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Age, sex, and the association of chronic kidney disease with all-cause mortality in Buddhist priests

An analysis of the standardized mortality ratio from the Korean Buddhist priests cohort

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Abstract

Buddhist priests lead a unique lifestyle, practicing asceticism, with a vegetarian diet. Such behavior may have an impact on clinical outcomes. Hence, we explored the mortality among Korean Buddhist priests as compared with the general population.

This study is a single-center, retrospective study. Among the 3867 Buddhist priests who visited Dongguk University Gyeongju Hospital between January 2000 and February 2016, 3639 subjects were available for mortality data from Statistics Korea. Standardized mortality ratio (SMR) was computed for all causes of death and compared with the general population using national statistics in Korea. Information regarding end-stage renal disease (ESRD) was investigated from the Korean Society of Nephrology registry. Among the 3639 patients, the baseline laboratory results were obtained in 724 patients. Chronic kidney disease (CKD) was defined as dipstick proteinuria ≥1 or an estimated glomerular filtration rate <60 mL/min/1.73 m^2.

The mean age was 50.0 ± 12.5 years, and 51.0% were men. During the follow-up period for 31.1 ± 35.6 months, 55 (7.6%) patients died. During the follow-up period, 3 (0.4%) and 23 (3.2%) patients developed ESRD and urinary stone, respectively. The SMR for all causes of death was 0.76 (95% confidence interval [CI] 0.57–0.99; men 0.91, 95% CI 0.65–1.23; women 0.52, 95% CI 0.28–0.87). Among 724 patients, 74 (10.2%) patients had CKD. The SMR for non-CKD patients (0.61, 95% CI 0.43–0.85) was significantly lower than the general population. Female and patients older than 50 years (0.74, 95% CI 0.55–0.98) had a significantly lower SMR. In the Cox proportional hazards model with adjustment, older age (adjusted HR 1.04, 95% CI 1.10–1.07) and presence of CKD (adjusted HR 2.55, 95% CI 1.07–6.06) were independently associated with increased all-cause mortality.

Buddhist priests and especially Buddhist priests without CKD showed a significantly lower mortality compared with the general population.

Abbreviations: CI = confidence interval, CKD = chronic kidney disease, DM = diabetes mellitus, eGFR = estimated glomerular filtration rate, EMR = electronic medical record, ESRD = end-stage renal disease, HR = hazard ratio, ICD = international classification of disease, KCD = Korean standard classification of disease, MDRD = the four-variable modification of diet in renal disease study, RRT = renal replacement therapy, SD = standard deviation, SMR = standardized mortality ratio.

Keywords: Buddhist priests, chronic kidney disease, mortality, vegetarian

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1. Introduction

Buddhist priests are committed to ascetic practices and to maintain a different lifestyle than the general population. As such, they are expected to have a different health profile than the general population.[1,2] Studies on religion and its relationship to health have typically been influenced by the proportion of that religious group within the overall population in a country. Studies on Buddhism and health are the most prevalent in Asia, especially in Thailand,[2–4] where 95% of the population are Buddhists.[5] Contrastingly, only 22% of Koreans identify themselves as Buddhists.[6] It is estimated that there would be 250,000 Buddhist priests in Thailand.[5] Several data from Thailand revealed that Buddhist priests have increased risk of diabetes,[3] obesity, hypertension, and hyperlipidemia.[4] However, there is no sufficient data, as there lacks a nation-wide survival rate of Buddhist priests in Thailand.

In South Korea, 22% of the entire population associate themselves with Buddhism[7]; among them, 70% are part of the Jogye Order, which is the largest sect of Buddhism in Korea. There are 13,576 Buddhist priests in the Jogye Order as of 2009.[6] There are 2444 Buddhist temples, 7155 men Buddhist priests, and 6421 women Buddhist priests in Korea. However, as in the case of Thailand, there is no national survival data on Buddhist priests to date in Korea.

