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The effect of a comprehensive mobile application program (CMAP) for family caregivers of home-dwelling patients with dementia: A preliminary research

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Abstract

Aim: The purpose of this study was to evaluate the effect of a comprehensive mobile application program in managing behavior and psychological symptoms of home-dwelling patients with dementia in South Korea.

Methods: A nonequivalent control group pretest-posttest design was conducted. A total of 26 family caregivers participated in this study. The application program consists of understanding of dementia, interventions, communication skills, coping methods, and bulletin boards. Data collection was performed from July 9, 2018, to October 4, 2018. Family caregivers' fatigue, sleep, and burden and patients with behavioral and psychological symptoms of dementia were measured. For data analysis, descriptive statistics, independent t tests, Mann–Whitney U test, repeated measures analysis of variance, and Friedman test were used.

Results: The application program offered environmental management in an intervention using communication skills and coping methods, depending on the behavioral and psychological symptom type. The results showed significant differences between the two groups in family caregivers' fatigue (F = 11.24, $p = .003$) and burden ($\chi^2 = 10.55$, $p = .005$).

Conclusion: The findings showed the application program improved family caregivers' fatigue and burden. It also suggested there is a need to develop a wandering persons location program to improve family caregivers' stress and patients' behavioral problems in future studies.

KEYWORDS
aggression, caregivers, dementia, mobile application

1 | INTRODUCTION

Dementia is a representative geriatric disease, and the rapid aging of the world's population has resulted in a rapid increase in the number of patients with dementia. The

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population of the elderly over 65 years accounted for 14.3% of the total population in South Korea in 2018 (Statistics Korea, 2018). The number of the elderly under home care services is 545,025, which is about seven times the number of the elderly under facility care service (81,399). Additionally, a large proportion, about 27%, of the elderly under home care services were patients with dementia as of 2013 (Ministry of Health and Welfare, 2013).

Patients with dementia show diverse health problems such as behavioral psychological symptoms including agitation, aggression. Given that behavioral psychological symptoms have a negative impact on the health and quality of life of not only patients themselves but also caregivers, it is an important care problem that must be improved for not only patients but also family caregivers (Ornstein & Gaugler, 2012). For family caregiving on BPSD (behavioral and psychological symptoms of dementia), the number of patients taking medications, the rate of use of medical services, and the family burden have increased in the face of a lack of expert knowledge and worsening patient symptoms (Bass et al., 2012). Thus, it is necessary to systematically provide appropriate programs for families of patients with dementia to prevent increase of their problems.

Although direct care was being provided to patients to improve their BPSD until recently, research is being conducted to provide care intervention to the families to identify BPSD effects because BPSD also causes health problems for family caregivers. In a study by Lee and Kim (2017), the authors provided education on dementia, quiz, role play, and so on and they reported improvement effects on awareness of dementia, burden of care, and depression. Whitebird et al. (2012) provided education on dementia (legal and financial issues, community resources, communication, self-care, grief and loss) and stress reduction intervention (mindfulness, practiced meditation and gentle yoga exercises). They showed improvement effects on stress and depression. However, because the intervention contents are mainly focused on understanding the general care content, communication, community resources, and legal/financial issues of dementia, they have limitations for managing BPSD.

Furthermore, most intervention application methods consist of conducting lectures and providing educational booklets. Because main family caregivers must control their care schedules by the intervention time, this can cause secondary burdens (Lewis, Hobday, & Hepburn, 2010). To reduce secondary burdens of care and use the time of family caregivers effectively, other countries are using web or app-based programs that allow people to obtain appropriate information (Ducharme, Dubé, Lévesque, Saulnier, & Giroux, 2011). However, currently, there are an insufficient number of such programs for the families of patients with dementia in Korea.

A few mobile applications related to dementia do exist in Korea. First, "Dementia Check" was developed by National Institute of Dementia Korea for patients and family caregivers (Central Dementia Center, 2017) and it includes useful information, dementia risk check, caregiving service, guides to respond to wandering person

scenarios, and guides for overcoming dementia together. However, it is limited in its understanding the BPSD of patients with dementia, which is the main cause of burden for family caregivers. In particular, information on understanding BPSD by the symptom and response method is insufficient, and an application that provides such information is needed.

Based on the limitations of previous studies, a comprehensive program through which main family caregivers can understand dementia, identify management methods of BPSD, and adopt appropriate response methods for BPSD that involve smooth communication is necessary for main family caregivers to manage the BPSD of patients with dementia. If this program can be offered in a mobile application form, allowing intervention contents to be efficiently used depending on individual schedules, improvements in BPSD and family burden may be anticipated.

