

# National long-term trends in health-related quality of life using EQ-5D-3L in South Korea, 2008-2021, including the COVID-19 pandemic: a representative serial study of 2.8 million people

H. KIM<sup>1</sup>, M. KIM<sup>2,3</sup>, S.Y. RHEE<sup>2,4</sup>, A. KOYANAGI<sup>5</sup>, L. SMITH<sup>6</sup>, M.S. KIM<sup>7</sup>,  
G. FOND<sup>8</sup>, L. BOYER<sup>8</sup>, S. KIM<sup>9</sup>, J.I. SHIN<sup>10</sup>, L. JACOB<sup>5,11</sup>, J. LEE<sup>12</sup>,  
M. RAHMATI<sup>13,14</sup>, S.G. YEO<sup>15</sup>, D.K. YON<sup>1,2,3,16</sup>

<sup>1</sup>Department of Medicine, Kyung Hee University College of Medicine, Seoul, South Korea

<sup>2</sup>Center for Digital Health, Medical Science Research Institute, Kyung Hee University College of Medicine, Seoul, South Korea

<sup>3</sup>Department of Regulatory Science, Kyung Hee University, Seoul, South Korea

<sup>4</sup>Department of Endocrinology and Metabolism, Kyung Hee University School of Medicine, Seoul, South Korea

<sup>5</sup>Research and Development Unit, Parc Sanitari Sant Joan de Deu, Barcelona, Spain

<sup>6</sup>Centre for Health, Performance and Wellbeing, Anglia Ruskin University, Cambridge, UK

<sup>7</sup>Medical and Population Genetics and Cardiovascular Disease Initiative, Broad Institute of MIT and Harvard, Cambridge, MA, USA

<sup>8</sup>Research Centre on Health Services and Quality of Life, Assistance Publique des Hôpitaux de Marseille, Aix Marseille University, Marseille, France

<sup>9</sup>Department of Family Medicine, Kyung Hee University Medical Center, Kyung Hee University College of Medicine, Seoul, South Korea

<sup>10</sup>Department of Pediatrics, Yonsei University College of Medicine, Seoul, South Korea

<sup>11</sup>Department of Physical Medicine and Rehabilitation, Lariboisière-Fernand Widal Hospital, AP-HP, Université Paris Cité, Paris, France

<sup>12</sup>Department of Biomedical Engineering, Kyung Hee University, Yongin, South Korea

<sup>13</sup>Department of Physical Education and Sport Sciences, Faculty of Literature and Human Sciences, Lorestan University, Khoramabad, Iran

<sup>14</sup>Department of Physical Education and Sport Sciences, Faculty of Literature and Humanities, Vali-E-Asr University of Rafsanjan, Rafsanjan, Iran

<sup>15</sup>Department of Otolaryngology – Head & Neck Surgery, Kyung Hee University Medical Center, Kyung Hee University College of Medicine, Seoul, South Korea

<sup>16</sup>Department of Pediatrics, Kyung Hee University Medical Center, Kyung Hee University College of Medicine, Seoul, South Korea

*H. Kim and M. Kim contributed equally to this study*

**Abstract. – OBJECTIVE:** There is a scarcity of literature investigating the impact of the coronavirus disease 2019 (COVID-19) pandemic on long-term trends in health-related quality of life (HrQoL) using large-scale and representative data. Thus, we aimed to investigate the nationwide and long-term trends in quality of life (QoL) using the European Quality of Life-5 dimensions, 3-level version (EQ-5D-3L) from a Korean representative serial study of 2.8 million people, 2008-2021.

**SUBJECTS AND METHODS:** This Korean study used data on adults between 2008 and 2021 who participated in the Community Health Survey. Timeframes were categorized as COVID-19 mid-pandemic (2021) and pre-pandemic (2008-2019). The mean EQ-5D-3L index for the whole population and subgroups stratified by demographic characters was evaluated for each timeframe, and differences between before and during the COVID-19 pandemic were also analyzed.

*Corresponding Authors:* Dong Keon Yon, MD, FACA, FAAAAI; e-mail: yonkkang@gmail.com;  
Masoud Rahmati, Ph.D; e-mail: rahmati.mas@lu.ac.ir;  
Seung Geun Yeo, MD, Ph.D; e-mail: yeo2park@gmail.com

**RESULTS:** 2,827,240 adults who responded to the survey, 2008-2021, were eligible for this study. Overall EQ-5D index persistently decreased from 2008-2016, then minimally decreased during the pandemic, still being much higher than forecasted before the COVID-19 pandemic. The reduction in the rate of decline in QoL after the COVID-19 outbreak was especially marked in white-collared, young adults, people with 'good' or 'very good' subjective health, and college-educated or above group. On the other hand, the previously increasing trend of QoL in the elderly group has decelerated during the pandemic, and QoL of the 'very bad' subjective health group recorded the lowest among the whole study period.

**CONCLUSIONS:** The present study investigated the long-term trend of QoL in Korean adults using serial data over the past 14 years, with a special emphasis on comparing the pre- and mid-COVID-19 pandemic periods.

*Key Words:*

Adult, COVID-19, Epidemiology, Trends, Quality of life, South Korea, EQ-5D.

## Introduction

The concept of health has moved from a dichotomized status of absence or presence of a disease to the continuum ranging from complete well-being to death<sup>1</sup>. Global life expectancy has been increasing, and it increased by more than 6 years between 2000 and 2019<sup>2</sup>. Therefore, goal of the healthcare professionals in this era is not only to increase the quantity but also the quality of life lived. In other words, estimating people's quality of life (QoL) has become an important matter in the field of healthcare<sup>3</sup>.

Health-related quality of life (HrQoL) is a measure that can be used in the clinical or economic evaluation of the quality of life<sup>4</sup>, for instance, to calculate quality-adjusted life year (QALY), a measurement for the burden of disease. European Quality of Life-5 dimensions (EQ-5D) is a worldwide standardized instrument to estimate HrQoL developed by the European QoL Group and is preferred in various studies because of its applicability and generalizability<sup>5,6</sup>.

