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## Original article

# Characteristics of Work-related Fatal Injuries Among Aged Workers in Republic of Korea

Jungsun Park<sup>1</sup>, Jong-shik Park<sup>2</sup>, Younghoon Jung<sup>3</sup>, Minoh Na<sup>4</sup>, Yangho Kim<sup>5,\*</sup>

<sup>1</sup> Department of Occupational Health, Catholic University of Daegu, Gyeongsan, Republic of Korea

<sup>2</sup> Korea Labor Institute, Sejong, Republic of Korea

<sup>3</sup> Department of Law, Pukyong National University, Busan, Republic of Korea

<sup>4</sup> Occupational Safety and Health Research Institute, Korea Occupational Safety and Health Agency, Ulsan, Republic of Korea

<sup>5</sup> Department of Occupational and Environmental Medicine, Ulsan University Hospital, University of Ulsan College of Medicine, Ulsan, Republic of Korea

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## ABSTRACT

**Objectives:** The present paper aimed to examine whether an aging workforce is associated with an increase in work-related fatal injuries and to explore the underlying reasons for this potential increase.

**Material and methods:** Aged workers were defined as those who were at least 55 years old. Work-related fatalities were assessed in aged and young workers who were registered with the workers' compensation system in 2021 in the Republic of Korea. Total waged workers, based on raw data from the Local Area Labor Force Survey in 2021, were used as the denominator to estimate the work-related fatality rates.

**Results:** Most work-related fatalities in the aged workers occurred among individuals working in the "construction sector" (58.9%), those with "elementary occupations (unskilled workers)" (46.1%), and those with the employment status of "daily worker" (60.8%). The estimated incidence (0.973/10,000) of work-related fatalities among aged workers was about four times higher than that (0.239/10,000) among younger workers. "Falling," "collision," "struck by an object," and "trip and slip" were more frequent types of work-related fatalities among aged workers relative to young workers. The category of "buildings, structures, and surfaces" was a more frequent cause of work-related fatalities among aged workers than among young workers.

**Conclusions:** Aged workers had a higher incidence of work-related fatalities than young workers. Frequent engagement in precarious employment and jobs, coupled with the greater physical vulnerability of aged workers, were likely causes of their higher level of work-related fatal injuries.

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## 1. Introduction

The population of the Republic of Korea (Korea) is aging more rapidly than any other country [1,2]. A demographic analysis reported that Korea became an "aging society" in 2000 and an "aged society" in 2018 and will become a "super-aged" society in 2025 [1]. Due to its low birth rate and the rapid aging of its population, Korea had the largest percentage of working age population in 2019, followed by a decline. This has led to a prediction that the employment of elderly workers will increase to offset the increasing labor shortages in many industries. Hence,

there is a continually increasing percentage of workers who are 55 to 79 years old [3]. The aging of the workforce will likely increase the rate of workplace accidents because more elderly workers suffer from physiological declines in their sensory systems, sense of equilibrium, and motor control [4–6]. Therefore, there is an increasing need for policies that can prevent occupational injuries in elderly workers in Korea in preparation for the rapid aging of the labor force that will be caused by labor shortages.

According to several Korean studies, the proportion of older workers with work-related injuries increased annually compared to

Jungsun Park: <https://orcid.org/0000-0003-0137-3872>; Jong-shik Park: <https://orcid.org/0000-0002-4492-7807>; Younghoon Jung: <https://orcid.org/0009-0002-2369-3746>; Minoh Na: <https://orcid.org/0009-0008-3751-911X>; Yangho Kim: <https://orcid.org/0000-0002-6462-0829>

\* Corresponding author. Ulsan University Hospital, University of Ulsan College of Medicine, 25 Daehakbyeongwon-ro, Dong-gu, Ulsan, 44033, Republic of Korea.  
E-mail address: [yanghokm@ulsan.ac.kr](mailto:yanghokm@ulsan.ac.kr) (Y. Kim).

that of younger workers [5,7]. However, the injuries were not confined to fatal injuries. Salminen [8] reviewed studies of fatal injuries and found that 64% of these studies reported a higher rate in older workers, 20% found no difference between older and younger workers, and 16% found a higher rate in younger workers. However, a recent systematic review concluded that 50% of publications suggested there were more fatal injuries in older workers, and the other 50% showed no difference between older and younger workers [9]. Notably, this review identified no studies in which younger workers had a higher fatality rate than older workers, in agreement with the results from other studies [10,11].