BPSD functions as a stress factor for main family caregivers (Ornstein & Gaugler, 2012) and frequent behavior psychological symptoms not only hinder main family caregivers' sleep but also increase their fatigue (Simpson & Carter, 2013) and long-term continuation increases burden (Onishi et al., 2005). Such stress, fatigue, inefficient sleep, and burden of main family caregivers can make them respond inappropriately when caring for patients, ultimately further increasing patients' BPSD (Kunik et al., 2010). Therefore, it is necessary to develop a comprehensive mobile application program (CMAP) for the management of BPSD for main family caregivers to reduce BPSD and identify the effect on main caregivers' stress, fatigue, sleep, and burden.

2 | METHODS

2.1 | Study design

This study is a preliminary research using a non-equivalent control group pretest-posttest design and uses a CMAP for the management of BPSD for main family caregivers (experimental group) and handbooks for the control group to test the differences in the effects between the two groups with the passage of time.

2.2 | Sample and setting

The study was conducted on main family caregivers who care for home-dwelling patients with dementia in D City. A total of 18 participants from four facilities (six from Facility A, four from Facility B, four from Facility C, and four from Facility D) agreed to participate in this

research. Specific selection criteria were as follows: (a) those who have cared for home-dwelling patients with dementia for more than 6 hours per day for at least 1 month; (b) those who have cared for 60-year-old patients with dementia who show behavior psychology symptoms more than once per week in accordance with the Korean Neuropsychiatric Inventory (K-NPI); (c) those who have a personal smart phone with internet and can use an application program; and (d) those who understand the purpose of this research and agree to participate in this research.

One of the inclusion criteria was family members who have cared for a dementia patient at home for more than 6 hours per day for at least 1 month. This criterion was based on the study by Lee, Seo, and Ahn (2003) on stress and depression of primary family caregivers, where the period for the primary family caregiver to perceive stress was set as 1 month.

Furthermore, the exclusion criteria for were as follows: (a) those who were diagnosed with psychiatric illnesses by a psychiatrist; (b) those who had illnesses that could affect saliva cortisol levels; and (c) those who experienced life events such as the death of a spouse, divorce, or separation within the last 6 months.

The basis of selecting the number of participants was calculated using the G Power 3.1 program. When F-test power of .80, significance level of α .05, effect size of .30, and three measurements (one pretest, two posttests) were applied, it was calculated that 10 participants per group or a total of 20 were needed. Considering a drop-off rate of 30%, a total of 26 participants or 13 per group participated. The choice of .30 as the effect size in our study was based on the fact that the effect size was .30 in research by Finkel et al. (2007) which applied a web-based dementia education program on main family caregivers of home-dwelling patients with dementia. In the duration of the study, a total of one subject in the experimental group (change in the place of living) and one subject in the control group (change from home care to a care facility) were dropped, resulting in a total subject drop-off rate of 7.7%.

2.3 | Ethical considerations

We started data collection after receiving approval from the institutional review board of K University (40525-201801-BR-104-03). The researcher explained information such as the purpose of research, participation procedures, dangers and benefits of participation, guarantee of privacy, and termination of research at any time with no negative consequences to the participants. After the participants voluntarily agreed to participate in the research and gave written consent, data collection was started. The researcher explained that participants may terminate the research at any time with no negative consequences.

2.4 | Theoretical framework for a CMAP

The theoretical framework of this study was established based on Kale's theoretical framework of reasons and management of BPSD (Kales, Gitlin, & Lyketsos, 2015). Kales et al. (2015) reported that the causes of BPSD were comprised of patient factors, caregiver factors, and environmental factors, that these factors make the patients vulnerable to stress, and that increased stress affects BPSD and health problems of the caregivers. For improvement in behavior psychology symptoms, these factors must be included as major factors of intervention. Therefore, our CMAP was established to include information about the purpose of this research and about patients with dementia to improve patient factors; about methods of communication with patients with dementia, about drug and non-drug treatments, and about response methods to improve caregiver factors; and finally about environmental management methods to improve environmental factors. The specific contents are as shown in Figure 1.