Since the start of the COVID-19 pandemic, many countries have imposed strict confinements to prevent the spread of the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2)<sup>7-9</sup>. Social activities were restricted, and schools and workplaces were closed for varying periods of time across the globe<sup>10</sup>. Literature showed that

self-isolation and social distancing resulted in significantly increased levels of depression and anxiety<sup>11</sup>, although this impact may be limited to the early phase of the pandemic<sup>12-14</sup>. While many studies have depicted worsened mental health and reduced physical activity among the general population<sup>15,16</sup>, the consequences of the pandemic on various aspects of the quality of life are still under investigation.

Previous studies<sup>17-21</sup> have reported decreased QoL index among some countries during the pandemic. However, studies comparing pre- and mid-COVID-19 pandemic periods using adequate control are scarce; moreover, no large-scale population-based study has been published thus far<sup>17-21</sup>. Also, long-term serial studies<sup>17-21</sup> are essential to identify the extent to which the COVID-19 pandemic contributed to change in QoL. Therefore, this study aims to examine the nationwide trend of QoL in South Korea using long-term serial and representative data from over two million individuals with an emphasis on comparing pre- and mid-pandemic data. Furthermore, risk factor analysis allows for distinguishing vulnerable groups during the pandemic, which can provide qualified data for policymakers.

## Subjects and Methods

### *Data and Study Population*

Community Health Survey (CHS) is a nationally representative survey of Korean adults (aged 19 and over) conducted by Korean Disease Control and Prevention Agency (KDCA), an organization under the South Korean Ministry of Welfare and Health<sup>22</sup>. CHS is conducted annually by trained interviewers through household visits. This self-reporting online survey targets about 900 adults in each of the 255 public health centers nationwide and consists of 18 domains and 163 questions about health. In 2021, a total of 229,242 subjects were surveyed<sup>22</sup>. The CHS data were anonymous, and the study protocol was approved by the Institutional Review Board of Kyung Hee University (KHUH 2022-06-042) and KDCA. Informed consent was obtained from all study participants.

CHS datasets from 2008 to 2021 were obtained to examine the nationwide trend of the quality of life measured by the validated Korean version of the European Quality of Life-5 dimensions, 3-level version (EQ-5D-3L) items. The CHS dataset in 2020, which omitted EQ-5D-3L items in its

questionnaire, was excluded. Then, for every year of data analyzed, subjects with missing height, weight or BMI were excluded. Therefore, the final sample for data analysis was 2,827,240 adults.

We set groups of consecutive years to stabilize the national prevalence; 2008-2010, 2011-2013, 2014-2016, 2017-2019, and 2021 (COVID-19 pandemic). Since the first COVID-19 case in South Korea was reported in January 2020, we considered 2021 as mid-COVID-19 and the other timeframes as pre-COVID-19<sup>11</sup>.

### **Covariates**

Covariates were considered for the following factors; age group (19-39, 40-59, or  $\geq 60$  years), sex, region of residence (urban or rural)<sup>23</sup>, household income [under 3 million KRW (Korean WON), over 3 million KRW, or unknown], livelihood recipient, body mass index (BMI) group [underweight ( $< 18.5 \text{ kg/m}^2$ ), normal ( $18.5\text{-}23.0 \text{ kg/m}^2$ ), overweight ( $23.0\text{-}25.0 \text{ kg/m}^2$ ), and obese ( $\geq 25.0 \text{ kg/m}^2$ )]<sup>24-27</sup>, smoking (smoker or non-smoker), alcohol consumption (no, 1-4 days per month, 5 days or more per month), depression, occupation (white-collar, blue-collar, or unknown), education (high school or below, or college or above), marital status, subjective stress (very high, high, low, or very low) and subjective health (very good, good, average, bad, very bad, or unknown).

### **Dependent Variables**

CHS questionnaire employed EQ-5D-3L, a worldwide standardized measure of health status developed by the EuroQol Group, in its 'Activity Limitation & Quality of Life' domain. EQ-5D-3L is a preference-based instrument comprising five dimensions (5D); mobility (MO), self-care (SC), usual activities (UA), pain/discomfort (PD), and anxiety/depression (AD). Each dimension has three levels (3L); no problems (level 1), some problems (level 2), and extreme problems (level 3). EQ-5D-3L requires participants to indicate their health state by choosing the most appropriate level in each of the five dimensions.

Dependent variables were the EQ-5D index value and the percentage of subjects who reported having problems in each EQ-5D dimension<sup>28,29</sup>. EQ-5D index is a single summary number for one's health status, in relation to the general population of their country or region. The index is derived from a formula that attaches weights to reported levels in each dimension. To reflect preferences of the general population of a country or

region, different weight sets for EQ-5D-3L have been derived for multiple countries. In this study, we used the South Korean formula adopted by KDCA<sup>29</sup>. The EQ-5D index ranges from 0 to 1, where 1 is given as a value for total health when all five dimensions are reported as level 1 (no problems, i.e., 11111). Otherwise, the index can be calculated by deducting the appropriate weights multiplied by levels from 1.

### **Statistical Analyses**

The mean EQ-5D index and number of people reporting problems in each dimension were evaluated for each timeframe, and the difference between before and during the COVID-19 pandemic was also analyzed. The linear regression model described as  $\beta$ -coefficients with 95% confidence interval (CI) and binary logistic regression model described as odds ratio (OR) with 95% CI were used<sup>30</sup>. Also, we analyzed trend difference comparing before (2008-2019) and during the pandemic (2021) using  $\beta$ -difference and odds ratio with 95% CI. Subgroup analysis was performed separately by age group, sex, region of residence, livelihood recipient, household income, BMI group, smoking, alcohol consumption, depression, occupation, education, marital status, subjective stress, and subjective health. Statistical analyses were conducted using SAS version 9.4 (SAS Inc., Cary, NC, USA) and SPSS version 29.0 (IBM Corp., Armonk, NY, USA). A two-sided  $p$ -value  $< 0.05$  was considered statistically significant<sup>31</sup>.