Previous studies of the construction industry workforce found that older age at the time of injury was related to higher injury-related costs, but age was unrelated to the number of injuries. A likely reason for the higher costs for elderly workers is their experience of more severe injuries [12–14]. Thus, younger workers get hurt more often, but older workers tend to have more serious injuries and more expensive claims [13]. However, our recent study showed that the incidence of non-fatal work-related injuries is higher among aged workers compared to their younger counterparts [15].

Kemmlert and Lundholm analyzed the Swedish Occupational Injury Information System, which included all industrial sectors. They reported that the proportions of slip, trip, and fall incidents were greater for male workers aged 45 years and older compared to workers less than 45 years old [16]. Coantonio et al. examined workers' compensation data from Ontario, Canada, and found that 76% of the traumatic brain injury (TBI) claims of construction workers aged 55–64 years were from falls, but only 45% of claims from workers aged 17 to 24 years were for TBI [17]. According to a recent Korean study, falling was the most common cause (33.7%) of nonfatal injuries in aged workers of the construction sector, whereas getting caught was the major cause (16.6%) in young workers of the “manufacturing” sector [15]. In contrast, Shishlov et al. [18] studied U.S. hospital emergency department data for construction-related injuries and reported a two-fold decrease in the fall-injury rate for workers 55 years and older compared to workers less than 20 years old. The possible reasons for these inconsistent results are differences among countries in record-keeping practices and among studies in the inclusion of industrial sectors and analysis of injury severity [9].

There is still controversy on whether the aging of the workforce will increase work-related fatalities and, if so, the reason for this increase. The objective of this paper is to investigate whether an aging workforce is associated with an increase in work-related fatal injuries and to explore the underlying reasons for this potential increase.

## 2. Methods

### 2.1. Materials and subjects

“Aged worker” was defined as at least 55 years old, as defined by the Enforcement Decree of the Act on Prohibition of Age Discrimination in Employment and Aged Employment Promotion. Work-related fatalities were assessed among aged and young workers who were registered with the workers' compensation system in Korea in 2021.

Total waged workers, who were used as the denominator to estimate the work-related fatality rates, were identified based on raw data of the Local Area Labor Force Survey in 2021 [19]. The Local Area Labor Force Survey provides representative data on the age distribution, industry sector, occupational class, and employment status of all waged workers ( $n = 21,111,723$ ).

### 2.2. Statistical analysis

The proportions of workplace fatalities in aged workers and younger workers were compared according to sex, industrial sector, occupational class, and employment status using a chi-squared test.

The number of aged workers registered for the workers' compensation system is not directly available. Thus, the proportions of waged workers under 55 years old (15,690,421) and 55 years old or more (5,421,302) in the 2021 Local Area Labor Force Survey [19] in October 2021 were used to calculate the number of workers registered for workers' compensation (19,378,565). The workers registered for workers' compensation, therefore, consisted of 14,402,322 individuals under 55 years old and 4,976,243 individuals 55 years old or more. These numbers were used as the denominator to estimate the work-related fatality rates of young and aged workers in 2021. In the same manner, the number of young and aged workers registered for workers' compensation in each industrial sector, occupational class, and employment status were also estimated. These numbers were used as the denominator to estimate the fatality rates (incidence per 10,000 workers) according to industrial sector, occupation, and employment status. Risk ratios with 95% confidence intervals (CIs) were obtained by dividing the fatality rates of aged workers by those of young workers to compare the fatality rates between young and aged workers.

SPSS version 20 (IBM Corp, Armonk, NY) was used for all statistical analyses, and a  $p$  value below 0.05 was considered significant.

## 3. Results

We first compared fatal work-related injuries in different age groups of males and females (Table 1). Among aged and younger workers, almost all work-related fatalities were in men (97.1% and 98.3%, respectively). Aged workers accounted for 58.2% of work-related fatalities in males and 70.0% of work-related fatalities in females.

The estimated rate of work-related fatalities of all aged workers was about four times higher than that of all younger workers (risk ratio: 4.072). In addition, the estimated rate of work-related fatalities of all aged male workers (1.782/10,000) was about 30 times higher than that of all aged female workers (0.060/10,000).