2.5 | Interventions

2.5.1 | A CMAP development

The experimental program in our study is a CMAP provided to primary family caregivers. A CMAP was developed following Vithani and Kumar's (2014) mobile application development stages. In the first stage (identification), we reviewed domestic and foreign previous research to establish the items of a CMAP and included the seven areas of understanding of dementia, drug treatments, non-drug treatments, environmental management, communication skills, methods of response to each symptom, and a bulletin board. In the second stage (design), we designed the functions necessary for all the items and the structure of the application and conducted the storyboard development and flowchart of the application based on the defined requested functions. In the third stage (development), we developed the user interface design and developed a prototype of a reactive web. When a CMAP is run for the first time, the first screen presents the major areas. For subject registration, we had each subject log-in using an ID and a password. A logo and an icon for the moving screen were placed. In the
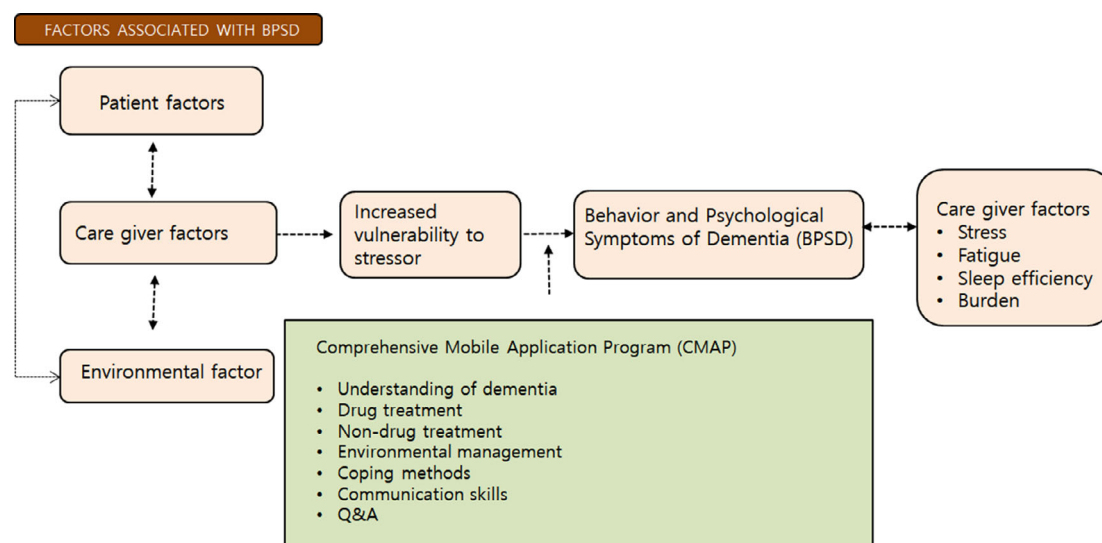
FIGURE 1 Conceptual framework. BSPD, behavioral and psychological symptoms of dementia

fourth stage (prototyping), we conducted the process of checking the differences in things such as screen size, image, and font size. No special error was found from the perspective of the user. Thus, the second CMAP was completed. In the fifth stage (evaluation), evaluation was conducted by an expert (one professor of nursing informatics, three computer science experts, and one digital media designer) and user evaluation (five medical personnel and five main family caregivers). After a revision based on these results, a CMAP was finalized.

2.5.2 | A CMAP (experimental group)

A CMAP was applied to the experimental group. The contents of the CMAP included: (a) understanding of dementia (purpose of research and understanding of dementia); (b) interventions (drug treatment, non-drug treatment, and environmental management); (c) communication skills (understanding of cause, positive attitude, and attitude and manner); (d) coping methods; and (e) bulletin boards (Q&A, news and announcements, schedule) (Figure 2). Drug treatment consisted of drug treatment type, precautions of drug treatment. Non-drug treatment consisted of music, art, reminiscences, aroma hand massage, walking outside. Environmental management consisted of provision of a safe environment, an environment that provides appropriate stimulation. Coping methods included the response methods based on the cause, delusion and hallucination, aggression and anxious behavior, wandering, and asking for help.

A researcher visited the home of each subject to obtain written consent, conduct a pretest, and simply explain how to use a CMAP. Participants used a CMAP freely whenever they wished for 4 weeks. The previous studies regarding the interventions using the application tool reported that the 2 weeks of intervention was enough to increase the outcomes (Chiu et al., 2009; Davis, Nies, Shehab, Shenk, & Alfonzo, 2014). That is why this study used the 4 weeks of intervention using the application. When the family caregivers want to know the "communication skills", they clicked the "communication skills" and reviewed the "understanding of cause", "positive attitude", and "attitude and manner" as soon as they want to review. The researcher called the participants one time per week for 5 min to answer participants' questions about care and prevent subject drop-off. Throughout the phone call, the application use was monitored and the participant was educated to use more than one time a week by the Principal Investigator (PI).

2.5.3 | Handbook (control group)

For the control group, the researcher visited the home of each subject to obtain written consent, conduct a pretest, and simply describe the handbook. Participants used the handbook freely whenever they wished for 4 weeks. The contents of the handbook and the method of the phone calls by the researcher were identical to those used for the experimental group.

2.6 | Outcome measures

Measurements of the main family caregivers included subject characteristics, stress, fatigue, sleep and burden.

FIGURE 2 The contents of comprehensive mobile application program

Measurements of patients with dementia included behavioral psychology symptoms. Participants' characteristics included age, gender, religion, marital status, education, housing type, employment, monthly income, health status, relationship with the patient, number of family members living together, duration of caregiving, caregiving hours, experience receiving education on dementia, grade of long-term care, and use of long-term care facilities.