Buddhist priests keep a vegetarian diet for religious reasons; and to date, there has been insufficient data regarding the direct health impact from keeping such a vegetarian diet on the kidney and the survival rate in East-Asian population. The so called, "Korean temple food," which is usually characterized by avoidance of animal origin food except dairy product, 5 pungent vegetables, alcohol, and highly processed food[8,9] has been hypothesized to have a different effect on health-related outcomes compared with the Western-style vegetarian diet. Korean vegetarians have a tendency to higher carbohydrate intake than Western-style vegetarian diet. However, Lee et al[8,10] showed that carbohydrate intake of women Buddhist priests was lower than catholic nuns. Buddhist priests lead a quite disciplined lifestyle, practicing asceticism, and at the same time, they also maintain various type of vegetarian diet. Vegetarian diets have been known to be associated with health-related advantages with respect to chronic diseases, such as diabetes,[11] hypertension,[12] and chronic kidney disease (CKD).[13] Such benefits would be assumed to result in a decrease in the overall mortality in Korean Buddhist priests, similar to the findings from a Japanese Buddhist priest study.[14]

In this study, we aimed to provide comprehensive data of health-related outcomes using the standardized mortality ratios (SMR) of Buddhist priests as compared with the general population in Korea. Moreover, we also tried to evaluate the renal outcomes for starting renal replacement therapy (RRT), such as hemodialysis and peritoneal dialysis, and urinary stone incidence among the Buddhist priests.

2. Methods

2.1. Study population

A retrospective study was conducted with subjects who visited Dongguk University Gyeongju Hospital (Gyeongju-si, Korea) between January 2000 and February 2016. Dongguk University was founded by the Jogye Order of Korean Buddhism. Among the 3867 subjects who visited our institution, the mortality data were available from Statistics Korea in 3639 subjects (Fig. 1). The mortality data were extracted until December 2014. The information of patients who underwent RRT, such as hemodialysis and peritoneal dialysis, have been registered in the Korean Society of Nephrology registry.[15] RRT information was