We then compared fatal work-related injuries in different industrial sectors (Table 2). Among aged workers, most work-related fatalities were in the “Construction” sector (58.9%), and this was followed by the “Manufacturing” sector (16.5%). The percentages of young workers with fatal injuries were also greatest in the “Construction” sector (38.4%) and the “Manufacturing” sector (30.2%). In addition, the proportion of aged workers in the “Construction” sector was the highest among industrial sectors.

For the “Construction” sector, the estimated rate of work-related fatalities of both aged and younger workers was much higher than the average rate of those in overall industrial sectors (3.583/10,000 and 0.834/10,000 vs. 0.973/10,000 and 0.239/10,000). Moreover, the estimated rate of work-related fatalities for aged workers was approximately four times higher than that for younger workers (risk ratio: 4.299). Although the estimated rate of work-related fatalities of aged and younger workers in the “Mining” sector was the highest, the proportion of aged workers in the “Mining” sector was the lowest among industrial sectors.

We also analyzed fatal work-related injuries according to occupational class (Table 3). Among aged workers, most work-related fatalities were for those in “elementary occupations” (unskilled workers) (46.1%), followed by “craft and related trade workers” (30.7%), and “workers related to equipment, machine

**Table 1**  
Fatal injuries according to gender

Gender	Age < 55 yr		Age ≥ 55 yr		Proportion of aged workers	Risk ratio (95% CI)
	N (%)	Incidence	N (%)	Incidence		
Men	338 (98.3)	0.423	470 (97.1)	1.782	58.2%	4.211 (3.662–4.843)
Women	6 (1.7)	0.009	14 (2.9)	0.060	70.0%	6.401 (2.460–16.657)
Total	344 (100.0)	0.239	484 (100.0)	0.973	58.5%	4.072 (3.547–4.676)

Workplace fatalities (%) in aged workers and younger workers were compared using the chi-squared test for gender ( $p$  value > 0.05). CI, confidence interval.

**Table 2**  
Fatal injuries according to industrial sector

Industrial sector	Age < 55 yr		Age ≥ 55 yr		Proportion of aged workers	Risk ratio (95% CI)
	N (%)	Incidence	N (%)	Incidence		
Service	33 (9.6)	0.054	27 (5.6)	0.139	45.0%	2.561 (1.540–4.258)
Construction	132 (38.4)	0.834	285 (58.9)	3.583	68.3%	4.299 (3.498–5.285)
Mining	5 (1.5)	8.366	4 (0.8)	9.344	44.4%	1.117 (0.300–4.162)
Manufacturing	104 (30.2)	0.323	80 (16.5)	1.079	43.5%	3.339 (2.495–4.470)
Agriculture, forestry, fishing	9 (2.6)	0.978	14 (2.9)	1.368	60.9%	1.399 (0.606–3.232)
Transportation, telecommunication	40 (11.6)	0.484	32 (6.6)	1.922	44.4%	3.975 (2.498–6.329)
Others	21 (6.1)	0.088	42 (8.7)	0.293	66.7%	3.330 (1.972–5.623)
Total	344 (100.0)	0.239	484 (100.0)	0.973	58.5%	4.072 (3.547–4.676)

Workplace fatalities (%) in aged workers and younger workers were compared using the chi-squared test for industrial sector ( $p$  value < 0.001). CI, confidence interval.

**Table 3**  
Fatal injuries according to occupation

Occupation	Age < 55 yr		Age ≥ 55 yr		Proportion of aged workers	Risk ratio (95% CI)
	N (%)	Incidence	N (%)	Incidence		
Managers	30 (9.5)	1.487	38 (8.0)	2.595	55.9%	1.745 (1.081–2.817)
Professionals and related workers	8 (2.5)	0.020	3 (0.6)	0.064	27.3%	3.167 (0.840–11.939)
Clerks	3 (0.9)	0.008	0 (0.0)	0.000	0.0%	—
Service workers	4 (1.3)	0.031	5 (1.1)	0.079	55.6%	2.577 (0.692–9.598)
Sales workers	2 (0.6)	0.017	0 (0.0)	0.000	0.0%	—
Skilled workers related to agriculture, forestry, and fisheries	7 (2.2)	2.656	12 (2.5)	6.062	63.2%	2.282 (0.899–5.800)
Craft and related trade workers	93 (29.3)	0.787	146 (30.7)	2.985	61.1%	3.794 (2.926–4.922)
Workers related to equipment, machine operating, and assembling	59 (18.6)	0.406	52 (10.9)	1.007	46.8%	2.478 (1.707–3.598)
Elementary occupations (unskilled work)	111 (35.0)	0.767	219 (46.1)	1.099	66.4%	1.432 (1.139–1.799)
Total	317 (100.0)	0.220	475 (100.0)	0.954	60.0%	4.337 (3.762–5.000)