2.6.1 | Stress

Stress was measured based on saliva cortisol levels. Fifteen minutes before collecting saliva, participants were asked to rinse their mouths with water and were banned from artificially stimulating saliva production or eating food. In our study, the collection of saliva cortisol occurred between 4 p.m. and 6 p.m. to minimize variance by time. Saliva was collected by having the participants

spit 2–3 mL into a sample collection tube. The researcher transferred the collected samples by storing them in a mobile refrigerator. The samples were stored frozen in a −20°C freezer until examination. To ensure that saliva samples were collected at the same time of day, the researcher provided the participants with a tube for sample collection with clear instructions to collect the saliva sample in the tube and freeze it between 4–6 p.m., even if the questionnaire was not administered between 4–6 p. m. Saliva examination was conducted by D Examination Agency. Samples were analyzed with an enzyme-linked immunosorbent assay method using a cortisol parameter assay kit (R&D System Inc., Minneapolis, MN, USA). The normal saliva cortisol levels ranged from 0.76 to 2.94 ng/ mL (Cummings et al., 1994). In this study, a high saliva cortisol level, which is a physiological indicator of stress, indicates high stress.

2.6.2 | Fatigue

Fatigue was measured using the Revised Piper Fatigue Scale developed by Piper et al. (1998) and translated by Sohn (2002). This tool is comprised of a total of 22 items: behavioral/severity (six items), affective meaning (five items), sensory (five items) and cognitive/mood (six items). Each item is indicated on a score of zero to 10. The total score ranges from zero to 220, with a higher score indicating higher fatigue. Cronbach's α values were .97 at the time of development, .87 in Sohn's (2002) research, and .95 in our study.

2.6.3 | Sleep

In our study, sleep was measured using sleep efficiency based on Lee (2003). Sleep efficiency was calculated using bed time, wake-up time, and awakening after sleep onset based on the sleep log-in the previous week. Sleep efficiency refers to the percentage of actual length of night-time sleep relative to the length of night-time sleep. Length of night-time sleep is measured from the time of entering sleep (time at which sleep was first started at night) to the time of waking up (time of waking up in the morning). Actual length of night-time sleep is the length of night-time sleep subtracted by time spent awake. A higher calculated value indicates a higher sleep efficiency.

2.6.4 | Burden

Burden of support was measured using the Burden Inventory developed by Zarit, Reever, and Bach-

Peterson (1980) and translated and revised by Kwon (1996). This tool consists of a total of 28 items on a five-point scale from "never" (one point) to "very true" (five points). The possible range of scores in this tool is from 28 to 140, with a higher score indicating a higher burden. Cronbach's α value was .91 at the time of its development by Zarit et al. (1980), .96 in the research by Kwon (1996), and .91 in our research.

2.6.5 | BPSD

Behavior psychology symptoms were measured using K-NPI, which is a Korean version of the NPI developed by Cummings et al. (1994) and translated by Choi et al. (2000). The primary family caregiver's BPSD was measured for 1 week. This tool consists of a total of 12 items. The score on each item is calculated by multiplying the frequency and severity of each item. Frequency is measured on a four-point scale ranging from "less than once per week" (one point) to "daily or continuously" (four points), whereas severity is measured on a three-point scale ranging from "mild" (one point) to "severe" (three points). The range of scores is from zero to 144, with higher score indicating more severe behavior psychology symptoms. Cronbach's α value was .85 at the time of its development by Choi et al. (2000) and .72 in our research.

2.7 | Data collection procedures

The researcher contacted 12 elderly care facilities in D City to recruit main family caregivers who cared for home-dwelling patients with dementia. The researcher personally visited eight facilities that allowed visitation and explained the purpose and content of the research to the head of each facility. Among these, four facilities offered opportunities to explain the purpose and content of the study to the participants. The researcher explained the purpose, method, and procedure to the main family caregivers of patients with dementia who use the four facilities. A total of 18 participants (six from Facility A, four from Facility B, four from Facility C, and four from Facility D) agreed to participate in this research. However, to meet the minimum sample size, the researcher obtained approval to visit one neurology clinic in G City. The researcher explained the purpose and content of the study to the main family caregivers of patients with dementia, and eight participants agreed to participate in this study (18 users of elderly care facilities and eight patients in a neurology clinic). Ultimately, 13 participants were assigned to the experimental group (10 from elderly

care facilities and three from a neurology clinic), and 13 participants were assigned to the control group (eight from elderly care facilities and five from a neurology clinic). The assignment method was as follows: those who could use applications were assigned to the experimental group, whereas those who could not were assigned to the control group.

