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Five-year survival rate among older adults participating in the national geriatric screening program: A South Korean population-based cohort study

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ABSTRACT

Introduction: This study aimed to assess the health benefits of a geriatric screening program comprising of physical function tests, screening questionnaires for depression and cognitive impairment, and bone mineral density measurements for women as a part of the National Screening Program for Transitional Ages (NSPTA). We compared the all-cause mortality between subjects who did and did not participate in the screening program.

Methods: This was a nationwide longitudinal study with a 5-year follow-up based on a 10% sample of the National Health Insurance beneficiaries aged 60 years and older. Mortality records were obtained from the qualification dataset in the elderly cohort database of 2005–2013 provided by the National Health Insurance Service. A Cox proportional hazards model was used to analyze the mortality risk. We sampled 11,986 subjects each in the screened (intervention) and non-screened (control) groups after exact matching using propensity score.

Results: After adjusting for demographic and socioeconomic characteristics (age, sex, household income, smoking, alcohol drinking, physical activity, body mass index, and the Charlson Comorbidity Index), all-cause mortality rates were found to be significantly lower (a) in the intervention group compared to the control group (hazard ratio = 0.73; 95% confidence interval: 0.65, 0.82) and (b) among women compared to men (hazard ratio = 0.50; 95% confidence interval: 0.44, 0.56). Lower hazard ratios were also observed among those with a higher body mass index, fewer comorbidities, and higher income.

Conclusion: A nationwide geriatric screening program might be helpful in reducing the incidence of premature deaths among older people.

1. Introduction

The number of older people has been increasing globally due to prolonged life expectancy, which also accounts for the rapidly rising healthcare expenditure (World Health Organization, 2015). In South Korea, which is projected to attain the highest average life expectancy by 2030 among the 35 industrialized countries (Kontis et al., 2017), the concept of healthy or active aging, defined as the maintenance of functional independence in late life, has increasingly gained attention as an important public health agenda (Fernández-Ballesteros, Robine, Walker, & Kalache, 2013; World Health Organization, 2015; Beard and Bloom, 2015). Functional decline is a hallmark of the geriatric syndrome and contributes to the disproportionate use of health services and long-term care (Leng, Chen, & Mao, 2014; Tinetti, Inouye, Gill, & Doucette, 1995). However, the deterioration in function, such as reduced leg strength or slowing walking speed, could be an early sign of progression to irreversible disability and is unlikely to be detected without regular screening and monitoring (Wolinsky, Stump, Callahan, & Johnson, 1996).

To address the need for the early detection and management of functional decline, a nationwide geriatric screening program, as a part of the National Screening Program for Transitional Ages (NSPTA), was initiated in 2007 (Kim, Shin, Lee, Kim, & Cho, 2012a; Kim, Shin, Lee, Kim, & Cho, 2012b). The conventional health screening program

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launched in 1995 had several limitations, including ineffective follow-up care, lifestyle modifications and screening for target diseases, which often did not reflect the subjects' physiologies (H. Kim et al., 2012, 2012b). To address these limitations, the NSPTA was initially set to screen people who turned 40 and 66 years of age, which were considered to be the transitional periods in one's life. The geriatric component of the NSPTA for those aged 66 years was developed not only to assess and prevent the risk factors of the geriatric syndrome, but also to promote healthy and active aging (Cho & Lee, 2011; Kim, Lee, & Cho, 2010). This was driven by the increasing recognition of the importance of early detection of frailty among older people. Older people with frailty are at a significant risk of falls, delirium, and immobility even after a seemingly small event such as a minor infection or administration of a new medication (Turner & Clegg, 2014).