Workplace fatalities (%) in aged workers and younger workers were compared using the chi-squared test for occupation ( $p$  value = 0.001). CI, confidence interval.

operating, and assembling” (10.9%). Among young workers, these three classes also comprised the majority of the proportion of work-related fatalities. In addition, aged workers accounted for large percentages of workers employed in “elementary occupations” (66.4%), “skilled workers related to agriculture, forestry, and fisheries” (63.2%), and “craft and related trade workers” (61.1%).

The highest estimated rate of work-related fatalities of aged workers was for those who were “skilled workers related to agriculture, forestry, and fisheries” (6.062/10,000), followed by “craft and related trade workers” (2.985/10,000), and “managers” (2.595/10,000), and workers with “elementary occupations” (1.099/10,000). The estimated rates of work-related fatalities of young workers were also greatest for those employed as “skilled workers related to agriculture, forestry, and fisheries” (2.656/10,000), “managers” (1.487/10,000), “craft and related trade workers” (0.787/10,000), and workers with “elementary occupations” (0.767/10,000). However, only a small proportion of work-related fatalities were for “skilled workers related to agriculture, forestry, and fisheries” (2.2–2.5%), although the fatality rate was highest among young and aged workers in that occupational class (2.656/10,000 and 6.062/10,000, respectively). The estimated rates of

work-related fatalities of aged workers employed in “elementary occupations” are similar to the average rate in the overall occupational class.

We then examined the effect of employment status (Table 4). The highest percentage of aged workers with work-related fatalities was for those employed as “daily workers” (60.8%) followed by “regular workers” (37.3%); the highest percentages for young workers were for those employed as “regular workers” (57.7%) followed by “daily workers” (40.2%). A comparison of all three categories of employment status showed that aged workers accounted for the largest percentage of “daily workers” (67.9%). Further analysis by industrial sectors showed that in both older and younger age groups, most work-related fatalities among daily workers occurred in the “Construction” sector (86.0% and 75.4%, respectively) (data not shown).

Analysis of “daily workers” showed that the estimated rate of work-related fatalities in the aged (5.830/10,000) and younger workers (2.275/10,000) was much higher than the average rate in any other employment status or overall employment status.

Analysis of the types of accidents responsible for work-related fatalities (Table 5) showed that “falling” was the major cause in

**Table 4**  
Fatal injuries according to employment status

Employment status		Age < 55 yr		Age ≥ 55 yr		Proportion of aged workers	Risk ratio (95% CI)
		N (%)	Incidence	N (%)	Incidence		
Employment status	Regular	198 (57.7)	0.176	179 (37.3)	0.690	47.5%	3.914 (3.198–4.791)
	Temporary	7 (2.0)	0.027	9 (1.9)	0.048	56.3%	1.753 (0.653–4.706)
	Daily	138 (40.2)	2.275	292 (60.8)	5.830	67.9%	2.564 (2.094–3.140)
	Total	343 (100.0)	0.238	480 (100.0)	0.964	58.3%	4.051 (3.526–4.653)

Workplace fatalities (%) in aged workers and younger workers were compared using the chi squared test for employment status (*p* value < 0.001). CI, confidence interval.