## **Results**

From 2008 to 2021, except for the 2020 where EQ-5D items were not included in the CHS questionnaire, 2,827,240 adults [mean age (standard deviation; SD) of 51.5 (16.9) years] who fully responded to the survey were eligible for this study. There were 650,530 adults from 2008 to 2010, 647,536 adults from 2011 to 2013, 653,195 adults from 2014 to 2016, 650,660 adults in 2017 to 2019 (all pre-COVID-19), and 225,319 adults in 2021 (mid-COVID-19). Distribution by sex was similar across all timeframes, with 46.5% male and 53.5% female overall (Table I). Age was divided into 3 categories: young (age 19-39), mid-aged (age 40-59), and the elderly (age 60 and over), and each accounted for 26.9%, 39.0%, and 34.1% overall. Table I presents the demographic characteristics of the study population.

**Table I.** Demographic characteristics of the subjects in CHS (total n=2,827,240).

Characteristics	Total	Pre-COVID-19				Mid-COVID-19 pandemic	
		2008-2010	2011-2013	2014-2016	2017-2019	2021	
Age, years, n (%)	19-39	760,374 (26.9)	203,813 (31.3)	182,595 (28.2)	172,001 (26.3)	151,745 (23.3)	50,220 (22.3)
	40-59	1,103,718 (39.0)	258,133 (39.7)	265,615 (41.0)	260,816 (39.9)	240,874 (37.0)	78,280 (34.7)
	≥ 60	963,148 (34.1)	188,584 (29.0)	199,326 (30.8)	220,378 (33.7)	258,041 (39.7)	96,819 (43.0)
Mean age (SD)	51.49 (16.89)	49.32 (16.37)	50.38 (16.43)	51.53 (16.85)	53.67 (17.23)	54.55 (17.58)	
Sex, n (%)	Male	1,315,696 (46.5)	306,264 (47.1)	301,901 (46.6)	304,442 (46.6)	299,189 (46.0)	103,900 (46.1)
	Female	1,511,544 (53.5)	344,266 (52.9)	345,635 (53.4)	348,753 (53.4)	351,471 (54.0)	121,419 (53.9)
Region of residence, n (%)	Urban	1,390,760 (49.2)	315,852 (48.6)	321,456 (49.6)	323,339 (49.5)	320,373 (49.2)	109,740 (48.7)
	Rural	1,436,480 (50.8)	334,678 (51.4)	326,080 (50.4)	329,856 (50.5)	330,287 (50.8)	115,579 (51.3)
Livelihood recipient, n (%)	No	2,730,967 (96.6)	624,225 (96.0)	627,855 (97.0)	632,843 (96.9)	629,927 (96.8)	216,117 (95.9)
	Yes	96,273 (3.4)	26,305 (4.0)	19,681 (3.0)	20,352 (3.1)	20,733 (3.2)	9,202 (4.1)
Household income, n (%)*	Under 3 million KRW	1,239,670 (43.8)	272,949 (42.0)	249,190 (38.5)	357,653 (54.8)	276,717 (42.5)	83,161 (36.9)
	Over 3 million KRW	1,049,159 (37.1)	158,602 (24.4)	212,462 (32.8)	288,893 (44.2)	295,053 (45.3)	94,149 (41.8)
	unknown	538,411 (19.0)	218,979 (33.7)	185,884 (28.7)	6,649 (1.0)	78,890 (12.1)	48,009 (21.3)
BMI, kg/m <sup>2</sup> , n (%)	Underweight (< 18.5)	145,184 (5.1)	37,474 (5.8)	35,990 (5.6)	33,480 (5.1)	28,393 (4.4)	9,847 (4.4)
	Normal (18.5-23.0)	1,248,630 (44.2)	309,284 (47.5)	298,746 (46.1)	289,109 (44.3)	259,473 (39.9)	92,018 (40.8)
	Overweight (23.0-25.0)	692,379 (24.5)	158,689 (24.4)	158,639 (24.5)	160,488 (24.6)	158,824 (24.4)	55,739 (24.7)
	Obese (≥ 25)	741,047 (26.2)	145,083 (22.3)	154,161 (23.8)	170,118 (26.0)	203,970 (31.3)	67,715 (30.1)
Smoking, n (%)	Nonsmoking	2,255,651 (79.8)	497,011 (76.4)	508,324 (78.5)	525,457 (80.4)	536,246 (82.4)	188,613 (83.7)
	Smoking	571,589 (20.2)	153,519 (23.6)	139,212 (21.5)	127,738 (19.6)	114,414 (17.6)	36,706 (16.3)