The geriatric screening program is modeled after the comprehensive geriatric assessment (CGA) and is primarily composed of physical function tests, screening questionnaires for depression and cognitive impairment, and bone mineral density measurement for women (Kim et al., 2010, 2012, 2012b). Bone mineral density (BMD) is measured in women to screen for the risk of osteoporotic fracture. BMD decreases rapidly after menopause in women due to hormonal changes, while in men the risk of the osteoporotic fractures increases at the age of 70 years and above. Therefore, BMD measurement is not included for men in the NSPTA because of its low benefits in preventing osteoporotic fractures. All participants who undergo primary screening are invited to a secondary screening, which is followed by counseling by a physician on lifestyle modifications regardless of the results of the primary screening. On the basis of the overall results of the primary screening, the primary care physicians counsel or provide appropriate care, including prescription based on the clinical guidelines for NSPTA (Kim, et al., 2012a, 2012b; Kim, 2008) (Supplement 1). For example, individuals with two or more falls during the last 6 months or with abnormal records on the (a) Timed Up and Go test ($\geq$20 s) or (b) unipedal stance test ($\leq$5 s) are evaluated with a physical and neurological examination. Additionally, their occupational and residential environments are assessed in depth. The government currently spends more than US$ 5 million annually on the National Geriatric Screening Program (Korean National Health Insurance Service, 2016).

The health benefits of such functional assessments and management have been reported for those acutely hospitalized or the frail elderly (Rubenstein, Siu, & Wieland, 1989; Van Craen et al., 2009). In a systematic review, a lower rate of institutionalization was demonstrated 1 year after discharge (odds ratio (OR) = 0.78, confidence interval (CI) = 0.66–0.92; P = 0.003) in the intervention group (Van Craen et al., 2009). Moreover, in a meta-analysis (Rubenstein et al., 1989), a significant (36%) reduction in the 6-month mortality rate was reported in the intervention group of inpatients (OR = 0.64; 95% CI = 0.50 - 0.83). Since hospitalization can further compromise the older person with decreased functional capabilities, due to acute medical distress and change in the environment, the intervention helps avoid irreversible disabilities and death. However, its effect when implemented on a wider scale, such as among the older population living in the community, is unclear. In a short-term follow-up study, the health benefits of the intervention might not be apparent in community-dwelling, relatively healthy older individuals, compared to the hospitalized older population. There appear to be some short-term benefits of the NSPTA screening, such as inducing positive behavioral changes following brief counseling sessions (Cho, 2013; Son et al., 2017). However, the long-term health effects of geriatric screening, such as on mortality, have not been studied, especially on a nationwide scale. In this study, we aimed to examine differences in the 5-year all-cause mortality based on the participation in the National Geriatric Screening Program.

2. Materials and methods

2.1. Data source

Data were obtained from the elderly cohort database of 2005–2013, managed by the National Health Insurance Service in South Korea (Lee, Lee, Park, Shin, & Kim, 2017). This database was developed by sampling 10% of health insurance subscribers and Medicare recipients aged 60 years and older, excluding foreigners. From the register of the national health insurance, those eligible as of the end of December 2002 were randomly sampled. The elderly cohort database is composed of several datasets, including those for qualifications, treatment, and medical check-ups. Data for demographics, socio-economic status, and mortality records were obtained from the qualification dataset, and Charlson Comorbidity Index (CCI), indicating chronic health conditions was calculated using the major and minor list of diagnostic codes in the treatment dataset. In addition, the medical history of hospitalizations, medical expenses and use of long-term facilities was also determined by using the treatment dataset. Information related to physical measurements and health behaviors was obtained from the medical check-up dataset.

2.2. Study design

This longitudinal study was designed to target individuals born in 1941–1942, and who were eligible to participate in the National Geriatric Screening Program in 2007–2008. However, those who (a) did not undergo the national primary health check-up during the baseline year of 2005–2006, (b) had any records of hospitalizations, (c) used long-term facilities, or (d) died during the washout period (2005–2008) were excluded from the study. Exclusion criteria were set to reduce the confounding effects of institutionalization indicating severe health conditions that would increase the mortality rate and decrease the participation rate in the national screening program. The enrolled population was classified into two groups based on whether or not they participated in the geriatric component of the NSPTA, including the physical function tests. In each group, we matched the fundamental characteristics known to affect all-cause mortality including demographics (sex, age), health behaviors (smoking, physical activity), comorbidities (CCI), and socio-economic status (household income). The matched population that participated in the screening program was defined as the intervention group, while those who did not comprise the control group. The follow-up period was from January 1, 2009, to December 31, 2013.