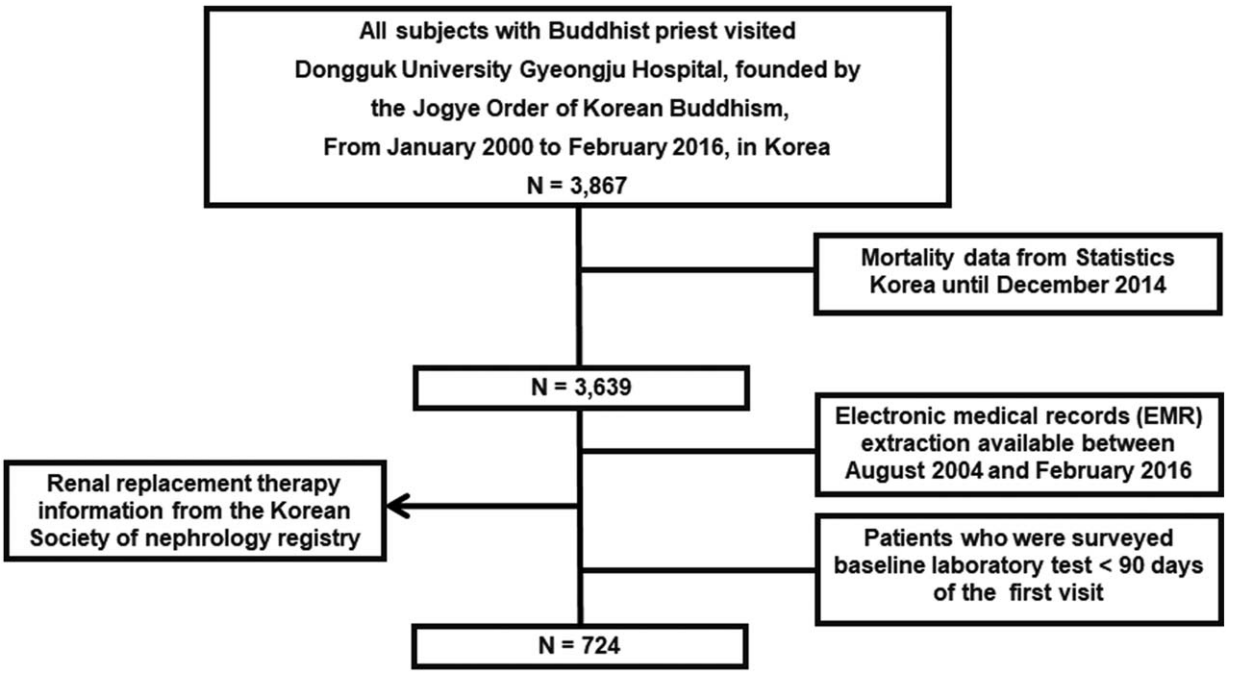

Figure 1. Subjects in the study analyses. All Buddhist priests visited Dongguk University Gyeongju Hospital, which was founded by the Korean Buddhism sect, Jogye Order, between January 2000 and February 2016 were evaluated. The mortality data were extracted from a data set of Statistics Korea until December 2014. Renal replacement therapy data were extracted from the Korean Society of Nephrology registry. Among the 3639 patients, the baseline laboratory test results (within 90 days from the first visit), including renal function, were obtained in 724 patients.

extracted from this registry. Our institution's electronic medical record (EMR) extraction was available only after August 2004. Among the 3639 patients with available mortality data, the initial laboratory test was conducted within 90 days from their first visit in 724 patients. We performed analyses of their characteristics and mortality in these 724 patients to minimize missing data.

2.2. Ethical issues

The study design was approved by the Institutional Review Board of Dongguk University Gyeongju Hospital (no. 110757–201604-HR-05–02). The study protocol was in accordance with the principles of the Declaration of Helsinki.

2.3. Clinical data collection and laboratory evaluations

The baseline clinical characteristics and laboratory values of the study subjects were extracted from EMR. The estimated glomerular filtration rate (eGFR) was estimated using the 4-variable modification of diet in renal disease (MDRD) study equation, via age, sex, race, and serum creatinine level.[16] Diabetes mellitus (DM) was defined as having a previous diagnosis of DM or the use of anti-diabetic medication (oral hypoglycemic agents or insulin). Hypertension was defined as having a previous diagnosis of hypertension or the use of anti-hypertension medication. Dyslipidemia was defined as having a previous diagnosis of dyslipidemia or the use of anti-dyslipidemic medication. Presence of urinary stone was defined as having a previous diagnosis of urinary tract stone or previous stone removal procedure, or presence of urinary tract stone on radiologic images (simple x-ray, ultrasound sonography, computed tomography, or pyelography).

2.4. Outcome measurement

The primary outcome was all-cause of death. We obtained the mortality data from Statistics Korea using a unique identifier. The mortality data were extracted until December 2014. Subjects without a follow-up at our institution and without an official report of death did not meet the primary end point at the time of closing the database. The causes of death were extracted according to the Korean Standard Classification of Diseases (KCD) code. The KCD system adopted, with modification, the International Classification of Diseases (ICD) system presented by World Health Organization to accommodate the situation in Korea. The incidence of end-stage renal disease (ESRD) and urinary stone development was evaluated.

2.5. Statistical analyses

Categorical variables were evaluated using the Chi-square test or Fisher's exact test, and presented as frequencies and percentages. Continuous variables were analyzed with student *t*-test. The Kolmogorov–Smirnov test was used to analyze the normality of the distribution of parameters. Results are presented as the mean ± standard deviation (SD) for normally distributed variables. SMR was used to compare between the Buddhist priest cohort and the general population, where the mortality rate among the general population was calculated using the Statistics Korea for years 2000 to 2014 life table (accessed at Korean Statistical Informational Service; http://kosis.kr/).[17] The SMR was estimated using an indirect standardization method, with the expected number of events computed using a person-year method. The 95% confidence interval (CI) was estimated based on the expectation that the number of observed events followed a Poisson distribution.[17] To estimate the number of expected events, we multiplied the age- and sex-specific mortality rates obtained from Statistics Korea, for years 2000 to 2014, by the number of person-years at risk for mortality in each age and sex categories in our cohort of Buddhist priests. In a subgroup analysis, SMR of CKD and non-CKD patients was analyzed comparing with the general population. CKD was defined as dipstick proteinuria ≥1 or an eGFR <60 mL/min/1.73 m^2. We employed a Cox proportional hazards model analysis with adjustments (the enter method), including the variables that were significant in a univariate analysis or other clinically relevant variables to investigate the risk factors of mortality in our cohort of Buddhist priests. *P*-values <.05 were considered statistically significant. All statistical analyses were performed using SPSS statistical software (SPSS version 20.0, IBM Co., Armonk, NY) and SAS statistical software (SAS system for Windows, version 9.3; SAS institute, Cary, NC) for all descriptive and outcome analyses.