Continued

Health-related quality of life and COVID-19 pandemic

**Table I (Continued).** Demographic characteristics of the subjects in CHS (total n=2,827,240).

Characteristics	Total	Pre-COVID-19				Mid-COVID-19 pandemic	
		2008-2010	2011-2013	2014-2016	2017-2019	2021	
Alcohol consumption, days/month, n (%)	0	1,350,001 (47.7)	319,593 (49.1)	306,198 (47.3)	300,788 (46.0)	313,618 (48.2)	109,804 (48.7)
	1-4	840,146 (29.7)	193,278 (29.7)	199,511 (30.8)	204,167 (31.3)	193,655 (29.8)	49,535 (22.0)
	5-30	637,093 (22.5)	137,659 (21.2)	141,827 (21.9)	148,240 (22.7)	143,387 (22.0)	65,980 (29.3)
Depression, n (%)	No	2,649,540 (93.7)	604,353 (92.9)	613,315 (94.7)	610,855 (93.5)	611,783 (94.0)	209,234 (92.9)
	Yes	177,700 (6.3)	46,177 (7.1)	34,221 (5.3)	42,340 (6.5)	38,877 (6.0)	16,085 (7.1)
Occupation, n (%)	White-collar	555,536 (19.6)	120,020 (18.4)	127,227 (19.6)	132,576 (20.3)	128,743 (19.8)	46,970 (20.8)
	Blue-collar	1,221,483 (43.2)	268,460 (41.3)	288,655 (44.6)	286,427 (43.9)	283,156 (43.5)	94,785 (42.1)
	Unknown	1,050,221 (37.1)	262,050 (40.3)	231,654 (35.8)	234,192 (35.9)	238,761 (36.7)	83,564 (37.1)
Education, n (%)	High school or below	1,827,727 (64.6)	445,785 (68.5)	424,845 (65.6)	412,082 (63.1)	409,182 (62.9)	135,833 (60.3)
	College or above	999,513 (35.4)	204,745 (31.5)	222,691 (34.4)	241,113 (36.9)	241,478 (37.1)	89,486 (39.7)
Marriage, n (%)	Married	1,996,734 (70.6)	466,982 (71.8)	469,167 (72.5)	460,502 (70.5)	450,239 (69.2)	149,844 (66.5)
	Unmarried	830,506 (29.4)	183,548 (28.2)	178,369 (27.5)	192,693 (29.5)	200,421 (30.8)	75,475 (33.5)
Subjective stress, n (%)	Very high	96,035 (3.4)	23,075 (3.5)	21,165 (3.3)	24,246 (3.7)	20,309 (3.1)	7,240 (3.2)
	High	614,280 (21.7)	150,253 (23.1)	147,818 (22.8)	143,284 (21.9)	129,927 (20.0)	42,998 (19.1)
	Low	1,507,628 (53.3)	341,846 (52.5)	350,380 (54.1)	347,227 (53.2)	347,287 (53.4)	120,888 (53.7)
	Very low	609,297 (21.6)	135,356 (20.8)	128,173 (19.8)	138,438 (21.2)	153,137 (23.5)	54,193 (24.1)
Subjective health, n (%)	Very good	164,628 (5.8)	36,485 (5.6)	38,190 (5.9)	41,070 (6.3)	34,278 (5.3)	14,605 (6.5)
	Good	946,538 (33.5)	240,799 (37.0)	222,959 (34.4)	205,431 (31.5)	199,703 (30.7)	77,646 (34.5)
	Average	1,166,975 (41.3)	243,670 (37.5)	260,650 (40.3)	278,750 (42.7)	287,890 (44.2)	96,015 (42.6)
	Bad	439,324 (15.5)	105,254 (16.2)	100,508 (15.5)	98,947 (15.1)	104,224 (16.0)	30,391 (13.5)
	Very bad	109,352 (3.9)	24,049 (3.7)	25,170 (3.9)	28,958 (4.4)	24,517 (3.8)	6,658 (3.0)
	Unknown	423 (0.0)	273 (0.0)	59 (0.0)	39 (0.0)	48 (0.0)	4 (0.0)

BMI, body mass index; CHS, community health service. \*Three million KRW is worth approximately \$2,400 (USD) in Jan 2023.



Table II shows the mean and 95% CI of the EQ-5D index of each demographic characteristic for each timeframe. While the overall EQ-5D index declined from 2008 to 2016 and then slightly increased from 2017 to 2019, during the COVID-19 pandemic, the decrease clearly slowed down ( $\beta_{diff}$  0.219; 95% CI, 0.192 to 0.245). This slowing decrease was consistent among most subgroups, but particularly among the white-collared ( $\beta_{diff}$  1.083; 95% CI, 0.942 to 1.223), young ( $\beta_{diff}$  0.909; 95% CI, 0.796 to 1.022), with 'good' ( $\beta_{diff}$  0.805; 95% CI, 0.705 to 0.905) or 'very good' ( $\beta_{diff}$  0.531; 95% CI, 0.242 to 0.820) subjective health, and college-educated or above ( $\beta_{diff}$  0.792; 95% CI, 0.708 to 0.877) groups, whose EQ-5D index slope showed the biggest change. Quality of life actually improved in the obese ( $\beta$ , 0.050; 95% CI, 0.037 to 0.064), those who frequently drink ( $\beta$ , 0.208; 95% CI, 0.184 to 0.232), were depressed ( $\beta$ , 0.038; 95% CI, 0.018 to 0.057), and with 'very high' level of subjective stress ( $\beta$ , 0.031; 95% CI, 0.006 to 0.056) groups; their EQ-5D index turned to an increasing trend during the pandemic.

Only the elderly and the 'very bad' subjective health group showed the opposite change. During the pandemic, observed increase in EQ-5D index of the elderly group was less than forecasted before the pandemic ( $\beta_{diff}$ , -0.172; 95% CI, -0.206 to -0.139). EQ-5D index of the 'very bad' subjective health group turned to decline during the pandemic ( $\beta_{diff}$ , -0.274; 95% CI, -0.336 to -0.212), which marked the lowest value among the whole study period.

**Supplementary Table I** describes the prevalence of problems in each EQ-5D dimension for each timeframe. Less adults reported problems in mobility (MO;  $\beta$ , -0.011; 95% CI, -0.013 to -0.008), self-care (SC;  $\beta$ , -0.012; 95% CI, -0.017 to -0.008) and usual activity (UA;  $\beta$ , -0.012; 95% CI, -0.015 to -0.009) dimensions during the pandemic, while prevalence increased in pain/discomfort (PD;  $\beta$ , 0.026; 95% CI, 0.024 to 0.028) and anxiety/depression (AD;  $\beta$ , 0.018; 95% CI, 0.015 to 0.020) dimensions. However, for every dimension, overall  $\beta_{diff}$  compared before and during the pandemic showed a negative value, which means that the pandemic has ameliorated subjective problems in all dimensions.

Subgroup analysis showed consistent health discrepancy in each dimension between the age groups. Directly opposite to the overall and young group's trend, the pandemic has accelerated the increasing prevalence or decreased problems in all five dimensions. The largest  $\beta_{diff}$  for the

elderly group was observed in the anxiety/depression dimension ( $\beta_{diff}$  -0.018; 95% CI, -0.023 to -0.013). No trend difference was observed between male and female groups for any dimension.