2.3. Measurements

We assessed demographic and socioeconomic factors including sex, age, household income, and health-related behaviors such as smoking, drinking, and physical exercise patterns. Household income assessed by the national health insurance premium was classified into income quintiles from the lowest to the highest. For smoking patterns, participants who reported that they had smoked fewer than 100 cigarettes during their lifetime were classified as non-smokers, while those who had smoked 100 cigarettes or more were classified as current smokers or past smokers based on whether they currently smoked or not (Schoenborn, Adams, & Peregoy, 2013). For drinking patterns, participants rated the number of times they had consumed alcohol recently (over 60 g of pure alcohol each time for men and over 40 g for women) (World Health Organization, 2000). Those who consumed alcohol more than twice a week were classified as heavy drinkers and the others as non- or light drinkers (Prevention, K. C. F. D. C. a., 2014). Physical activity was assessed by asking how often the participants engaged in physical exercise for more than 30 min, with mild to moderate intensity or more than 20 min with high intensity during the last week. Participants who answered 3 times and more to the questions regarding

physical activity were defined as the physically active group and others as the inactive group (Bull, Maslin, & Armstrong, 2009; Oh, Yang, Kim, & Kang, 2007).

2.4. Statistical analysis

The CCI score was calculated using 1 major and up to 11 minor disease codes recorded in the National Health Insurance database. Exact matching was carried out using the propensity score, in which binary logistic regression was applied for making predictions based on age, sex, smoking, physical activity, household income, and CCI that were defined as explanatory variables. Using the package "MatchIt" in R version 2.1.5 (The Comprehensive R Archive Network, http://cran.r-project.org), both the intervention and control groups were matched, and data were extracted using the exact matching function. The Mann-Whitney *U* test and Pearson's chi-squared test were used to compare the baseline characteristics and the accumulated cost of medical expenses after matching between the two groups. After confirming that the log-minus-log survival plots showed no evidence of non-proportionality, with the Schoenfeld residuals test revealing no violation of the proportional hazards assumption ($P = 0.15$), the Kaplan-Meier analysis and Cox proportional hazard regression analyses were used to evaluate the survival rates using SPSS version 19.0 (IBM Corp., Armonk, NY, USA).

2.5. Ethical considerations

In accordance with Articles 18, 19 and 25 of the Basic Health Insurance Act, all patients partaking in the national health screening program filled out the 'Consent Form for Follow-up Management of Health Check-ups.' The study protocol was approved by the Ethical Committee of the Institutional Review Board of Ajou University Hospital (AJIRB-MED-EXP-17-355). The need for informed consent was waived due to the retrospective nature of the study and the anonymity of the data after de-identification.

3. Results

Of the 83,292 individuals born in 1941–1942, subjects who did not undergo the national primary health check-up at baseline (n = 30,347) and those with any record of hospitalization during 2005–2008 (n = 12,036) were excluded. Eligible subjects (Supplement 2) were classified into an intervention group (n = 21,070) and a control group (n = 19,839) based on their participation in the NSPTA. Finally, the participants included in the analysis were sampled by exact matching in each group of 11,986 (Fig. 1).

Table 1 shows that exact matching worked well with no differences in the baseline characteristics of the variables (age, sex, smoking, physical activity, household income, and CCI) between the two groups. In both groups, the mean age of the participants was 64.7(± 0.46) years with 52.7% of them being women. Among the participants, 17.5% were in the lowest quintile group for the national level of household income, while 28.5% were in the highest quintile group. The prevalence of current, past and non-smoking were 14.6%, 3.2%, and 79.3%, respectively in both groups. About a quarter of the participants in each group exercised three times or more per week. Also, regarding alcohol consumption, body mass index (BMI) and CCI, no significant differences were observed between the intervention and control groups at the baseline (Table 1).