3. Results

3.1. Baseline clinical characteristics of the study subjects

A total of 724 Buddhist priests, with a mean age of 50.0 ± 12.5 years (men, 51.0 ± 12.5 years; women, 48.8 ± 12.4 years) were included; 51.0% (369 patients) were men (Table 1). Sixty-seven patients (9.3%) had diabetes, and 142 patients (19.6%) had hypertension. DM (*P* <.001), hypertension (*P* <.001), and dyslipidemia (*P* =.024) were more prevalent among the men Buddhist priests compared with women Buddhist priests. Patients who had CKD accounted for 10.2% (74 subjects). The prevalence of CKD was not significantly different between

Table 1

The clinical characteristics of the study subjects.

Variables	Total (N = 724)	Sex		*P*-value
		Male (n = 369)	Female (n = 355)	
Age, mean ± SD, y	50.0 ± 12.5	51 ± 12.5	48.8 ± 12.4	.013
Diabetes, n (%)	67 (9.3)	48 (13.0)	19 (5.4)	<.001
Hypertension, n (%)	142 (19.6)	94 (25.5)	48 (13.6)	<.001
Dyslipidemia, n (%)	132 (18.2)	79 (21.4)	53 (14.9)	.024
ACEi or ARB, yes, n (%)	72 (9.9)	51 (13.8)	21 (5.9)	<.001
eGFR, mL/min/1.73 m^2	93.7 ± 28.5	90.0 ± 25.0	97.6 ± 31.3	<.001
Hemoglobin, g/dL	13.7 ± 1.9	14.6 ± 1.8	12.7 ± 1.4	<.001
WBC, /uL	7776 ± 3309	8230 ± 3590	7314 ± 2930	<.001
Total protein, g/dL	7.2 ± 0.6	7.2 ± 0.6	7.2 ± 0.6	.597
Albumin, g/dL	4.4 ± 0.5	4.4 ± 0.6	4.3 ± 0.4	.675
Corrected Ca, mg/dL	8.8 ± 0.4	8.9 ± 0.4	8.8 ± 0.4	.027
Total bilirubin, mg/dL	0.7 ± 0.9	0.7 ± 0.6	0.8 ± 1.2	.223
Total cholesterol, mg/dL	185.5 ± 42.3	181.5 ± 43.1	189.1 ± 41.2	.035
LDL cholesterol, mg/dL	109.7 ± 39.4	103.6 ± 36.1	119.1 ± 42.9	.027
HDL cholesterol, mg/dL	47.9 ± 14.4	44.3 ± 14.1	51.4 ± 13.9	<.001
Triglyceride, mg/dL	144.9 ± 91.2	151.8 ± 95.9	138.4 ± 86.3	.214
Na, mmol/L	141.2 ± 3.6	141.1 ± 3.9	141.5 ± 3.1	.214
K, mmol/L	4.1 ± 0.4	4.1 ± 0.5	4.0 ± 0.4	.008
Proteinuria, ≥1+, n (%)	41 (7.0)	26 (8.2)	15 (5.6)	.232
CKD*, yes, n (%)	74 (10.2)	44 (11.9)	30 (8.5)	.123
Urinary stone, yes, n (%)	23 (3.2)	13 (3.5)	10 (2.8)	.588

ACEi = angiotensin converting enzyme inhibitor, ARB = angiotensin receptor blocker, Ca = calcium, CKD = chronic kidney disease, eGFR = estimated glomerular filtration rate by MDRD equation, K = potassium, Na = sodium, SD = standard deviation, WBC = white blood cell.

* Dipstick proteinuria ≥1 or an estimated glomerular filtration rate (eGFR) <60 mL/min/1.73 m^2.

Table 2

The clinical characteristics of subjects with respect to chronic kidney disease.

