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ORIGINAL ARTICLE

Assessment of sunlight exposure across industries and occupations using blood vitamin D as a biomarker

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Abstract

Objective: Exposure to ultraviolet (UV) radiation from sunlight induces the production of essential vitamin D, whereas overexposure to sunlight leads to skin cancer. Sunlight exposure has been measured using questionnaires, dosimeters, and vitamin D levels. Several studies have measured vitamin D in the working population; however, these studies were limited to certain occupations such as farmers and construction workers. In the present study, we evaluated sunlight exposure using blood vitamin D as an exposure surrogate across industries and occupations.

Methods: The Korea National Health and Nutrition Examination Survey (KNHANES) is a nationwide study representing the Korean population. We analyzed data from KNHANES between 2008 and 2009. We examined the association between vitamin D levels and pertinent personal, seasonal, residential, and occupational factors. Furthermore, we developed a multiple regression model with factors other than occupational factors (industry and occupation) and obtained residual values. We computed the third quartile (Q3) of the residuals and then calculated the fractions exceeding the Q3 level for each combination of industry and occupation.

Results: Age, sex, body mass index, year, season, latitude, living area, living in an apartment, industry, and occupation were significantly associated with vitamin D levels. Based on the exceeding fraction, the armed forces showed the highest exceeding fraction level of 0.71.

Conclusions: Our results present the high exposure groups to sunlight across industries and occupations. Our results may provide a source for prioritizing occupational groups with a high risk of adverse health effects from sunlight exposure.

KEYWORDS
cancer, carcinogen, exposure, occupational exposure, sunlight, ultraviolet radiation

1 | INTRODUCTION

Vitamin D is essential for human life, facilitating calcium absorption from the intestinal tract. Vitamin D is produced internally by skin exposure to solar ultraviolet B (UVB) radiation. On exposure to UVB radiation, cholesterol is converted to 25-hydroxyvitamin D (25(OH)D), an inactive form of vitamin D. Subsequently, 25(OH)D is converted to the active form 1,25-dihydroxyvitamin D. However, because 25(OH)D is more stable, 25(OH)D is commonly used for monitoring vitamin D levels in the human body.[1]

Exposure to sunlight increases vitamin D production. Vitamin D deficiency can lead to rickets and osteomalacia. On the contrary, overexposure to sunlight increases the risk of skin damage and cancer.[2] Exposure to UV radiation is a known carcinogen causing skin cancers, such as malignant melanoma, squamous cell carcinoma, and basal cell carcinoma.[3] It is estimated that 6.31% of non-melanoma skin cancer cases are attributable to occupational exposure to solar UV radiation in Canada.[4] In addition, overexposure to sunlight increases the risk of deadly heat stress in outdoor workers.[5]

Sunlight exposure is associated with personal, environmental, and occupational factors.[6] Personal factors include the use of protective clothing, the use of sunscreen, outdoor activity, food and supplement intake, and skin melanin content.[7] Environmental factors include climate, season, latitude, and altitude. Occupational factors are also very important because workers with certain types of jobs are continuously exposed to sunlight. For instance, farmers and fishermen are inevitably exposed to sunlight during their routine jobs.

Many studies have examined UV radiation exposure levels across various occupations to protect workers from skin cancer.[8–10] Exposure to sunlight has been measured in various ways, such as questionnaires, dosimeters, and blood metabolites. Most studies have used questionnaires or dosimeters to assess exposure to sunlight, which mainly focuses on protective behavior and outdoor activity.[10–12] For instance, the Sun Exposure and Protection Index questionnaires assessed sun exposure habits and propensity to increase sun protection.[13] UV radiation is also measured externally. For instance, the standard erythemal dose (SED) is measured, which is equivalent to 100 J/m^2. Outdoor workers commonly exceed the occupational limit of 30 J/m^2 for a working day (8 h) recommended by the American Conference of Governmental Industrial Hygienists.[14] Exposure to UV radiation in the construction sector, agricultural sector, and other occupations has been measured using the SED.[14,15]