The mean follow-up duration was 57.7 (± 6.8) months. During that period, medical expenses were significantly lower in the intervention group (US$ 6642) compared with that in the control group (US$ 6754) in our study ($P < 0.001$). At the end of the follow-up, 482 (4.0%) participants in the intervention group were deceased compared to 654 (5.5%) in the control group (log-rank test, $P < 0.001$). The Kaplan-Meier survival curve indicates that there were significantly more deaths in the control group, compared with those in the intervention group (Fig. 2).

The hazard ratio for mortality in the intervention group was 0.73 (95% confidence interval: 0.65–0.82), after adjusting for confounders (Table 2). Additionally, the mortality rate among women was half that of men (hazard ratio = 0.50; 95% confidence interval: 0.44–0.59). Lower household income was associated with an increased risk of deaths. Current smokers had 1.75 times higher mortality risk, compared with non-smokers ($P < 0.001$). Low BMI and high CCI scores were associated with a significantly increased risk of death ($P < 0.001$).

4. Discussion

To the best of our knowledge, this retrospective cohort study is the first to assess the objective health effects of national geriatric screening by evaluating the incidence of mortality among older adults dwelling in the community. We found that the National Geriatric Screening Program provided health benefits in terms of reducing mortality in older adults. Crude 5 year-survival rates for the control and intervention groups in this study were 94.5% and 96.0%, respectively. The 5-year all-cause mortality was reduced by 27% (95% CI = 18% − 35%) in the group that participated in the NSPTA at the age of 66 years, compared with the control group, after adjusting for demographic (age, sex), socio-economic (household income), and health-related (smoking, alcohol drinking, physical activity, BMI, CCI) factors.

These findings are consistent with those of other studies that reported that screening provides an opportune moment to improve patients' health literacy and motivate adherence to healthy lifestyles (Cox et al., 2003; Son et al., 2017). Son et al. (2017) reported that lifestyle changes, especially smoking cessation, were observed among older adults after NSPTA, while other responses varied depending on the conditions of the participants. These results support the idea that behavioral changes after the intervention could have been responsible for the decrease in all-cause mortality. In our study, the hazard ratio for all-cause of death was significantly higher in the current smokers when compared with the non- and past-smokers. Therefore it can be inferred that the NSPTA contributed to reducing the all-cause mortality by decreasing the risk of death among smokers. Moreover, NSPTA might have also influenced other modifiable factors associated with mortality such as BMI and CCI, thereby reducing all-cause mortality. However, further studies on the association between time-dependent habitual changes and death rate among participants are required to confirm these findings.

In terms of the total health expenditure during the follow-up period, participation in the NSPTA could possibly be associated with a reduction in the healthcare cost. In spite of a longer duration of follow-up, the intervention group spent approximately US$ 112 less on medical expenses. However, we cannot attribute the difference in the medical expenses to only the economic benefits of the NSPTA; other essential factors including indirect costs and benefits in the scope of health expenditure should be considered to determine the cost effectiveness of the NSPTA. Following this study, medico-economic analysis of cost-utility for the NSPTA could contribute to supporting an efficient national screening system by providing practical evidence.

Considering the potential health benefits of mass screening (Deutekom et al., 2010; Imperial Cancer Research Fund OXCHECK Study Group, 1995; Thomassen, Bakketeig, & Krohn, 1983), it is conceivable that the National Geriatric Screening Program would not only identify those at high risk of frailty and functional decline but would also be conducive to raising awareness to the importance of health-promoting behaviors. In Germany, a 20% reduction in mortality and a 22% lower risk of nursing-home admissions were shown in the CGA group compared with the usual care among 1620 community-living persons aged 70 years or older (Frese, Deutsch, Keyser, & Sandholzer, 2012). Previous reports have shown some positive health benefits of NSPTA in older people (Cho, 2013; Son et al., 2017). Older women who