Variables	non-CKD group (n = 650)	CKD* group (n = 74)	*P*-value
Age, mean ± SD, y	49.0 ± 11.8	58.4 ± 15.0	<.001
Sex, male, n (%)	325 (50.0)	44 (59.5)	.123
Diabetes, n (%)	58 (8.9)	9 (12.2)	.362
Hypertension, n (%)	113 (17.4)	29 (39.2)	<.001
Dyslipidemia, n (%)	107 (16.5)	25 (33.8)	<.001
ACEi or ARB, yes, n (%)	61 (9.4)	11 (14.9)	.136
eGFR, mL/min/1.73 m^2	99.6 ± 15.4	66.0 ± 29.0	<.001
Hemoglobin, g/dL	13.7 ± 1.8	13.5 ± 2.6	.001
WBC, /uL	7537 ± 2890	9817 ± 5369	.001
Total protein, g/dL	7.2 ± 0.6	6.8 ± 0.8	.001
Albumin, g/dL	4.4 ± 0.4	3.9 ± 0.8	<.001
Corrected Ca, mg/dL	8.9 ± 0.4	8.7 ± 0.6	.194
Total bilirubin, mg/dL	0.7 ± 1.0	0.7 ± 0.5	.680
Total cholesterol, mg/dL	185.8 ± 40.7	182.5 ± 56.0	.678
LDL cholesterol, mg/dL	110.1 ± 35.8	107.7 ± 55.3	.848
HDL cholesterol, mg/dL	48.9 ± 14.3	39.5 ± 12.8	.001
Triglyceride, mg/dL	141.8 ± 86.9	170.2 ± 118.8	.096
Na, mmol/L	141.4 ± 3.1	139.9 ± 5.6	.035
K, mmol/L	4.1 ± 0.4	4.1 ± 0.7	.557
Urinary stone, yes, n (%)	20 (3.1)	3 (4.1)	.722

ACEi = angiotensin converting enzyme inhibitor, ARB = angiotensin receptor blocker, Ca = calcium, CKD = chronic kidney disease, eGFR = estimated glomerular filtration rate by MDRD equation, K = potassium, Na = sodium, SD = standard deviation, WBC = white blood cell.

* Dipstick proteinuria ≥1 or an estimated glomerular filtration rate (eGFR) <60 mL/min/1.73 m^2.

men and women Buddhist priests ($P = .123$). Buddhist priests with CKD were generally older ($P < .001$) and had more hypertension ($P < .001$) and dyslipidemia ($P < .001$) (Table 2). Total protein ($P = .001$) and serum albumin ($P < .001$) were significantly lower in Buddhist priests with CKD.

3.2. Standardized mortality ratios according to age, sex, and the presence of chronic kidney disease

During the follow-up period for 31.1 ± 35.6 months, 55 (7.6%) patients died, in which 41 (11.1%) were men and 14 (3.9%) were women. The overall SMR for all causes of death was 0.76 (95% CI 0.57–0.99) (Table 3). The overall mortality of the Buddhist priests was 24% lower compared with the general population, with significance. With respect to sex, the mortality rate was significantly lower in women Buddhist priests (SMR 0.52, 95% CI 0.28–0.87) than the general population, while no differences were observed in men Buddhist priests (SMR 0.91, 95% CI 0.65–1.23). Women Buddhist priests showed significantly lower mortality than men ($P < .001$, Fig. 2). The SMR was significantly lower in patients ≥50 years of age (SMR 0.74, 95% CI 0.55–0.98), whereas not in patients <50 years (SMR 0.97, 95% CI 0.36–2.12). In the aspect of presence of CKD, Buddhist priests without CKD showed a significantly lower SMR (0.61, 95% CI 0.43–0.85), but SMR of Buddhist priests with CKD was not significantly different compared with the general population (1.41, 95% CI 0.85–2.21).

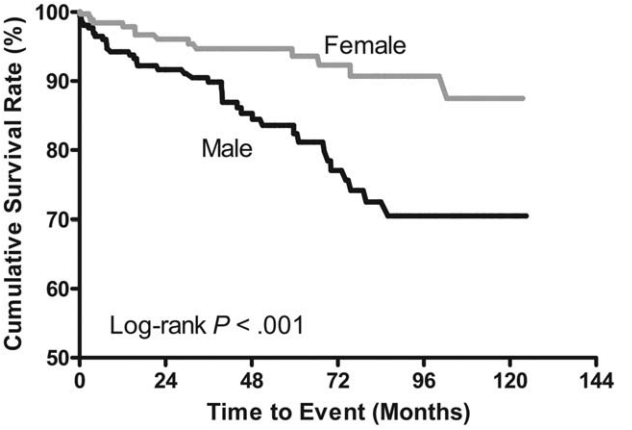

Figure 2. All-cause mortality according to sex. Women Buddhist priests showed significantly lower mortality than men ($P < .001$).