Some studies have used blood vitamin D levels as a biomarker of exposure.[16] These studies have usually been focused on jobs where high exposure is likely to occur.[17] For instance, farmers, fishermen, construction workers, and soldiers have high vitamin D levels. However, few studies have examined vitamin D levels as a surrogate for sunlight exposure across industries and occupations. In the present study, we sought to evaluate sunlight exposure across industries and occupations using the Korea National Health and Nutrition Examination Survey (KNHANES), which is a nationwide survey representing the Korean population.[18]

2 | METHODS

2.1 | Data sources

We used data from the fourth wave of KNHANES between 2008 and 2009 because these two surveys contain information on the industry, occupation, and vitamin D levels simultaneously.[18]

The age was restricted to 20–69 years, representing the Korean working population. Participants without industry or occupation codes were excluded from further analyses. In addition, participants who consumed vitamin supplements or medications for osteoporosis were excluded.[19] Participants without information on the body mass index (BMI) were also excluded.

2.2 | Industry and occupation classification

In KNHANES, industries were classified into 15 groups. Occupations were classified into 10 major groups. Occupations were classified according to the Korea Standard Classification of Occupation (sixth revision), which is based on the International Standard Classification of Occupation (eighth revision).

2.3 | Vitamin D measurement

Vitamin D levels were analyzed by a central laboratory. Blood samples were collected, immediately refrigerated, and transported in cold storage to the laboratory. Blood samples were analyzed within 24 h, using a 1470 Wizard gamma counter (Perkin Elmer, Turku, Finland) and radioimmunoassay (DiaSorin).[20]

2.4 | Statistical analysis

Vitamin D levels showed a right-skewed distribution; thus, vitamin D levels were log-transformed and approximated to a normal distribution. Age was categorized with 10-year intervals from 20 to 69 years. BMI was classified into normal (<23 kg/m^2), overweight (23–25 kg/m^2), and obese (≥25 kg/m^2). Examination dates were categorized into 2 years (2008 and 2009) and four seasons (spring: 3–5, summer: 6–8, autumn: 9–11, and winter: 12–2). Latitude was classified into 33°, 34°, 35°, 36°, 37°, and 38°. Latitude was assigned to the participants based on their city or country. Living areas were categorized into urban and rural areas. Housing was categorized into apartments and houses. Industries were classified into 15 groups. Occupations were classified into 10 major occupational groups.

Summary statistics including mean, standard deviation (SD), geometric mean, and geometric SD were calculated according to sex, age, BMI, year, season, latitude, area, housing, industry, and occupation. In addition, the t-test or analysis of variance test was conducted for each variable to examine differences in vitamin D levels within the categories of each variable.

Multiple regression analyses were conducted, incorporating sex, age, year, BMI, season, latitude, area, and housing, in addition to industry and occupation as independent variables to evaluate the differences in vitamin D by industry and occupation while accounting for several known factors associated with the level of vitamin D.

Furthermore, we refitted the same multiple regression model but without industry and occupation as in Equation (1) and obtained residuals, which can be regarded as the residual vitamin D level after all the effects of the known factors in the model were subtracted.

$$\ln(25\,(\mathrm{OH})\,\mathrm{D}) = \beta_0 + \beta_1 * \mathrm{sex} + \beta_2 * \mathrm{age} + \beta_3 * \mathrm{BMI} + \beta_4 * \mathrm{year} + \beta_5 * \mathrm{season} + \beta_6 * \mathrm{latitude} + \beta_7 * \mathrm{area} + \beta_8 * \mathrm{housing} + \varepsilon \quad (1)$$

In this model, β_0 represents the intercept of the model and ε represents the error term (residual). Residuals showed an approximately normal distribution. The overall third quartile (Q3) level of residuals regardless of industry and occupation was computed and used as a cutoff value to indicate whether the vitamin D level was high or low. We calculated the fraction exceeding the Q3 level of residuals for each combination of industry and occupation. If an industry and occupation combination is higher than 0.25 of the exceedance fraction, the combination may have more exposure than the average working population. This approach was demonstrated in a previous study on the exposure assessment of polycyclic aromatic hydrocarbons.[21] Combinations of industry and occupation comprising <10 measurements were not presented because small samples may be vulnerable to bias. It also complies with the policy of the Korea Center for Disease Control and Prevention (KCDC) for small sample data.

