	−11.27
5–6: Severe impairment/total dependence	41	0.331	−0.066	.001	−19.99
ADL subgroups					
0–2: Intact/mild impairment	181	0.175	−0.010	.289	−5.64
3–4: Moderate impairment	156	0.253	−0.018	.094	−7.32
5–6: Severe impairment/total dependence	140	0.276	−0.029	.006	−10.41

Note: ADL = activities of daily living; QI = quality indicator.
[a]Subgroup analysis was adjusted for age, sex, and logarithm of length of stay. Five cases dropped as they had no valid data for assigning them to a subgroup; the impact of the missing cases was negligible in a sensitivity analysis with an imputed data of the cases (not shown).

strict than that for RCFs. Second, our study setting was a more human resource-limited setting. The public LTCI law requires one nursing staff member per 25 residents (Kim, 2020), so the capacity for assessing and planning nursing care to promote health and functional outcomes was quite limited.

There are several possibilities that may explain the positive outcomes of the SPEC program. First, the intervention study was designed and implemented based on rich and concrete evidence from earlier studies by the research team on the care needs of the target population (Kwon et al., 2013), the challenges facing care staff in delivering health and wellness services (Park et al., 2015), factors associated with several key QIs (Bae et al., 2020; Chun & Kim, 2018; Yoo & Kim, 2016), and also psychometric tests of the assessment tools in the Korean nursing home context (Kim et al., 2013; Lee, Jung, & Kim, 2017). Second, the SPEC, an ICT-enhanced, CGA-based care management intervention, was well targeted and addressed a gap in care: the current lack of health and functional care in public LTCI-funded nursing homes, which mainly deliver assistance in daily living through personal care assistants (KNHIS, 2016). Third, the five components of the SPEC program were carefully designed based on the CCM and its key components (Kim et al., 2017) and were implemented quite well in most of the participating homes (Kim, 2016). Fourth, the roles of the SPEC consultant and the onsite SPEC coordinator team were well designed and executed. Fifth, the SPEC information system's support in coordinating CP and monitoring (Kim et al., 2017) was effective and useful in giving staff a clear picture of the needs of their residents and the services that had been provided.

This study provided solid empirical evidence that a CCM-based, ICT-enhanced integrated care model can be implemented in resource-limited nursing homes with public funding in a non-Western country. Methodologically, the 21-month stepped-wedge CRT with a relatively large sample size was a novel approach in LTC research, and it had several advantages (Keriel-Gascou et al., 2014; Spiegelman, 2016). The design allowed the research team to better manage the trial by rolling it out sequentially to two homes every 3 months in this study. It also enabled us to examine time-specific program effects and within- and between-resident effects. The assurance that all participating homes would receive care in the SW-CRCT was an incentive for nursing homes that were interested in quality improvement to participate in the SPEC study in spite of their high day-to-day operational burdens.

There are also several limitations of the study. The SPEC program was implemented in 10 publicly funded nursing homes in a metropolitan area in Korea, which limits the generalizability of our findings. The inclusion criteria for participants in the participating homes were quite broad, but the profiles of participating and non-participating older residents might not be the same; the people who refused to participate in the study may have been more complex cases in great need of the intervention. Publicly funded nursing homes in Korea are older adults' welfare institutions, so residents are transferred to health care institutions when their conditions are unstable or worsen; this might partially contribute to the positive intervention effect. Some care team members might have positively reported resident conditions when asked externally for their input during data collection. Even so, the SPEC program is still likely to be effective in supporting the care team in nursing homes to identify and transfer residents who have a risk of worsening health or functional conditions. Due to limitations in funding and other resources, we adopted an incomplete SW-CRCT and carefully adjusted cluster, seasonal, and secular trend effects and correlations among repeated measurements from the same resident statistically; there could be bias, however, due to a lack of measures. The program was implemented in a real practice setting, so the implementation period and the switch between the control and intervention terms may have been about 1 or 2 weeks shorter or longer across the homes if more urgent operational situations came up.

Conclusions

The SPEC is the first structured, complex intervention tested by an RCT in Korea, and it improved the quality of nursing home care measured by QIs in various functional domains of older residents, the main policy agenda in LTC in Korea and beyond. This study suggests the SPEC program, a structured multidisciplinary approach to CGA-based care management using ICT, was effective in health care-limited public nursing homes in a non-Western country. SPEC's synergetic five components (Kim et al., 2017) were effective, and it was well implemented through data-driven feedback to the participating care teams regarding their CP and execution as well as through the critical role of the SPEC consultant as a coach for the implementation process (Kim, 2016). Further study is needed with a larger scale of implementation to advance the generalizability of the current study, in which the selection of more targeted residents and QIs might have led to larger effects. As the components of the SPEC program are quite universal, the SPEC program has the potential to be slightly modified and adapted in home- and community-based settings. It is recommended to apply the SPEC program to less frail populations than nursing home residents and test improvement in the health and well-being of the populations.

Supplementary Material

Supplementary data are available at *The Gerontologist* online.

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Conflict of Interest

None declared.

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