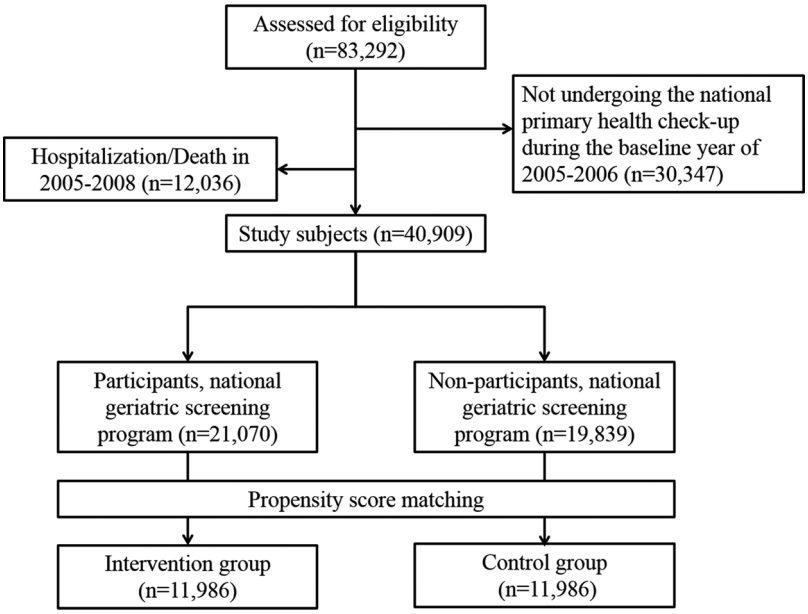

Fig. 1. Flowchart of participant inclusion in the study.

Table 1
Participant characteristics at the baseline (2005–2006): propensity score-matched pairs.

Characteristics	Control group (n = 11,986)	Intervention group (n = 11,986)	P[b]
Age (years)	64.7 ± 0.46	64.7 ± 0.46	1.00
Women, n (%)	6,320 (52.7)	6,320 (52.7)	1.00
Household income, n (%)			
5th quintile (highest)	3,417 (28.5)	3,417 (28.5)	1.00
4th quintile	2,895 (24.2)	2,895 (24.2)	
3rd quintile	1,904 (15.9)	1,904 (15.9)	
2nd quintile	1,671 (13.9)	1,671 (13.9)	
1st quintile (lowest)	2,099 (17.5)	2,099 (17.5)	
Smoking status, n (%)			
Non-smokers	9,502 (79.3)	9,502 (79.3)	1.00
Past smokers	738 (3.2)	738 (3.2)	
Current smokers	1,746 (14.6)	1,746 (14.6)	
Alcohol Consumption,[a] n (%)			
Non- or light drinkers	10,722(89.8)	10,698(89.5)	0.39
Heavy drinkers	1,214(10.2)	1,256(10.5)	
Physical activity, n (%)			
Inactive group	2,898 (24.2)	2,898 (24.2)	
Active group	9,088 (75.8)	9,088 (75.8)	1.00
BMI (kg/m^2)[a]	24.17 ± 3.03	24.19 ± 2.96	0.75
CCI (scores)	1.06 ± 1.22	1.06 ± 1.22	1.00

Values are presented as mean ± standard deviation or frequency (percentage).
BMI: Body mass index; CCI: Charlson comorbidity index.
[a] Participants with missing values were excluded from the analysis.
[b] P value was calculated using analysis of variance and Pearson's chi-squared test.