"Survey" package[22] of R was used for the analyses to account for a complex survey sampling scheme including strata, cluster, and sampling weights in the KNHANES.[23] Each year was equally weighted by multiplying 0.5 to each weight of the year. The distribution of vitamin D was graphically examined using the "EnvStats" package using the cumulative distribution function (CDF).[24]

3 | RESULTS

In the KNHANES between 2008 and 2009, data from 20 277 individuals were collected. After excluding data not eligible for analysis, a total of 4909 blood vitamin D data were used for analysis.

The CDF plot indicated that vitamin D levels have a distribution that is close to a log-normal distribution (Figure 1).

In the univariate tests, there were significant differences in sex, age, BMI, year, latitude, area, housing, industry, and occupation, while a non-significant difference was found in season (Table 1).

In the multiple regression model, men showed a significantly higher 25(OD)D level than the female working population (Table 2). In terms of age, those with an older age showed a higher level of 25(OH)D compared with individuals in their twenties. Those with the overweight or obese BMI category showed higher 25(OH)D levels than those with a normal BMI. The measurements in 2008 were significantly higher than those in 2009. 25(OH)D measurements during summer and autumn were significantly higher than those in spring. Higher

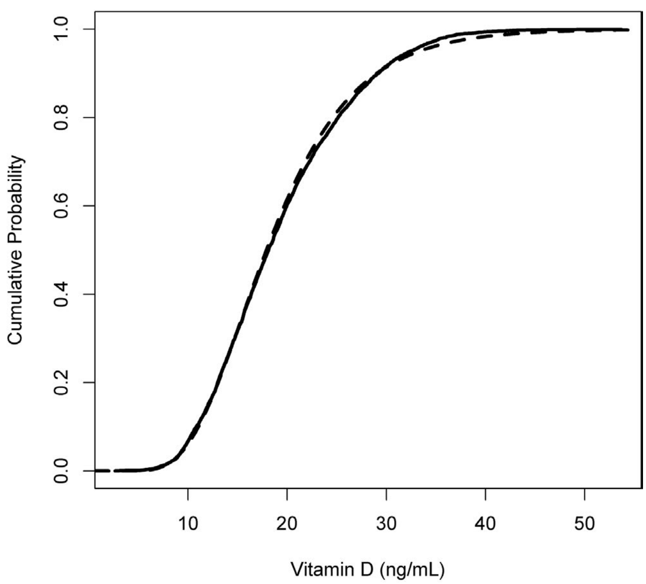

FIGURE 1 Empirical cumulative distribution function (CDF) of vitamin D (solid line) with fitted log-normal CDF (dash line)