Data collection occurred for 3 months from July 9, 2018, to October 4, 2018. The data collection process was performed solely by the researcher. Pretests were conducted by the researcher prior to the start of the program on the characteristics, stress, fatigue, sleep, and burden of the primary family caregiver and the BPSD of the person with dementia at each home. Posttests were also conducted using the same method as the pretest at the homes of the participants. Times of measurement for both groups occurred immediately after the termination of the program and 2 weeks after the termination of the program for a total of two times. The rationale of measuring the follow-up test 2 weeks after the termination of the program was based on the research method of a previous study (Yoo & So, 2014) which conducted the follow-up test 2 weeks after the termination of the family caregiver program. The investigation method was as follows: family caregivers were primarily asked to answer. The researcher helped the subject answer if they had difficulty indicating their responses because of physical difficulties. Saliva measurement was conducted immediately after the questionnaires were administered.

2.8 | Data analysis

The data collected in this research was analyzed using SPSS Window Version 21.0 program (IBM Corp., Armonk, NY, USA). The specific analyses methods were as follows. (a) The characteristics of the participants were analyzed using frequency, percentage, mean, and standard deviation. (b) To test the homogeneity of the experimental and control groups, stress and fatigue were analyzed using t test, chi-square test, and Fisher's exact test, while sleep, burden, and BPSD were analyzed using Mann–Whitney U test. (c) Repeated measures analysis of variance (ANOVA) was used for stress and fatigue, and Friedman test was used for sleep, burden, and BPSD analyses.

3 | RESULTS

3.1 | Participants' characteristics and homogeneity test

The findings of the participants' characteristics and homogeneity test between the experimental group and

control group are presented in Table 1. In the experimental group, more than half of them were female (66.7%), Christian/Catholic (58.3%), married (83.3%), college graduation or above (58.3%), and living in an apartment (66.7%). Participants had monthly incomes below 2 million won (66.7%), good health status (58.3%), and were the child of patients with dementia (58.4%), and duration of caregiving was 39.08 ± 5.92 months. Participants' caregiving was 6 hours (75.0%), no experience receiving education on dementia (58.3%), and using long-term care facilities in the type of day-and-night care (83.3%).

In the control group, more than half of them were female (50.0%), Buddhist-Atheist (75.0%), married (83.3%), high school graduation or below (83.3%), and living at home (66.7%). Participants had having monthly incomes below 2 million won (100.0%), average or good health status (83.4%), and were children of patients with dementia (83.4%), and duration of caregiving was 24.00 ± 4.61 months. Those participants' caregiving was more than 7 hours per day (66.7%), no experience receiving education on dementia (66.7%), and using long-term care facilities in the type of day-and-night care (66.7%). There was no significant difference in participants' characteristics between the two groups.

3.2 | Dependent variables and homogeneity test

The findings of dependent variables and homogeneity test are presented in Table 2. There was no significant difference in dependent variables prior to CMAP between the two groups.

3.3 | Differences in dependent variables between experimental and control groups with the passage of time

3.3.1 | Stress, fatigue, sleep, burden and BPSD

Differences in dependent variables between the experimental group and control group with the passage of time are presented in Table 3.

3.3.2 | Family caregiver

For the experimental group, family caregivers' stress increased from 1.56 ± 0.63 before the program to 2.19 ± 2.05 immediately after the program but decreased to

TABLE 1 Participants' characteristics and homogeneity test (N = 24)

Characteristic (unit)	Categorization	Experimental group (n = 12)n (%) or mean ± SD	Control group (n = 12)n (%) or mean ± SD	χ^2/t	p
Age (years)		54.50 ± 3.71	61.00 ± 6.42	16.00	.191[a]
Sex	Male	4 (33.3)	6 (50.0)	0.69	.408[b]
	Female	8 (66.7)	6 (50.0)		
Religion	Christian or Catholic	7 (58.3)	3 (25.0)	2.74	.214[b]
	Buddhist or atheist	5 (41.7)	9 (75.0)		
Marital status	Married	10 (83.3)	10 (83.3)	0.00	>.999[b]
	Widowed or unmarried	2 (16.7)	2 (16.7)		
Education	High school graduation or below	5 (41.7)	10 (83.3)	4.44	.089[b]
	College graduation or above	7 (58.3)	2 (16.7)		
Housing type	House	4 (33.3)	8 (66.7)	2.68	.220[b]
	Apartment & multiplex	8 (66.7)	4 (33.3)		
Employment	Yes	6 (50.0)	6 (50.0)	0.00	>.999[b]
	No	6 (50.0)	6 (50.0)		
Monthly income	Below 2 million won	8 (66.7)	12 (100.0)	4.80	.093[b]
	Above 2 million won	4 (33.3)	0 (0.0)		
Health status	Good	7 (58.3)	5 (41.7)		
	Average	3 (25.0)	5 (41.7)	0.83	.659[a]
	Bad	2 (16.7)	2 (16.6)		
Relationship with patient	Spouse	1 (8.3)	1 (8.3)		
	Child	7 (58.4)	10 (83.4)	2.33	.312[a]
	Daughter-in-law	4 (33.3)	1 (8.3)		
Number of family members living together		3.58 ± 0.34	3.50 ± 0.34	6.34	.096[a]
Duration of caregiving (months)		39.08 ± 5.92	24.00 ± 4.61	11.33	.332[a]
Caregiving hours (hr/day)	6 hr	9 (75.0)	4 (33.3)	4.20	.100[b]
	More than 7 hr	3 (25.0)	8 (66.7)		
Experience receiving education on dementia	Yes	5 (41.7)	4 (33.3)	0.18	.673[b]
	No	7 (58.3)	8 (66.7)		
Grade of long-term care	3≤	6 (50.0)	9 (75.0)	1.60	.400[b]
	≤4	6 (50.0)	3 (25.0)		
Use of long-term care facilities	Day-and-night care	10 (83.3)	8 (66.7)	4.44	.089[b]
	Visitation care and support for medication costs	2 (16.7)	4 (33.3)		