## Discussion

### Findings of Our Study

To our knowledge, this study is the first long-term, large-scale, and general population-based study to investigate the national trend of the QoL of Korean adults. Using a population-based and representative dataset of 2,827,240 Korean adults, this study also investigated the influence of the COVID-19 pandemic. In this study, the result indicates that the overall EQ-5D index persistently decreased from 2008 to 2016, then minimally decreased during the pandemic, still being much higher than forecasted before the COVID-19 pandemic. Subgroups stratified by sex, region of residence, household income, livelihood recipient, smoking, occupation, education, and marriage all showed similar rates during the COVID-19 pandemic. This slowing decrease in QoL after the COVID-19 outbreak is especially marked in white-collared, young, of 'good' or 'very good' subjective health, and college-educated or above group. In comparison, the COVID-19 pandemic has decelerated the increase of QoL in the elderly and significantly worsened the QoL in 'very bad' subjective health group.

Further analysis identified that fewer adults reported problems in mobility, self-care, and usual activity dimensions. While prevalence still increased in pain/discomfort and anxiety/depression dimensions, the pace of increase slowed during the pandemic. However, for the elderly, the pandemic has either accelerated the increasing prevalence or decreased problems in all dimensions.

### Comparison with Previous Studies

Several studies have reported the trend of HRQoL during the pandemic. Most showed lowered QoL among adults (US,  $n=2,746^{18}$ ; Estonia,  $n=1,781^{19}$ ; Hong Kong,  $n=503^{20}$ ,  $n=1,048$ ; Japan,  $n=826^{21}$ ; and Morocco,  $n=537^{17}$ ) while a few described unchanged (China,  $n=1,139^{32}$  and Singapore,  $n=81^{33}$ ) or improved (Korea,  $n=1,139^{34}$ ) results. Many studies suggested various factors (i.e., comorbidities, lower education, women, lower economic status, unmarried, and worries for COVID-19 infection) associated with low-

Health-related quality of life and COVID-19 pandemic

**Table II.** Stratified mean EQ-5D index trend (95% CI), by period, 2008-2021.

	Pre-COVID-19				Mid-COVID-19 pandemic 2021	Trend before entering the COVID-19 pandemic, $\beta$ (95% CI)	Trend after entering the COVID-19 pandemic, $\beta$ (95% CI)	Trend difference, $\beta$ diff (95% CI)
	2008-2010	2011-2013	2014-2016	2017-2019				
<b>Overall</b>	0.943 (0.943 to 0.944)	0.937 (0.936 to 0.937)	0.931 (0.931 to 0.931)	0.935 (0.935 to 0.935)	0.933 (0.933 to 0.934)	-0.242 (-0.253 to -0.231)	-0.024 (-0.031 to -0.016)	<b>0.219 (0.192 to 0.245)</b>
<b>Age, years</b>								
19-39	0.985 (0.985 to 0.985)	0.979 (0.979 to 0.979)	0.975 (0.975 to 0.975)	0.978 (0.978 to 0.978)	0.976 (0.975 to 0.976)	-1.027 (-1.072 to -0.981)	-0.118 (-0.151 to -0.084)	<b>0.909 (0.796 to 1.022)</b>
40-59	0.965 (0.965 to 0.965)	0.960 (0.960 to 0.960)	0.958 (0.957 to 0.958)	0.963 (0.963 to 0.964)	0.962 (0.961 to 0.962)	-0.126 (-0.151 to -0.102)	-0.054 (-0.073 to -0.035)	<b>0.072 (0.010 to 0.135)</b>
≥ 60	0.869 (0.868 to 0.869)	0.867 (0.866 to 0.868)	0.865 (0.864 to 0.866)	0.884 (0.883 to 0.884)	0.889 (0.888 to 0.889)	0.211 (0.197 to 0.225)	0.039 (0.030 to 0.048)	<b>-0.172 (-0.206 to -0.139)</b>
<b>Sex</b>								
Male	0.958 (0.957 to 0.958)	0.953 (0.952 to 0.953)	0.948 (0.948 to 0.949)	0.952 (0.951 to 0.952)	0.951 (0.950 to 0.951)	-0.222 (-0.240 to -0.204)	-0.016 (-0.028 to -0.003)	<b>0.206 (0.163 to 0.249)</b>
Female	0.931 (0.930 to 0.931)	0.923 (0.922 to 0.923)	0.916 (0.915 to 0.916)	0.921 (0.921 to 0.922)	0.919 (0.918 to 0.919)	-0.248 (-0.262 to -0.234)	-0.030 (-0.040 to -0.020)	<b>0.218 (0.184 to 0.252)</b>
<b>Region of residence</b>								
Urban	0.955 (0.955 to 0.956)	0.946 (0.945 to 0.946)	0.942 (0.941 to 0.942)	0.945 (0.945 to 0.946)	0.942 (0.942 to 0.943)	-0.331 (-0.348 to -0.313)	-0.048 (-0.060 to -0.036)	<b>0.283 (0.241 to 0.325)</b>
Rural	0.932 (0.932 to 0.933)	0.928 (0.928 to 0.928)	0.920 (0.920 to 0.921)	0.925 (0.925 to 0.926)	0.925 (0.924 to 0.926)	-0.191 (-0.206 to -0.177)	-0.005 (-0.015 to 0.005)	<b>0.186 (0.152 to 0.221)</b>
<b>Household income</b>								
Under 3 million KRW	0.921 (0.921 to 0.922)	0.905 (0.904 to 0.906)	0.904 (0.903 to 0.904)	0.899 (0.898 to 0.899)	0.892 (0.891 to 0.893)	-0.369 (-0.382 to -0.356)	-0.049 (-0.058 to -0.040)	<b>0.320 (0.287 to 0.352)</b>
Over 3 million KRW	0.973 (0.973 to 0.974)	0.967 (0.967 to 0.968)	0.964 (0.964 to 0.965)	0.967 (0.966 to 0.967)	0.963 (0.962 to 0.963)	-0.365 (-0.392 to -0.338)	-0.118 (-0.136 to -0.101)	<b>0.247 (0.183 to 0.311)</b>
Unknown	0.949 (0.948 to 0.949)	0.944 (0.944 to 0.945)	0.944 (0.941 to 0.947)	0.946 (0.946 to 0.947)	0.947 (0.946 to 0.948)	-0.090 (-0.116 to -0.064)	0.017 (-0.009 to 0.043)	<b>0.107 (0.033 to 0.180)</b>
<b>Livelihood recipient</b>								
No	0.948 (0.948 to 0.949)	0.941 (0.940 to 0.941)	0.935 (0.935 to 0.935)	0.939 (0.939 to 0.939)	0.938 (0.938 to 0.939)	-0.293 (-0.305 to -0.282)	-0.012 (-0.020 to -0.004)	<b>0.281 (0.253 to 0.310)</b>
Yes	0.826 (0.823 to 0.828)	0.815 (0.812 to 0.818)	0.803 (0.800 to 0.806)	0.818 (0.815 to 0.821)	0.820 (0.816 to 0.824)	-0.119 (-0.156 to -0.083)	0.011 (-0.015 to 0.036)	<b>0.130 (0.040 to 0.219)</b>