TABLE 1 General characteristics of blood vitamin D levels

						Test	
Variable	***N***	**Mean (ng/ml)**	**SD (ng/ml)**	**GM (ng/ml)**	**GSD**	***t* or *F***	***P*-value**
Sex							
Male	2638	20.11	7.07	18.90	1.43	−16.2	<.01
Female	2271	16.64	6.10	15.58	1.45		
Age							
20–29	615	16.22	5.94	15.25	1.42	62.6	<.01
30–39	1137	18.14	6.60	17.01	1.43		
40–49	1374	18.94	6.85	17.71	1.45		
50–59	1009	20.52	7.05	19.30	1.43		
60–69	774	21.31	7.63	19.88	1.48		
BMI							
<23	2059	17.91	7.11	16.62	1.47	36.6	<.01
23–25	1152	19.24	6.84	18.05	1.44		
>=25	1698	19.45	6.64	18.31	1.43		
Year							
2008	2175	19.79	7.34	18.41	1.48	−3.6	<.01
2009	2734	17.87	6.41	16.80	1.42		
Season							
Spring	1336	16.03	5.81	15.04	1.43	6.4	.09
Summer	1357	21.77	7.21	20.55	1.42		
Autumn	1224	20.84	6.79	19.75	1.39		
Winter	992	15.90	5.31	15.07	1.39		
Latitude							
33°	167	20.18	6.79	18.95	1.44	114	<.01
34°	244	23.05	6.67	22.06	1.35		
35°	1646	19.35	6.89	18.13	1.44		
36°	739	20.51	7.60	19.13	1.46		
37°	2069	17.56	6.47	16.44	1.44		
38°	44	23.60	9.01	21.71	1.55		
Area							
Rural	1464	21.24	7.40	19.92	1.44	−5.6	<.01
Urban	3445	18.09	6.63	16.93	1.44		

TABLE 1 (Continued)

Variable	*N*	Mean (ng/ml)	SD (ng/ml)	GM (ng/ml)	GSD	Test: *t* or *F*	Test: *P*-value
Housing							
House	3022	19.34	7.25	18.02	1.47	−2.8	<.01
Apartment	1887	17.93	6.34	16.85	1.43		
Industry							
Agriculture, forestry, fishery	913	22.20	7.70	20.79	1.45	96.7	<.01
Mining	<10						
Manufacturing	717	18.16	6.38	17.04	1.44		
Electricity, gas, water	68	19.12	6.69	17.94	1.44		
Construction	296	20.89	7.23	19.68	1.42		
Wholesale, retail, maintenance, and repair	634	18.58	6.58	17.46	1.43		
Accommodation, food, and beverage service	369	17.67	6.70	16.48	1.46		
Transportation	199	20.33	7.35	19.06	1.44		
Telecommunication	44	16.65	5.99	15.72	1.40		
Finance, insurance	118	16.69	5.89	15.64	1.45		
Real estate, renting, and leasing	38	17.57	5.63	16.72	1.38		
Business support services	153	17.44	6.03	16.46	1.41		
Public administration and defense	202	20.90	7.25	19.64	1.44		
Education	389	16.39	5.79	15.42	1.42		
Health care, social work	141	17.07	6.01	16.13	1.40		
Arts, recreation, sports	53	17.56	6.55	16.54	1.41		
Other public, repair, and personal services	574	17.85	6.74	16.64	1.47		

(Continues)

TABLE 1 (Continued)

Variable	N	Mean (ng/ml)	SD (ng/ml)	GM (ng/ml)	GSD	Test: t or F	Test: P-value
Occupation							
Managers	135	18.81	6.38	17.76	1.41	131	<.01
Professionals and related workers	770	16.97	5.87	16.01	1.41		
Clerks	594	17.33	6.12	16.32	1.42		
Service workers	441	17.37	6.49	16.22	1.45		
Sales workers	644	17.87	6.56	16.72	1.45		
Skilled agricultural, forestry, and fishery workers	703	23.93	7.33	22.77	1.39		
Craft and related trades workers	464	19.99	7.38	18.65	1.46		
Equipment, machine operating, and assembling workers	403	19.90	6.94	18.71	1.43		
Elementary workers	738	19.48	7.15	18.15	1.47		
Armed forces	17	26.28	6.11	25.63	1.26		

Abbreviations: BMI, body mass index; GM, geometric mean; GSD, geometric standard deviation; *N*, number of measurements; Pr, proportion; SD, standard deviation; SE, standard error.