[a]Chi-square test.
[b]Fisher's exact test.

1.86 ± 0.96 2 weeks after the termination of the program. For the control group, stress increased from 1.57 ± 0.80 before the program to 3.00 ± 2.44 immediately after the program but decreased to 1.81 ± 1.18 2 weeks after the termination of the program. Results of conducting a repeated measures ANOVA to test the difference in stress between the two groups with the passage of time showed no statistical significance.

For the experimental group, fatigue decreased from 95.42 ± 34.23 before the program to 81.25 ± 40.48 immediately after the program and to 66.08 ± 34.49 2 weeks after the termination of the program. For the control group, fatigue increased from 73.97 ± 35.21 before the program to 78.50 ± 37.64 immediately after the program but decreased to 76.25 ± 36.17 2 weeks after the termination of the program. Results of preforming a repeated

measures ANOVA to test the difference in stress between the two groups with the passage of time showed statistical significance (F = 11.24, p = .003).

For the experimental group, sleep remained similar from 89.78 ± 12.58 before the program to 89.03 ± 18.12 immediately after the program and increased to 91.57

TABLE 2 Dependent variables and homogeneity test (N = 24)

Variables	Experimental group (n = 12) mean ± SD	Control group (n = 12) mean ± SD	t/U	p
Family caregivers				
Stress	1.56 ± 0.63	1.57 ± 0.80	−.045	.492[a]
Fatigue	95.42 ± 34.23	73.67 ± 35.21	1.53	.794[a]
Sleep	89.78 ± 12.58	87.30 ± 19.23	0.37	.126[b]
Burden	74.17 ± 17.69	63.58 ± 19.6	1.41	.594[b]
Patients with dementia				
Behavioral and psychological symptoms of dementia	19.83 ± 18.85	22.75 ± 16.85	−0.40	.767[a]

[a]t test.
[b]Mann–Whitney U test.

± 18.26 2 weeks after the termination of the program. For the control group, sleep increased from 87.30 ± 19.23 before the program to 92.26 ± 14.67 immediately after the program and to 95.29 ± 6.94 2 weeks after the termination of the program. Results of preforming a Friedman test to test the difference in sleep between the two groups showed no statistical significance.

For the experimental group, burden decreased from 74.17 ± 17.69 before the program to 57.92 ± 13.64 immediately after the program and to 53.92 ± 18.32 2 weeks after the termination of the program. For the control group, burden remained similar from 63.58 ± 19.06 before the program to 64.42 ± 16.42 immediately after the program and decreased to 58.08 ± 17.30 2 weeks after the termination of the program. Results of performing a Friedman test showed a statistically significant difference in the burden of the experimental group with the passage of time (χ^2 = 18.17, p < .001).

3.3.3 | Patients with dementia

For the experimental group, patients' BPSD decreased from 19.83 ± 18.85 before the program to 17.17 ± 13.48 immediately after the program and continuously decreased to 15.75 ± 15.53 2 weeks after the termination of the program. For the control group, the BSPD

TABLE 3 Differences in dependent variables between experimental and control groups with the passage of time

Variable	Group	Pretest Mean ± SD	Posttest 1 Mean ± SD	Posttest 2 Mean ± SD	Source	F/χ^2	p
Family caregivers							
Stress	Experimental group (n = 12)	1.56 ± 0.63	2.19 ± 2.05	1.86 ± 0.96	Group	0.39	.540
	Control group (n = 12)	1.57 ± 0.80	3.00 ± 2.44	1.81 ± 1.18	Time	1.26	.273
					Group×time	0.15	.902
Fatigue	Experimental group (n = 12)	95.42 ± 34.23	81.25 ± 40,48	66.08 ± 34.49	Group	0.11	.748
	Control group(n = 12)	73.67 ± 35.21	78.50 ± 37.64	76.75 ± 36.17	Time	7.37	.013
					Group × Time	11.24	.003
Sleep[a]	Experimental group (n = 12)	89.78 ± 12.58	89.03 ± 18.12	91.57 ± 18.26		2.69	.261
	Control group (n = 12)	87.30 ± 19.23	92.26 ± 14.67	95.29 ± 6.94		0.25	.882
Burden[a]	Experimental group (n = 12)	74.17 ± 17.69	57.92 ± 13.64	53.92 ± 18.32		18.17	<.001
	Control group (n = 12)	63.58 ± 19.06	64.42 ± 16.42	58.08 ± 17.30		0.30	.862
Patients with dementia							
Behavioral and psychological symptoms of dementia[a]	Experimental group (n = 12)	19.83 ± 18.85	17.17 ± 13.48	15.75 ± 15.53		2.65	.266
	Control group (n = 12)	22.75 ± 16.85	25.58 ± 26.85	18.00 ± 19.96		3.30	.192