In the Cox proportional hazards model after the adjustment for sex, age, diabetes, hypertension, dyslipidemia, presence of CKD, hemoglobin, white blood cell count, total cholesterol, and serum albumin, older age (adjusted hazard ratio [HR] 1.04, 95% CI 1.10–1.07, $P = .004$), hypertension (adjusted HR 4.04, 95% CI 1.63–10.02, $P = .003$), and CKD (adjusted HR 2.55, 95% CI 1.07–6.06, $P = .034$) were independently related to increased all-cause mortality (Table 4).

3.3. Cause of death by the KCD code

Table 5 shows the primary causes of death stratified by the KCD code. The most common cause of death was cancer (n = 21, 38.2%). Death from cardiovascular causes accounted for 16.4%. The causes of death were quite different for subjects <50 and ≥50 years of age. In subjects <50 years of age, trauma was relatively common (30.0%) and no death of cardiac or cerebral origin was observed. On the other hand, in subjects ≥50 years of age, death from cardiac (11.1%) and cerebral origin (8.9%) accounted for a substantial portion of the cohort.

Table 3

Standardized mortality ratios of subjects according to age, sex, and the presence of chronic kidney disease.

		Person-year	Observed deaths	Expected deaths	SMR (95% CI)
Subjects* (N = 724)		1880.4	55	72.2	0.76 (0.57, 0.99)
Sex	Male (n = 369)	939.5	41	45.2	0.91 (0.65, 1.23)
	Female (n = 355)	940.9	14	27.0	0.52 (0.28, 0.87)
Age*	<50 y (n = 374)	940.9	14	27.0	0.97 (0.36, 2.12)
	≥50 y (n = 350)	1085.8	49	66.0	0.74 (0.55, 0.98)
Presence of CKD*	non-CKD (n = 650)	1714.9	36	58.8	0.61 (0.43, 0.85)
	CKD (n = 74)	165.5	19	13.4	1.41 (0.85, 2.21)

CI = confidence interval, CKD = chronic kidney disease, SMR = standardized mortality ratio.

* Adjusted for sex.

Table 4

Variables independently associated with mortality by the Cox proportional hazard models.

Variable	Crude HR (95% CI)	*P*-value	Adjusted HR[a] (95% CI)	*P*-value
Sex (male vs female)	2.94 (1.60–5.40)	<.001	1.85 (0.71–4.80)	.207
Age (per year)	1.08 (1.06–1.10)	<.001	1.04 (1.01–1.07)	.004
Diabetes (yes vs no)	1.16 (0.52–2.56)	.719	0.33 (0.09–1.17)	.086
Hypertension (yes vs no)	1.47 (1.45–4.20)	.001	4.04 (1.63–10.02)	.003
Dyslipidemia (yes vs no)	1.29 (0.72–2.31)	.393	0.30 (0.11–0.77)	.013
CKD[*] (yes vs no)	5.66 (3.23–9.92)	<.001	2.55 (1.07–6.06)	.034
Hemoglobin (per 1 g/dL)	0.79 (0.68–0.91)	.001	0.93 (0.70–1.22)	.587
WBC (per 1/uL)	1.00 (1.00–1.00)	.001	1.00 (0.99–1.00)	.489
Total cholesterol (per 1 mg/dL)	0.99 (0.98–0.99)	<.001	1.00 (0.99–1.01)	.430
Albumin (per 1 g/dL)	0.19 (0.13–0.28)	<.001	0.37 (0.17–0.80)	.012

CI = confidence interval, CKD = chronic kidney disease, HR = hazard ratio, WBC = white blood cell.

[*] Dipstick proteinuria ≥1 or an estimated glomerular filtration rate <60 mL/min/1.73 m^2.

[a] Adjusted for sex, age, diabetes, hypertension, dyslipidemia, CKD, hemoglobin, WBC, total cholesterol, and albumin.

$P < .05$ was considered significant.