TABLE 2 Parameters of a regression model on log-transformed vitamin D levels[a]

Variable	Estimate (95% CI) (ng/ml)
Intercept	19.25** (17.08, 21.70)
Sex	
Male	1 (reference)
Female	0.83** (0.81, 0.85)
Age	
20–29	1 (reference)
30–39	1.08** (1.04, 1.12)
40–49	1.11** (1.07, 1.15)
50–59	1.15** (1.10, 1.19)
60–69	1.14** (1.08, 1.19)
BMI	
<23	1 (reference)
23–25	1.03** (1.01, 1.06)
>=25	1.03** (1.01, 1.06)
Year	
2008	1 (reference)
2009	0.95** (0.92, 0.98)
Season	
Spring	1 (reference)
Summer	1.35** (1.29, 1.41)
Autumn	1.30** (1.24, 1.35)
Winter	1.00 (0.96, 1.05)
Latitude	
33°	1 (reference)
34°	1.12* (1.02, 1.23)
35°	0.98 (0.91, 1.05)
36°	0.99 (0.91, 1.06)
37°	0.89** (0.83, 0.96)
38°	0.97 (0.87, 1.07)
Area	
Rural	1 (reference)
Urban	0.95* (0.92, 0.99)
Housing	
House	1 (,)
Apartment	0.96* (0.93, 1.00)
Industry	
Agriculture, forestry, fishery	1 (reference)
Manufacturing	1.00 (0.94, 1.06)
Electricity, gas, water	0.99 (0.90, 1.09)
Construction	1.07* (1.01, 1.13)
Wholesale, retail, maintenance, and repair	1.03 (0.97, 1.10)

TABLE 2 (Continued)

Variable	Estimate (95% CI) (ng/ml)
Accommodation, food, and beverage service	0.99 (0.92, 1.06)
Transportation	1.04 (0.97, 1.12)
Telecommunication	0.95 (0.87, 1.05)
Finance, insurance	0.99 (0.91, 1.08)
Real estate, renting, and leasing	0.99 (0.89, 1.09)
Business support services	1.02 (0.95, 1.09)
Public administration and defense	1.06 (0.99, 1.14)
Education	1.02 (0.96, 1.10)
Health care, social work	1.03 (0.95, 1.11)
Arts, recreation, sports	1.04 (0.95, 1.15)
Other public, repair, and personal services	0.98 (0.93, 1.04)
Occupation	
Managers	1 (reference)
Professionals and related workers	1.01 (0.94, 1.08)
Clerks	1.01 (0.95, 1.09)
Service workers	1.02 (0.94, 1.11)
Sales workers	1.01 (0.94, 1.08)
Skilled agricultural, forestry, and fishery workers	1.20** (1.10, 1.31)
Craft and related trades workers	1.05 (0.97, 1.13)
Equipment, machine operating, and assembling workers	1.03 (0.95, 1.12)
Elementary workers	1.08* (1.01, 1.16)
Armed forces	1.36** (1.21, 1.54)

Abbreviations: BMI, body mass index; CI, confidence interval.

[a]Exponentiated β coefficient from the multiple regression model.

*$P < .05$; **$P < .01$.

latitude tended to present a lower 25(OH)D level, showing a significantly lower level at 37° latitude. Those living in urban areas and apartments showed significantly lower 25(OH)D levels than those living in rural areas and houses. In terms of industry, the "construction" industry showed a significantly 25(OH)D higher level, compared with the "agriculture, forestry, fishery" industries. In terms of occupation, "skilled agricultural, forestry, and fishery workers," "elementary workers," and " those in the armed forces" showed significantly higher 25(OH)D levels compared with "managers."

The exceedance fractions of Q3 level of residuals are presented for the top 10 and bottom 10 ranked combinations of industry and occupation (Table 3). The combination of the "public administration and defense" industry and the "armed forces" occupation showed the highest exceedance fraction of Q3 of residuals (0.71), while the combination of the "manufacturing" industry and the "managers" occupation showed the lowest exceedance fraction (0.06). The results for all combinations of industry and occupation containing 10 or more measurements are presented in Table S1.

4 | DISCUSSION

Blood vitamin D has been used to assess sunlight exposure in workers; however, previous studies have been confined to certain highly exposed occupations.[17] To the best of our knowledge, no systematic study has assessed sunlight exposure using blood vitamin D levels across a wide range of industries and occupations. In the current study, we assessed sunlight exposure across industries and occupations using a nationally representative database that is specific to the Korean working population.