**Table 5**  
Accident types responsible for fatal injuries

	Age < 55 yr N (%)	Age ≥ 55 yr N (%)	Total N (%)	Proportion of aged workers
Falling	113 (32.8)	238 (49.2)	351 (42.4)	67.8%
Getting caught	57 (16.6)	38 (7.9)	95 (11.5)	40.0%
Collision	26 (7.6)	46 (9.5)	72 (8.7)	63.9%
Being struck by an object	15 (4.4)	37 (7.6)	52 (6.3)	71.2%
Trip, slip	2 (0.6)	15 (3.1)	17 (2.1)	88.2%
Others	131 (38.1)	110 (22.7)	241 (29.1)	45.6%
Total	344 (100.0)	484 (100.0)	828 (100.0)	58.5%

Workplace fatalities (%) in aged workers and younger workers were compared using the chi-squared test for accident type (*p* value < 0.001).

aged workers (49.2%) and in young workers (32.8%). The second-most common cause was “collision” in aged workers (9.5%) and “getting caught” in young workers (16.6%). Additionally, “falling,” “collision,” “being struck by an object,” and “trip and slip” were more frequent causes of work-related fatalities in aged workers than in young workers.

We also examined the specific agents responsible for fatal work place injuries (Table 6). The primary agent in aged workers was “buildings, structures, and surfaces (e.g., floor, steps, various building and structural components, etc.)” (45.5%). In contrast, the most common agent in young workers was “equipment and machinery” (41.6%). Furthermore, “buildings, structures, and surfaces” were a more frequent cause of work-related fatalities in aged workers than young workers.

#### 4. Discussion

Our study of aged workers in Korea during 2021 demonstrated the greatest percentages of work-related fatalities were among

**Table 6**  
Agents responsible for fatal injuries

Fatal injury-causing agent	Age < 55 yr N (%)	Age ≥ 55 yr N (%)	Total N (%)	Proportion of aged workers
Buildings, structures, and surfaces (e.g., floor, steps, various building and structural components, etc.)	86 (25.0)	220 (45.5)	306 (37.0)	71.9%
Equipment and machinery	143 (41.6)	112 (23.1)	255 (30.8)	43.9%
Means of transportation	74 (21.5)	81 (16.7)	155 (18.7)	52.3%
Parts, accessories, and materials	17 (4.9)	37 (7.6)	54 (6.5)	68.5%
Others	24 (7.0)	34 (7.0)	58 (7.0)	58.6%
Total	344 (100.0)	484 (100.0)	828 (100.0)	58.5%

Workplace fatalities (%) in aged workers and younger workers were compared using the chi-squared test for causing agent (*p* value < 0.001).

workers in the “construction sector” (58.9%), those with an “elementary occupation” (46.1%), and those with a status of “daily worker” (60.8%). Additionally, the highest percentages of aged workers were employed in the “construction sector” (68.3%), had an “elementary occupation” (66.4%), and had an employment status of “daily worker” (67.9%). Moreover, the estimated rates of work-related fatalities among aged workers employed in the “Construction” sector (3.583/10,000) or as “daily workers” (5.830/10,000) were greater than those in most industrial sectors, occupations, and employment status. This indicates that work-related fatalities in older workers were more likely to occur in the industrial sector, occupation, and employment status that had the most elderly workers. Hence, aged workers who have precarious employment and jobs that expose them to more occupational safety and health risks suffer from more work-related fatalities. Our previous publication also found that “elementary occupations” had the largest proportion of aged workers [20]. Bravo et al. found that the higher fatality rate in aged workers may be related to the type of industry and nature of the occupation [9]. For example, the construction and agriculture sectors, which employ many aged workers, normally have higher fatality rates [9,21]. This suggests that employment in physically demanding jobs makes elderly workers more vulnerable to workplace fatalities [9,21].

A previous study found that 44% of work-related fatalities in 2005 were among construction workers over the age of 45 years [22]. Jackson et al. [23] found that the crude death rate was highest for workers aged 65 to 74 years (31/100,000 person-years) and lowest for workers aged 18–24 years (18.3/100,000 person-years). A recent systemic review found that 5 of the 10 analyzed studies (50%) reported that older workers had a higher risk of fatal injuries than younger workers, and none of the studies reported that advanced age was a protective factor against fatal occupational injuries [9]. In the present study, the overall estimated rate of work-related fatalities per 10,000 workers was much greater in elderly workers (0.973) than in young workers (0.239); these rates were also greater for elderly workers than for young workers who were employed in the “construction sector,” had an “elementary occupation,” and had an employment status of “daily worker.” A possible interpretation is that aged workers do more dangerous work than younger workers in the same industry, occupation, or employment status. However, a more reasonable interpretation is that the higher fatality rate of aged workers is because their physical limitations make them more vulnerable to injury.