3.4. Incidence of renal replacement therapy and urinary stone

We also investigated the incidence of RRT and development of urinary stone. During the follow-up period, 3 (0.4%) patients started hemodialysis or peritoneal dialysis according to the Korean Society of Nephrology registry. A total of 23 (3.2%) patients developed urinary stone.

4. Discussion

In the present study, we investigated age- and sex- adjusted SMR among 724 Korean Buddhist priests from a single-center, retrospective cohort. The results indicate that a much lower SMR was observed in Buddhist priests compared with the general population. Among subjects in our study cohort, men Buddhist priests were generally older with more comorbidities, such as diabetes, hypertension, and dyslipidemia; our data revealed that Buddhist priests may live longer than the general population, especially women priests, >50 years of age and without CKD.

There is little data on the health-related outcomes, especially with respect to the SMR of modern religious groups. Studies on the longevity of religious groups have been conducted by members of the Seventh-day Adventist Church in Japan,[18] USA,[19] Netherlands,[20] and Mormons in USA,[21,22] both of which prohibit smoking and drinking strictly. Studies of Mormons have been thorough, providing data on the occurrence of cardiovascular outcomes[21] and incidence of cancer,[22] primarily focusing on Mormons living in Utah. However, these studies are limited because they are either outdated or are concerned only with religious groups of Western countries. In East Asia, a study including 4352 men Buddhist priests in Japan from 1955 to 1978 has been conducted.[14] SMR was shown by the cause of death using the ICD code; and consistent with our findings, SMR of men Buddhist priests was found to be significantly lower (SMR 0.82, $P < .001$) compared with the Japanese general men population. However, since this study was reported in 1984 and with the primary focus on men Buddhist priests, its generalizability for all modern Buddhist priests as a whole is highly limited. Although their SMR was a little lower compared with our data, the mortality rate was higher than our data (152 cases/15,383.4 person-year in our study vs 1396 cases/68,686.0 person-year in Japanese study). There may be a difference in the average life expectancy 30 years ago, at the time of their study. Nonetheless, we assumed that the main reason for the discrepancy is the difference in age group between the 2 studies. In our study, the inclusion rate of Buddhist priests over the age of 60 years was only 21%, while the aforementioned Japanese study reached up to 45% for this age group.[14] The second reason is that our study is made up of men and women Buddhist priests, while their study consisted of only men Buddhist priests.

Table 5

Primary causes of death stratified by the Korean Standard Classification of Diseases code.

Cause of death	Total (N = 55)	Age <50 (n = 10)	Age ≥50 (n = 45)
Cardiac origin, n (%)	5 (9.1)	0 (0.0)	5 (11.1)
Cerebral origin, n (%)	4 (7.3)	0 (0.0)	4 (8.9)
Infection, n (%)	3 (5.5)	0 (0.0)	3 (6.7)
Cancer, n (%)	21 (38.2)	4 (40.0)	17 (37.8)
Other, n (%)	14 (25.5)	3 (30.0)	11 (24.4)
Trauma, n (%)	7 (12.7)	3 (30.0)	4 (8.9)
Unknown, n (%)	1 (1.8)	0 (0.0)	1 (2.2)

A recent meta-analysis study focusing on vegetarian diet, including religious groups, have shown that there was no significant difference in the overall mortality between the vegetarian group and their non-vegetarian counterpart (HR 0.91, 95% CI 0.66–1.16).[23] However, studies conducting for the clergy group such as Seventh-day Adventists priest,[19,20] Buddhist priest[14] was shown for survival benefit significantly. This might be indirect evidence that the behavioral characteristics of the clergy group, such as ascetic lifestyle and its related health benefit, that is, low alcohol consumption, no smoking, and regular physical activity, may have an effect on positive health outcome, regardless of vegetarian diet.