Note: Posttest 1: immediately after the termination of the program. Posttest 2: 2 weeks after the termination of the program.
[a]Friedman test.

increased from 22.75 ± 16.85 before the program to 25.58 ± 16.42 immediately after the program and decreased to 18.00 ± 19.96 2 weeks after the termination of the program. Results of performing a Friedman test to test the difference in BPSD between the two groups showed no statistical significance.

4 | DISCUSSION

In this study, we applied a CMAP for the management of BPSD on main family caregivers who care for home-dwelling patients with dementia and evaluated its effect on the BPSD of patients with dementia and the stress, depression, fatigue, sleep, and burden of main family caregivers.

A CMAP in this study is significant in that we developed the tool to provide real-time support for families caring for patients with dementia. A CMAP provides information in an application form so that families can receive detailed training on response methods for each symptom. To improve upon the app, main family caregivers can report the inappropriate methods they use because they have little information about response methods to BPSD and because their understanding and experience of the response methods to BSPD are lacking (Ornstein & Gaugler, 2012). Most existing programs for main family caregivers to improve BPSD of patients with dementia are related to understanding the concept of dementia, prevention of dementia, day-to-day life care, and stress management (Lee & Kim, 2017).

Furthermore, similar existing programs have been conducted in places like health clinics, senior centers, and dementia centers, making this a factor that increases family burden because they have to make time to visit these places. A CMAP applied in our research does not require moving locations and can be used at any time. It is significant that a program does not require caregivers to be apart from the patient. Information technology like web or app-based programs can help main family caregivers who have been caring for home-dwelling patients with dementia for a long time to respond to care needs appropriately and reduce their burden (Elvish, Lever, Johnstone, Cawley, & Keady, 2013). Intervention through the internet or smart phone is a method that has easy spatiotemporal approachability and allows for efficient care of patients because caregivers can participate while individually caring for patients at home. Therefore, it may be one of the most important care intervention methods for home-dwelling patients with dementia and their families.

At the time of developing a CMAP, the results of reviews of previous research on delusion and hallucination, aggressive behavior, anxious behavior, and wandering were severe. BPSD of patients with dementia can cause main family caregivers to experience discomfort when caring for the patients (Matsumoto et al., 2007). Response methods to these symptoms were discussed in detail in the CMAP. However, the home-dwelling patients with dementia included in our study showed symptoms such as depression and apathy more frequently, although they did show behaviors such as aggressive behavior, anxious behavior, delusion, and hallucination. Main family caregivers also reported problems with these symptoms. Therefore, when developing an application for main family caregivers of patients with dementia in the future, it is necessary to examine, in detail, the BPSD of home-dwelling patients with dementia and build a program in accordance with the results.

The statistically significant results of testing the differences in the fatigue of main family caregivers between the experimental and control groups showed that these differences change with time as trends change. Although direct comparison is difficult because there were no previous studies that measured the effect of the use of applications by family caregivers of patients with dementia on fatigue, our results are in line with those of Trop, Hanson, Hauge, Ulstein, and Magnusson (2008), which reported differences in problems between an experimental group of dementia patients' caregivers, who were provided a web-based program and a control group. In the case of main family caregivers who used a CMAP, they immediately resolved problems related to patients that occurred in the duration of the intervention using the Q&A approach. Immediate problem-solving is thought to have reduced the fatigue of family caregivers compared to the unidirectional transfer of knowledge such as a handbook.

Testing the differences between the experimental group and control group in the sleep of the main family caregivers who used the CMAP obtained no statistically significant results. Although both groups improved their sleep, no major differences between the two groups were found. This is in line with Callan et al. (2016), who found no differences in sleep between the control group and experimental group, who both used, for 4 weeks, an application training program for spouses of patients with dementia. In the case of sleep of main family caregivers, not only BPSD of patients with dementia but also various exogenous variables, such as the health condition of the main family caregiver, home environment, and caring schedule played a role (Simpson & Carter, 2013). Thus, measuring the pure effect that a CMAP has on the sleep of main family caregivers is difficult, and there are limitations in generalizing the results of this study.