Falls are the most common cause of fatal injuries [24,25]. Kemmlert and Lundholm analyzed the Swedish Occupational Injury Information System and reported that the proportions of slip, trip, and fall incidents were greater among male workers aged 45 years and older compared to workers less than 45 years old [16]. Coantonio et al. examined workers’ compensation data from Ontario, Canada, and found that 76% of the TBI claims of construction workers aged 55 to 64 years were from falls, but 45% of the TBI claims from workers aged 17 to 24 years were from falls [17]. Furthermore, Schoenfisch et al. [26] found that injuries among more senior workers were more likely to cause serious problems



that required longer hospitalization stays, indicating a slower recovery from injury. Our national representative study found that “falling” was the most common type of work-related fatality in aged workers than young workers. Falls often occur when working at heights and may also be related to inadequate safety measures and the more limited physical abilities (muscle strength and agility) of aged workers. Furthermore, “collision,” “struck by an object,” and “trip and slip” accidents were also more common causes of work-related fatalities in aged workers than young workers. Workers with physical limitations are likely more vulnerable to these types of accidents. Our analysis of injury-causing agents also showed that “buildings, structures, and surfaces” were a more common cause of work-related fatalities in aged workers than young workers. Taken together, these results strongly suggest that the physical limitations of elderly workers were responsible for their higher frequency of occupational injuries. Other studies also reported that aged workers who had poor muscle strength and elasticity and limited range of joint motion were more likely to suffer from work-related fatal injuries [4,27,28].

The more frequent engagement in precarious employment and jobs, coupled with the greater physical vulnerability of aged workers are likely responsible for their higher rate of work-related fatal injuries. In agreement, previous research also concluded that precarious employment and jobs made aged workers more vulnerable to work-related fatalities because of age-based declines in physical capacity [9,21].

The present study has several strengths. First, it was based on a representative national workers' compensation database for Korea that covers all industrial sectors and occupations. Second, it estimated the incidences of work-related fatalities of aged workers relative to young workers according to industrial sector, occupational class, and employment status.

Our study also had several limitations. First, because this was a cross-sectional observational study, we cannot infer causality, but we can only report observations of associations. Second, this study was unable to calculate the precise incidence rates of work-related fatalities in aged workers because the exact age distribution, occupational class, and employment status of all workers who are registered for the workers' compensation scheme were not available. Hence, our data are estimates of the incidence of work-related fatalities based on data from a representative Local Area Labor Force Survey, which is a representative big data on characteristics of waged employees in Korea. Finally, underreporting work-related injuries has been a long-lasting occupational health issue in Korea [29–32]. Employers are still very reluctant to reveal work-related injuries to the government authority to avoid penalties, avoid increases in insurance premiums, and, in the case of construction companies, avoid restrictions in government-ordered construction projects [29,30]. It seems that they preferred to pay for medical treatment with the National Health Insurance scheme and suspension of employment. However, almost all the fatal injuries were reported because employers could hardly bear the economic burden that they had to endure to compensate the survivors of victims [29].

In conclusion, aged workers have a higher incidence of work-related fatalities than young workers. The frequent engagement in precarious employment and jobs, coupled with the greater physical vulnerability of aged workers, likely contribute to their higher rate of work-related fatalities. Thus, to prevent fatal workplace injuries, employers should improve the safety and health standards for the types of employment and jobs in which aged workers are most common. In addition, preventive measures that improve the physical and functional capacities of aged workers, with a focus on balance and muscle strength, may help prevent fatal injuries in these individuals.

## Authors' contributions

Design and concept of the study: Yangho Kim.

The acquisition, analysis of data for the work; Jong-shik Park, Younghoon Jung, Minoh Na.

Drafting the manuscript of the study; Jungsun Park.

Revising manuscript critically; Yangho Kim.

Final approval of the version to be published; Yangho Kim, Jungsun Park, Jong-shik Park, Younghoon Jung, Minoh Na.

Accountability for the accuracy and integrity of any part of this paper: Yangho Kim.

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## Institution and ethics approval

The present study was exempted for IRB review according to the Korean Bioethics and Safety Act (IRB FILE No: UUH 2023-03-024).

## Disclaimer

None.

## Conflicts of interest

The authors declare no conflicts of interest.

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