The main assumption that Korean Buddhist priests, following Mahayana Buddhism, are expected to show different health-related outcomes is their dietary habits of the Korean "temple food." Most Korean Buddhist priests, at 30 years ago, have been known to be vegan-vegetarians[24]; however, modern Buddhist priests occasionally have dairy products (lacto-vegetarian).[25] Vegetarian diet is mainly comprised of vegetable protein, instead of animal protein, and include a lot of grain and dietary fiber.[26–28] It also includes a variety of antioxidant-rich foods. All of this combined, vegetarian diet is thought to have many positive health benefits, such decreased risk of endothelial dysfunction,

cardiovascular diseases, including ischemic heart disease, stroke, and hypertension,[13,29,30] as well as lowered risk of cancer.[13] However, conflicting results have been reported in the past regarding deficiencies of certain nutrients, such as vitamin B12, iron, and n-3 fatty acid,[9,13] increasing the risks of diabetes[3,11] and osteoporosis,[13,30] especially in women Buddhist priests.[31] In this study, we reported that the prevalence of chronic disease was lower in Buddhist priests compared with the general population; in addition the prevalence difference of chronic disease compared with general population was much greater in women Buddhist priests than men, which might have contributed to a lower SMR. The prevalence of diabetes was 15.7% for men and 11.9% for women in the general Korean population (13.0% for men and 5.4% for women in the present study participants).[32] The prevalence of hypertension was 32.9% for men and 23.7% for women in the general population (25.5% for men and 13.6% for women in the present study participants).[33] In Taiwanese study, risk of diabetes in vegetarians compared with omnivores was lower, more prominent in women than men; women vegetarians consumed more green leafy vegetables and whole grain than men vegetarians.[34] Low glycemic index foods, such as whole grain rather than refined rice, have positive effect on lowering risk of diabetes.[35,36] The difference of carbohydrate food composition may have greater influence in Asia, where portion of carbohydrate is larger than Western countries.

In the case of blood pressure, the benefits of a vegetarian diet are consistently observed regardless of race, region, and type of vegetarian diet in both clinical trials and observational data.[12] In this study, the presence of hypertension and CKD was an independent risk factor for death according to the Cox regression analysis. The group with hypertension, even though they had maintained a vegetarian diet, could be interpreted as a group with greater severity of endothelial dysfunction and vascular stiffness,[29] which might have contributed to the risk of death.[37]

As shown in our study results, SMR was lower in Buddhist priests without CKD, but there was no difference in SMR in those with CKD; CKD was an independent risk factor for death. Vegetable protein is known to have a lower rate of phosphorus absorption than animal protein; therefore, it may have a protective effect on disease progression of patients with CKD when considering the undesirable side effects of hyperphosphatemia in those with CKD.[13] In our study, the prevalence of CKD was 10.2%, and the incidence of ESRD was only 0.4%. In a previous cross-sectional study from Taiwan, a simple comparison of renal function has been conducted between women Buddhist priests and matched-control omnivores group; but renal function, estimated by glomerular filtration rate, was not significantly different between the vegetarians and the omnivores.[38] In our study, data of development of ESRD was obtained using the nation-wide registration data from Korean Society of Nephrology.[15] We intended to reveal the relationship of CKD population and ESRD risk in Buddhist priest group, however, it was hard to present in this study since the incidence was too low. Urinary stone disease was also surveyed, in which, we found that 23 (3.2%) patients newly developed urinary stone. Further study is needed to better determine the association between the incidence of urinary stone and vegetarian diet in Buddhist priests group.[39]

Our study has several strengths. First, to the best of our knowledge, this is the first report obtaining the SMR of Buddhist priests based on the national Statics data. Furthermore, the cohort of our research is the largest representative group of Buddhist priests in Korea, although the data were retrospectively analyzed. Dongguk University Hospital, where this study was conducted, is a Buddhist hospital practicing Jogye Order, which is the largest sect in Korean Buddhism, and has been conducting health checkups and medical treatment for many Buddhist priests, with a primary focus on kidney disease.[40] Despite our strengths, this study has some limitations. First, we were unable to account for when our subjects became Buddhist priests, which may very well be different for each individual. Second, quantification of the unique lifestyle of Buddhist priests, such as type of vegetarian diet and meditation, was not possible. Third, there may be a selection bias since subjects were self-motivated for a health check-up, and unsolved confounding was remained because of retrospective study design.

In conclusion, we clarified that Buddhist priests have a significantly lower mortality rate compared with the general population, especially those without CKD using the SMR of Buddhist priests as compared with the general population in South Korea. Further prospective design studies with full dietary surveys and life style modification are necessary in the Korean Buddhist priest population.

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