Continued

**Table II (Continued).** Stratified mean EQ-5D index trend (95% CI), by period, 2008-2021.

	Pre-COVID-19				Mid-COVID-19 pandemic 2021	Trend before entering the COVID-19 pandemic, $\beta$ (95% CI)	Trend after entering the COVID-19 pandemic, $\beta$ (95% CI)	Trend difference, $\beta$ diff (95% CI)
	2008-2010	2011-2013	2014-2016	2017-2019				
<b>BMI, kg/m<sup>2</sup></b>								
Underweight (< 18.5)	0.905 (0.903 to 0.907)	0.903 (0.902 to 0.905)	0.895 (0.893 to 0.897)	0.907 (0.905 to 0.909)	0.897 (0.894 to 0.901)	-0.022 (-0.055 to 0.011)	-0.067 (-0.094 to -0.041)	-0.045 (-0.129 to 0.039)
Normal (18.5-23.0)	0.946 (0.946 to 0.947)	0.940 (0.940 to 0.941)	0.934 (0.933 to 0.934)	0.939 (0.939 to 0.940)	0.934 (0.933 to 0.934)	-0.249 (-0.266 to -0.233)	-0.075 (-0.087 to -0.063)	<b>0.174 (0.133 to 0.215)</b>
Overweight (23.0-25.0)	0.949 (0.948 to 0.949)	0.940 (0.940 to 0.941)	0.935 (0.935 to 0.936)	0.940 (0.939 to 0.940)	0.938 (0.937 to 0.939)	-0.305 (-0.329 to -0.281)	-0.023 (-0.040 to -0.007)	<b>0.281 (0.224 to 0.339)</b>
Obese ( $\geq$ 25)	0.940 (0.940 to 0.941)	0.934 (0.933 to 0.935)	0.929 (0.929 to 0.930)	0.931 (0.930 to 0.931)	0.934 (0.934 to 0.935)	-0.265 (-0.287 to -0.244)	0.050 (0.037 to 0.064)	<b>0.315 (0.264 to 0.367)</b>
<b>Smoking</b>								
Nonsmoking	0.938 (0.937 to 0.938)	0.931 (0.931 to 0.932)	0.926 (0.926 to 0.926)	0.931 (0.931 to 0.931)	0.930 (0.929 to 0.930)	-0.188 (-0.200 to -0.176)	-0.016 (-0.024 to -0.008)	<b>0.172 (0.143 to 0.201)</b>
Smoking	0.961 (0.961 to 0.962)	0.957 (0.956 to 0.957)	0.951 (0.951 to 0.952)	0.955 (0.954 to 0.956)	0.952 (0.951 to 0.953)	-0.302 (-0.331 to -0.272)	-0.051 (-0.073 to -0.029)	<b>0.250 (0.177 to 0.324)</b>
<b>Alcohol, days/month</b>								
0	0.918 (0.917 to 0.918)	0.909 (0.908 to 0.909)	0.900 (0.900 to 0.901)	0.907 (0.907 to 0.908)	0.905 (0.904 to 0.906)	-0.221 (-0.234 to -0.208)	-0.021 (-0.030 to -0.012)	<b>0.200 (0.168 to 0.232)</b>
1-4	0.970 (0.970 to 0.971)	0.964 (0.964 to 0.964)	0.959 (0.959 to 0.960)	0.963 (0.962 to 0.963)	0.954 (0.953 to 0.954)	-0.507 (-0.537 to -0.477)	-0.225 (-0.245 to -0.206)	<b>0.282 (0.210 to 0.354)</b>
5-30	0.965 (0.964 to 0.965)	0.959 (0.958 to 0.959)	0.954 (0.954 to 0.955)	0.959 (0.959 to 0.960)	0.966 (0.965 to 0.966)	-0.322 (-0.354 to -0.290)	0.208 (0.184 to 0.232)	<b>0.530 (0.450 to 0.611)</b>
<b>Depression</b>								
No	0.952 (0.952 to 0.952)	0.943 (0.943 to 0.944)	0.939 (0.938 to 0.939)	0.942 (0.942 to 0.943)	0.941 (0.941 to 0.942)	-0.325 (-0.337 to -0.312)	-0.016 (-0.024 to -0.007)	<b>0.309 (0.279 to 0.339)</b>
Yes	0.832 (0.830 to 0.834)	0.819 (0.817 to 0.821)	0.819 (0.817 to 0.821)	0.824 (0.822 to 0.826)	0.831 (0.828 to 0.834)	-0.078 (-0.104 to -0.052)	0.038 (0.018 to 0.057)	<b>0.116 (0.050 to 0.181)</b>
<b>Occupation</b>								
White-collar	0.986 (0.986 to 0.987)	0.980 (0.980 to 0.981)	0.976 (0.976 to 0.977)	0.978 (0.978 to 0.978)	0.975 (0.974 to 0.975)	-1.307 (-1.366 to -1.248)	-0.224 (-0.263 to -0.186)	<b>1.083 (0.942 to 1.223)</b>
Blue-collar	0.962 (0.961 to 0.962)	0.953 (0.952 to 0.953)	0.947 (0.947 to 0.948)	0.952 (0.951 to 0.952)	0.950 (0.950 to 0.951)	-0.538 (-0.561 to -0.515)	-0.038 (-0.054 to -0.022)	<b>0.500 (0.444 to 0.556)</b>
Unknown	0.905 (0.904 to 0.905)	0.893 (0.892 to 0.894)	0.885 (0.885 to 0.886)	0.892 (0.892 to 0.893)	0.891 (0.890 to 0.892)	-0.210 (-0.223 to -0.196)	-0.011 (-0.020 to -0.001)	<b>0.199 (0.166 to 0.232)</b>