Women are more likely to sunbathe, while they tend to use sunscreen more frequently than men.[25] In our study, women also showed lower vitamin D levels than men. People older than 65 years tend to show the lowest level of sunlight exposure, and aging leads to a decrease in vitamin D production, along with the lowest tendency to use sunscreen.[25,26] However, in the current study, the older adult population (aged 60–69 years) showed the highest level of vitamin D level among the age categories (Table 1). The contradictory result might be because a high proportion of the older adult population was engaged in the "agriculture, forestry, and fishery" industry (51% in aged 60–69). When we further analyzed data in multiple regression analysis models controlling for industry, people aged 60–69 showed a lower vitamin D level than those aged 50–59 (Table 2). BMI has been reported to be negatively associated with vitamin D levels.[27,28] However, our study showed results contradictory to previous studies, which requires further evaluation in future studies.

Latitude affects vitamin D production.[29] South Korea is located between 33°N and 38°N. In our results, higher latitude tended to show lower vitamin D levels. Vitamin D levels are heavily influenced by seasonality.[6,30] We also observed a consistent influence in the current study. The residential area also affects blood vitamin D levels. Those residing in urban areas showed lower vitamin D levels than those residing in rural areas, which is in line with previous studies.[31] In our study, those residing in apartments showed lower vitamin D levels than those living in houses.

Regarding occupational factors, in the current study, those in the armed forces, construction workers, and agricultural workers showed high exceedance fractions, which is consistent with previous studies.[15,16,32] Furthermore, we were able to account for the variability within the industry.

TABLE 3 The fraction of exceeding Q3 level of residuals for selected combinations of industry and occupation (top and bottom 10 ranked)

Industry	Occupation	*N*	Mean (ng/ml)	SD (ng/ml)	GM (ng/ml)	GSD	Exceedance	
							Fraction	SE
High-exposure combinations of industry and occupation								
Public administration and defense	Armed forces	16	26.43	6.16	25.77	1.26	0.71	0.08
Business support services	Service workers	10	17.97	6.97	16.77	1.48	0.46	0.17
Education	Equipment, machine operating, and assembling workers	11	22.92	6.71	21.95	1.38	0.43	0.18
Public administration and defense	Elementary workers	32	22.75	8.59	21.16	1.49	0.40	0.10
Education	Elementary workers	20	19.22	6.46	18.14	1.43	0.39	0.15
Construction	Elementary workers	44	21.61	5.59	20.86	1.32	0.38	0.10
Construction	Craft and related trades workers	103	22.26	8.02	20.80	1.46	0.34	0.05
Agriculture, forestry, fishery	Skilled agricultural, forestry, and fishery workers	698	23.94	7.34	22.77	1.39	0.33	0.03
Wholesale, retail, maintenance, and repair	Elementary workers	58	19.64	6.72	18.51	1.42	0.33	0.07
Telecommunication	Clerks	10	18.77	5.82	17.97	1.37	0.33	0.15
Low-exposure combinations of industry and occupation								
Agriculture, forestry, fishery	Professionals and related workers	55	15.99	5.97	14.97	1.44	0.14	0.05
Transportation	Clerks	13	16.32	2.10	14.46	1.60	0.13	0.09
Business support services	Elementary workers	19	16.56	6.16	15.46	1.47	0.13	0.10
Wholesale, retail, maintenance and repair	Craft and related trades workers	53	19.31	6.50	18.24	1.41	0.13	0.05
Agriculture, forestry, fishery	Service workers	11	20.24	8.11	18.69	1.53	0.13	0.10
Arts, recreation, sports	Professionals and related workers	20	15.16	3.95	14.76	1.26	0.11	0.07
Accommodation, food, and beverage service	Sales workers	19	18.44	6.38	17.42	1.42	0.10	0.07
Other public, repair, and personal services	Equipment, machine operating and assembling workers	14	17.25	5.04	16.58	1.34	0.08	0.05
Telecommunication	Professionals and related workers	12	14.73	4.06	14.22	1.32	0.07	0.07
Manufacturing	Managers	33	18.19	6.47	17.09	1.44	0.06	0.05

Abbreviations: GM, geometric mean; GSD, geometric standard deviation; *N*, number of measurements; Pr, proportion; Q3, the third quartile; SD, standard deviation; SE, standard error.