participated in the NSPTA, compared with non-participants, the rate of hospitalization for hip fractures was 17% lower while the frequency of outpatient clinic visits for osteoporosis was 35% higher (Cho, 2013). The odds of smoking cessation were also higher in the 66-year-old participants than non-participants, sustained two years after the one-time counseling (Son et al., 2017). Participation in tests of functioning included in the NSPTA for older people, such as the Timed Up and Go test and the unipedal stance test that are known to predict frailty and the risk of falls (Michikawa, Nishiwaki, Takebayashi, & Toyama, 2009; Shumway-Cook, Bauer, & Woollacott, 2000), might have contributed to the prevention and better management of these geriatric conditions. However, geriatric assessment targeting the community-dwelling elderly is not always recommended because of the requirement for considerable resources, such as time, manpower, organization, and money (Iliffe and Orrell, 2006). Frese et al. (2012), however, have reported on the cost-effectiveness of geriatric screening at a community level by demonstrating a decrease in all-cause mortality lasting over six years in the elderly aged 70 years or older. Burton et al. (1995) and Burton, German, and Shapiro (1997) while examining the effects of annual preventive visits to primary care physicians by US Medicare beneficiaries that involved physical examination and optional counseling over a two-year period, found a modest but significant improvement in health status (measured by the Quality of Well-Being Scale) and greater use of some preventive services (Pap smear and rectal exam). However, no significant changes in health behaviors related to smoking, alcohol drinking, and sedentary lifestyle were observed (Burton et al., 1995; 1997). The health benefits, however, were not sustained two years after cessation of the program. The different contents of the screening programs might have led to varied responses in the two populations. Whereas the screening program in Burton et al. (1995, 1997) did not include tests of functioning, the participants of this study underwent physical function tests, possibly raising awareness to the importance of maintaining functional status. Further studies, however, are required to identify potential mechanisms underlying the prevention of premature deaths by performing the geriatric screening.

Our results on other baseline factors affecting mortality such as sex, household income, BMI, smoking, alcohol drinking, and comorbid status (CCI) were consistent with those of previous studies (Ibarra-Castillo et al., 2018; Jee et al., 2006). However, the frequency of physical exercise was not significantly associated with mortality after adjusting for all covariates, unlike other studies (Table 2) (Deutekom et al., 2010). This could be that the questionnaire used in this study assessed the physical activities among participants during the preceding week, a relatively short period to reflect one's health behavior. Alternatively, the strength of the association could be reduced due to adjusting for other factors possibly associated with physical activity, including CCI or BMI, although no significant interactions were observed with the frequency of physical activity.

This study has several limitations that need to be considered when interpreting the findings. The age of the participants when they participated in the baseline studies before the NSPTA was 64.7 (± 0.46)

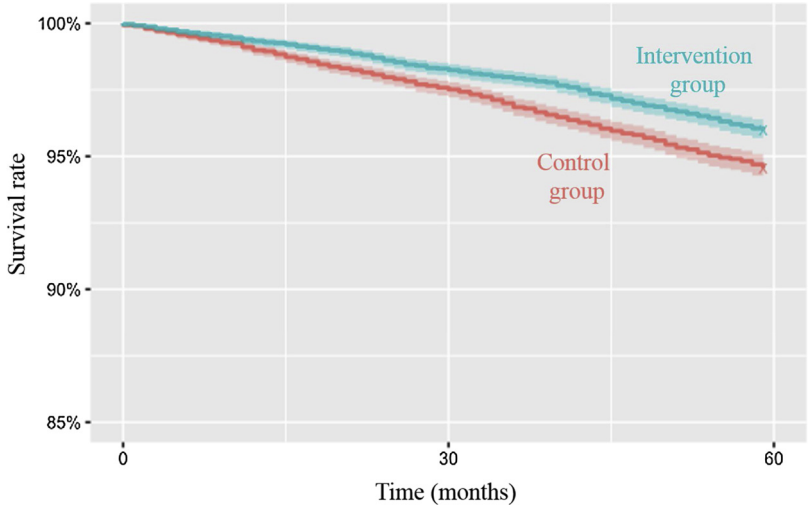

Fig. 2. Kaplan-Meier survival curves of the intervention and control groups.

Table 2
Risk of death in the intervention group who participated in the National Geriatric Screening.