Continued



Health-related quality of life and COVID-19 pandemic

**Table II (Continued).** Stratified mean EQ-5D index trend (95% CI), by period, 2008-2021.

	Pre-COVID-19				Mid-COVID-19 pandemic 2021	Trend before entering the COVID-19 pandemic, $\beta$ (95% CI)	Trend after entering the COVID-19 pandemic, $\beta$ (95% CI)	Trend difference, $\beta$ diff (95% CI)
	2008-2010	2011-2013	2014-2016	2017-2019				
<b>Education</b>								
High school or below	0.925 (0.924 to 0.925)	0.916 (0.916 to 0.917)	0.907 (0.906 to 0.907)	0.913 (0.912 to 0.913)	0.909 (0.908 to 0.910)	-0.292 (-0.304 to -0.280)	-0.034 (-0.042 to -0.025)	<b>0.259 (0.230 to 0.287)</b>
College or above	0.983 (0.983 to 0.983)	0.976 (0.976 to 0.976)	0.972 (0.972 to 0.972)	0.974 (0.973 to 0.974)	0.970 (0.970 to 0.971)	-0.943 (-0.979 to -0.908)	-0.151 (-0.174 to -0.128)	<b>0.792 (0.708 to 0.877)</b>
<b>Marriage</b>								
Married	0.950 (0.950 to 0.951)	0.943 (0.943 to 0.943)	0.938 (0.938 to 0.938)	0.943 (0.943 to 0.943)	0.942 (0.941 to 0.942)	-0.257 (-0.271 to -0.243)	-0.019 (-0.029 to -0.009)	<b>0.237 (0.203 to 0.272)</b>
Unmarried	0.925 (0.924 to 0.926)	0.920 (0.920 to 0.921)	0.914 (0.913 to 0.915)	0.918 (0.917 to 0.918)	0.917 (0.916 to 0.918)	-0.176 (-0.193 to -0.158)	-0.009 (-0.021 to 0.003)	<b>0.166 (0.124 to 0.209)</b>
<b>Subjective stress</b>								
Very high	0.854 (0.851 to 0.857)	0.845 (0.842 to 0.848)	0.841 (0.838 to 0.844)	0.847 (0.844 to 0.849)	0.853 (0.849 to 0.858)	-0.072 (-0.106 to -0.039)	0.031 (0.006 to 0.056)	<b>0.104 (0.020 to 0.188)</b>
High	0.924 (0.923 to 0.925)	0.913 (0.913 to 0.914)	0.907 (0.906 to 0.908)	0.912 (0.911 to 0.913)	0.910 (0.908 to 0.911)	-0.254 (-0.273 to -0.234)	-0.023 (-0.037 to -0.008)	<b>0.231 (0.182 to 0.280)</b>
Low	0.958 (0.957 to 0.958)	0.951 (0.951 to 0.952)	0.947 (0.946 to 0.947)	0.949 (0.949 to 0.950)	0.947 (0.946 to 0.947)	-0.347 (-0.365 to -0.329)	-0.051 (-0.063 to -0.038)	<b>0.296 (0.252 to 0.340)</b>
Very low	0.944 (0.943 to 0.944)	0.939 (0.938 to 0.939)	0.932 (0.931 to 0.932)	0.934 (0.934 to 0.935)	0.933 (0.932 to 0.934)	-0.296 (-0.320 to -0.272)	-0.016 (-0.031 to -0.001)	<b>0.280 (0.222 to 0.338)</b>
<b>Subjective health</b>								
Very good	0.991 (0.991 to 0.992)	0.989 (0.988 to 0.989)	0.985 (0.985 to 0.986)	0.987 (0.987 to 0.988)	0.984 (0.984 to 0.985)	-0.811 (-0.927 to -0.695)	-0.280 (-0.366 to -0.194)	<b>0.531 (0.242 to 0.820)</b>
Good	0.985 (0.985 to 0.985)	0.979 (0.979 to 0.980)	0.976 (0.976 to 0.977)	0.977 (0.977 to 0.978)	0.973 (0.973 to 0.974)	-1.038 (-1.080 to -0.997)	-0.233 (-0.261 to -0.205)	<b>0.805 (0.705 to 0.905)</b>
Average	0.962 (0.961 to 0.962)	0.953 (0.953 to 0.954)	0.949 (0.949 to 0.950)	0.952 (0.952 to 0.953)	0.945 (0.944 to 0.945)	-0.561 (-0.586 to -0.535)	-0.197 (-0.214 to -0.181)	<b>0.363 (0.303 to 0.424)</b>
Bad	0.856 (0.855 to 0.857)	0.848 (0.847 to 0.849)	0.841 (0.840 to 0.842)	0.850 (0.849 to 0.851)	0.835 (0.833 to 0.836)	-0.142 (-0.165 to -0.120)	-0.120 (-0.135 to -0.105)	0.022 (-0.032 to 0.077)
Very bad	0.646 (0.642 to 0.649)	0.662 (0.659 to 0.666)	0.663 (0.660 to 0.666)	0.679 (0.676 to 0.682)	0.640 (0.634 to 0.647)	0.172 (0.147 to 0.198)	-0.102 (-0.120 to -0.084)	<b>-0.274 (-0.336 to -0.212)</b>
Unknown	0.941 (0.923 to 0.959)	0.932 (0.903 to 0.962)	0.972 (0.955 to 0.988)	0.927 (0.893 to 0.960)	0.978 (0.909 to 1.047)	-0.030 (-0.778 to 0.717)	0.294 (-0.378 to 0.967)	0.324 (-1.687 to 2.336)

BMI, body mass index; CI, confidence interval. Estimated  $\beta$  (95% CI) was derived using linear regression model. Bold numbers indicate statistical significance ( $p < 0.05$ ).

er QoL, almost uniformly implicating that the COVID-19 pandemic has deteriorated health inequalities<sup>19,35,36</sup>. However, none of the above-analyzed long-term trends and samples were not representative. Conversely, the present study benefits from the population-based representative sample of 2,827,240 Korean adults with serial data since 2008.