For instance, we differentiated skilled agricultural workers (exceedance fraction = 0.33) and professional workers (exceedance fraction =0.14) who were all assigned to a common "agriculture, forestry, and fishery" industry (Table 3).

The combination of the "business support services" industry and "service workers" occupation showed a higher exceedance fraction (0.46), while the mean vitamin D level was relatively low (17.97 ng/ml) (Table 3). When we further investigated the cause of the difference, we found that vitamin D samples of the combination were collected mostly between winter and spring (70%), with a high proportion of individuals living in urban areas (90%) and high latitudes (80% in 37°). Thus, we were able to account for the confounding effects of relevant variables. Despite these advantages, we could not assess exceedance fractions in 53 combinations (45%) among the 119 combinations of industry and occupation due to the small number of samples, which is a limitation of this study.

In several studies on vitamin D levels, indoor workers and shift workers have shown a high rate of vitamin D deficiency.[8,32,33] Shift work is associated with decreased exposure to sunlight.[8] In our study, only those working in the afternoon shift showed a significantly lower level after controlling for sex, age, and year, while night shift, rotating shift, and 24-h shift workers showed no significant result (data not shown). Since shift work can be a characteristic of industry or occupation, we did not incorporate it into the analysis model.

Some studies have reported an association between vitamin D levels and education.[19] However, in our data, education level is strongly associated with age (the younger age groups show a higher educational level); therefore, we did not incorporate it as a variable. Education is also an indicator of the socio-economic status, which may affect jobs that are more likely to be associated with exposure to sunlight, such as manual construction workers. The current smoking status was not significantly associated with vitamin D levels (data not shown).

Continuous exposure to UV radiation leads to thickening of the skin and skin pigmentation, which leads to sun protection.[9,34] Outdoor workers, such as farmers and seamen, are continuously exposed to sunlight, leading to skin changes.[9] These changes may counteract the increase in vitamin D production caused by exposure to sunlight to some degree.

Vitamin D is synthesized endogenously when solar UVB radiation causes 7-dehydrocholesterol to 25(OH)D in the skin.[8] Endogenous vitamin D accounts for 90% of the total vitamin D, while vitamin D from food and supplements accounts for the rest.[8] Vitamin D is obtained from foods such as salmon and beef liver, and certain cereals and orange juices are fortified with vitamin D.

5 | CONCLUSIONS

In summary, we evaluated exposure to sunlight across a wide range of industries and occupations in the Korean working population. To do so, we used vitamin D as an exposure surrogate using the KNHANES data, which are national representative data. Our results may aid in prioritizing occupational groups with a high risk of adverse health effects such as skin cancer. Furthermore, the results may provide a source for sunlight exposure assessment in future epidemiological studies.

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DISCLOSURE

The study protocol was reviewed and approved by the Institutional Review Board of the Catholic Kwandong University, International St. Mary's Hospital, Incheon, Korea (IS21EISI0047). The authors declare that there is no conflict of interest.

AUTHOR CONTRIBUTIONS

Koh DH: conceptualization, analysis, writing. Park JH: validation, analysis, review and editing, Lee SG: validation, review and editing, Kim HC: validation, review and editing, Jung H: validation, review and editing, Kim I: validation, review and editing, Choi S: validation, review and editing, Park D: validation, review and editing.

DATA AVAILABILITY STATEMENT

The KNHANES data are available upon request from the KCDC.

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SUPPORTING INFORMATION

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