However, because the CMAP and the handbook helped improve sleep in both groups, management methods such as a CMAP can be considered to improve the sleep of home-dwelling patients with dementia in the future. Furthermore, we had the main family caregivers complete a sleep log each day in our study to measure sleep efficiency. However, completion of sleep logs is a self-reported evaluation method that is completed based on one's memories and may have low accuracy. Therefore, when testing effects on sleep in future research in this area, an effort to objectively evaluate the results of an intervention using measurement tools such as ActiGraph (ActiGraph, Pensacola, FL, USA) may be necessary.

Results of testing the burden of main family caregivers in the experimental and control groups showed that the differences in trends in changes by time in the experimental group were statistically significant. This is similar to the report by Chiu et al. (2009), who found a significant difference in burden between the control group, for which a handbook was applied, and the experimental group, for which an internet program was applied, on the families of patients with dementia. In our study, the burden of the experimental group before intervention gradually reduced from immediately after the intervention to 2 weeks after the intervention. The burden of the control group before intervention also gradually reduced from immediately after the intervention to 2 weeks after the intervention, but the change in the experimental group was larger. The greater reduction in burden in a CMAP format is similar to the results in previous studies where conducting immediate problem-solving and management using an application when problems with the patient arise reduce the burden of participants (Davis et al., 2014). In cases where patients with dementia are diagnosed or show BPSD, the burden of the families appears to be high. As such, it is necessary to apply management methods to the families to meet their demands using various methods such as applications.

The results of our research showed that BPSD before the intervention in both groups were lower than the reported BPSD of Gang et al. (2016), which measured BPSD in patients with dementia who live in facilities using the same tool. Even when considering that the BPSD of home-dwelling patients with dementia is lower than that of patients with dementia in facilities, the occurrence of their night-time behaviors hinders the sleep and care schedule of their family caregivers. Thus, they can be considered behaviors that must be appropriately managed. The CMAP developed in our study focused on managing delusion, hallucination, aggressive and anxious behavior, and wandering based on previous studies, and thus its contents related to managing night-time behavior were insufficient. When developing an application for the family caregivers of home-dwelling patients with dementia in the future, it will be necessary to include contents for the management of night-time behavior.

This study developed a CMAP for the management of BPSD of home-dwelling patients with dementia and tested its effects by applying it to main family caregivers. Based on the results, a CMAP can be used by nurses in practical settings such as dementia safety centers or adult day care center to manage BPSD and for main family caregivers to solve problems such as stress, fatigue, sleep, and burden. This study has some limitations. First, because participants who could use an application program were assigned to the experimental group, subject selection bias was possible. Additionally, the final sample size was small, so there were limitations in interpreting the results of this study. In addition, it will be necessary to obtain more participants from various locations to measure the effects of intervention using a randomly assigned research design for future studies. Second, the results of our research after program intervention showed there were no differences between the experimental and control groups in BPSD or the stress and sleep of main family caregivers. It may be necessary to measure these factors by considering the characteristics of the participants through in-depth analyses in future studies. Finally, the medication uses related to stress or sleeping were not measured as the extrinsic variable in this study so that those extrinsic variables need to be controlled for futures studies.

For further studies, certain symptoms of BPSD need to be managed and measured according to the subjects' characteristics because the symptoms of BPSD vary. In addition, because the frequency of using the application by participants were not measured in this study, it needs to be measured to see the participants' stress level of using the application and determine the appropriate frequency of using the application without stress in future studies. Nevertheless, our study is significant in that it systematically built and applied a theoretical basis for a CAMP among main family caregivers who cared for patients with dementia so that they could use it to manage BPSD.

5 | CONCLUSION

This study is a preliminary study using a nonequivalent control group pretest-posttest design and applied a CMAP among main family caregivers for the management of BPSD of home-dwelling patients with dementia to test its effects. When the CMAP was applied to main family caregivers who cared for patients with dementia in South Korea, there

were statistically significant effects on fatigue and burden compared to the control group (which used handbooks). Reduction in fatigue and burden can be anticipated when applying this program to the main family caregivers of patients with dementia in care settings. Because the CMAP was not found to have an effect on the stress and sleep of main family caregivers or the BPSD of patients with dementia in our study, it is necessary to strengthen various contents of the CMAP when developing such an application in the future. Finally, based on long-term research on the results of applying a program for the management of BPSD of home-dwelling patients with dementia, an observational study to improve their symptoms is necessary.

CONFLICT OF INTEREST

No potential conflict of interest has been declared by the authors.

AUTHOR CONTRIBUTIONS

This authorship statement confirms that the listed authors meet the authorship criteria and that all authors agree with the content of the manuscript.

Study design: P.H. and P.E. Data collection and analysis: P.E. Writing manuscript and approval for the final submission: P.H., P.E., and K.E.K.

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