	HR	95% CI		P
		Lower	Upper	
Intervention Group	0.73	0.65	0.82	< 0.001
Age (years)	1.13	0.93	1.28	0.069
Women	0.50	0.44	0.59	< 0.001
Household income				
4th quintile	1.25	1.05	1.45	0.012
3rd quintile	1.30	1.08	1.57	0.007
2nd quintile	1.45	1.2	1.76	< 0.001
1st quintile (lowest)	1.45	1.21	1.74	< 0.001
Smoking status				
Past smokers	1.16	0.92	1.46	0.22
Current smokers	1.75	1.51	2.02	< 0.001
Alcohol Consumption				
Heavy drinkers	0.94	0.79	1.12	0.45
Physical activity				
Active group	1.11	0.96	1.28	0.15
BMI (kg/m^2)	0.95	0.94	0.97	< 0.001
CCI (scores)	1.15	1.1	1.2	< 0.001

BMI: body mass index; CCI: Charlson Comorbidity Index; HR: hazard ratio; CI: confidence interval.

years, which could be regarded as a relatively young age to predict the 5-year mortality rate, especially given that the average life expectancy in Korea is nearly 80 years (Salomon et al., 2012). Although the differences in the survival rates between groups were assumed to depend on the types of diseases (Supplement 3), additional analysis based on specific causes of death was not feasible because of the small number of incident cases among the participants. To assess the various effects of the national screening on the specific types of diseases, it would be necessary to obtain data with a longer follow-up or a larger sample size.

Second, the results of this study cannot be generalized to other populations because of the sampling method of exact matching by propensity score. Matching was done to exclude confounding effects due to differences in the characteristics of the participants and non-participants. However, because unhealthy individuals or those with low health literacy tend to be less likely to undergo health screening, the sampled population might be in better health compared with the general population. The population in this study was more likely to be healthier than the general population because we selected subjects who had participated in the national examination more than once during 2005–2006 and were without a history of hospitalization during the washout period. According to the population census conducted by the Korea National Statistical Office every five years, the population aged 67 years was 376,102 in 2010, and the number of people aged 72 years was 350,517 in 2015. In summary, the 5-year survival rate of elderly individuals aged 67 years in 2010 was about 93.19% in Korea. The survival rates of the control and intervention groups in this study were 94.5% and 96.0%, respectively, and the survival rate of the group included in the study was higher than the overall survival rate regardless of the group classification. Therefore, the intervention effects are greater when the high-risk population requiring improvements are included, and the positive effects of the Geriatric Screening Program observed in this study might thus be an underestimation because of the relatively healthier subjects. Third, because whether the subjects participate in the NSPTA was not assigned by randomization, the results of our study cannot fully rule out the confounding effects of the subjects' health literacy despite the strictly defined inclusion criteria. However, we believe that the effects of the difference in the health literacy between the two groups have not significantly influenced our results, as health-related behaviors such as smoking and physical activities as well as the CCI, which are generally dependent on health literacy, were exactly matched between the two groups (Berkman, Sheridan, Donahue, Halpern, & Crotty, 2011; Pleasant, Cabe, Patel, Cosenza, & Carmona, 2015). Finally, the residual confounding cannot be ruled out due to the lack of variables, especially clinical indicators such as the severity of chronic diseases, medication adherence, and family history, because the health insurance database used in this study was developed for administrative purposes. Further, because the NSPTA at 66 years was a one-time screening event, any changes in the functional status and health behaviors of the study population could not be assessed. To evaluate the mechanisms of decreasing mortality after NSPTA in the elderly, future studies considering compliance and post-screening management among participants would be required.

5. Conclusions

This study supports the health benefits of a nationwide mass screening for functional status among community-dwelling older people. The results of this population-based longitudinal study suggest that early detection and monitoring of geriatric risk factors as one enters a late-life transitional stage may help to prolong survival.

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Appendix A. Supplementary data

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