Apart from the finding that COVID-19 slowed the decline of overall QoL in Korea, subgroups that benefitted the most or the least in this study are the same as those identified in previous studies. People with high socioeconomic status, including young, white-collared, healthy, and well-educated groups, benefitted more during the pandemic. The fact that studies conducted in Korea during the pandemic concluded enhanced QoL among Korean adults supports the present findings<sup>34</sup>.

#### **Possible Explanations of Our Results**

The COVID-19 pandemic had an ameliorating effect on the decreasing EQ-5D index among Korean adults, which can possibly be explained by several components. Being one of the most technologically advanced countries, the Korean society has both rapidly and efficiently reformed as a minimal-contact society with the aid of already-existing infrastructures, such as delivery app, online market, and social network services. Public schools and universities officially shifted to online classes, and telecommuting workers increased tenfold during the pandemic. Frequent lockdowns due to the COVID outbreaks at the workplace allowed normally commuting workers to spend many weeks at home as well, resulting in the new-coined word, ‘COVID-19 vacation’<sup>37</sup>. Accompanied physical comfort and lessened business interactions may explain why all kinds of occupations, but the particularly white-collared group that could take advantage of telecommuting appears to have benefitted the most during the pandemic in the present study<sup>8</sup>. The age-specific death rate of COVID-19 would have both brought relief to young people and locked up the elderly more than ever at the same time. People with underlying diseases also had to face the biggest threat of COVID-19 infection, which could be fatal to them. A previous study has reported that anxiety and depression during the pandemic were greater in those with pre-existing mental/physical health conditions. Also, individuals with pre-existing health conditions faced the most significant risk of contracting

potentially fatal COVID-19 infections. A prior study<sup>38</sup> has indicated that anxiety and depression levels were notably higher during the pandemic among those with pre-existing mental or physical health issues. Accordingly, in our study, the elderly and people with ‘very bad’ subjective health states were the only subgroups that showed opposite QoL slope change during the pandemic<sup>39</sup>.

#### **Policy Implications**

During a crisis, vulnerable groups with fewer resources become even more marginalized. Although the average QoL of Korean adults has benefitted from the pandemic, the elderly and the ‘very bad’ subjective health group reported more problems in various aspects and the worst QoL score during the pandemic, respectively. Pandemics can worsen health disparity and may result in a further polarized society. Therefore, besides providing medical support for vulnerable groups, the government must investigate and consider economically or socially susceptible groups before implementing new policies.

Digital accessibility plays an important role in achieving equality in the post-COVID-19 society, where many face-to-face activities have become digitalized<sup>40</sup>. A study<sup>41</sup> revealed that social interaction could alleviate the symptoms of depression and anxiety amidst the COVID-19 pandemic. Still, this benefit would have been primarily accessible to the digitally literate young population in Korean society. We suggest the government target the elderly to increase digital literacy by providing formal education and opportunities to utilize smart devices. Also, policymakers should develop guidelines to ensure that the elderly are not left out. Public affairs such as vaccine reservations or health guidance systems always need to offer face-to-face options together.

The long-term trend of the mean QoL in Korean adults is consistently declining. Although this decrease in QoL slowed down during the COVID-19 pandemic, the government must prepare for the post-COVID-19 era that may accompany the abrupt decrease in QoL. Particular focus should be on groups that benefitted temporarily during the pandemic.

As of 2023, many countries, including South Korea, have ended massive quarantines and lifted the ban on wearing face masks. While inheriting the technology and convenience COVID-19 has brought to society, it is important to understand and overcome the barriers that keep the vulnerable behind.

### **Limitations and Strengths**

There are several limitations of this study that deserve mention. First, it is noteworthy that only 2021 was included as mid-pandemic year in the present study because EQ-5D items were not included in the 2020 survey<sup>8</sup>. While pre-pandemic data was set in groups of three consecutive years to stabilize the prevalence, mid-pandemic data lacks this stabilization. Moreover, conditions other than the COVID-19 pandemic could have ameliorated the previously decreasing QoL of Korean adults. Our study does not prove causal relationship, and the survey did not include detailed explanations of the QoL state. Third, as the study population only consisted of adults living in South Korea, the result shows only a nationwide tendency. This may differ from the global trend. Fourth, the study participants were living in the community, and therefore, the results may not be generalized to those living in institutions. Finally, the present study only includes pre- to mid-pandemic data<sup>42</sup>, so continuous monitoring of QoL trend is required.

Nevertheless, the present study has many strengths, being the first study to establish the long-term trend of QoL in Korea using a nationwide dataset of 2,827,240 adults. Describing the change for 14 years starting from 2008 to 2021, we also compared the pre- and mid-pandemic results to identify the impact of the COVID-19 pandemic on the QoL of Korean adults. The findings of our study may be reflected in future policies to increase life quality and reconcile the discrepancy among adults in South Korea.

### **Conclusions**

The present study investigated the long-term trend of QoL of Korean adults using a serial data over the past 14 years, with a special emphasis on comparing the pre- and mid- COVID-19 pandemic periods. While the overall QoL index has demonstrated a decreasing trend, during the COVID-19 pandemic, rate of decline was less than what was expected before the outbreak of the pandemic. Further analysis implicates that white-collared, young, of good subjective health and well-educated were the most benefitted groups during the pandemic. In comparison, previously improving QoL trend of the elderly slowed down during the pandemic, reporting largest increase in anxiety/depression dimension. Also, QoL of the ‘very bad’ subjective health group turned to decline for

the first time during the pandemic, recording the lowest value of all times among the study period. Future studies might want to follow up the QoL trend to further examine its association with suspected risk factors.

---

### **Conflict of Interest**

The authors declare that they have no conflict of interests.

---

### **Funding**

This research was supported by a grant of the Korea Health Technology R&D Project through the Korea Health Industry Development Institute (KHIDI), funded by the Ministry of Health & Welfare, Republic of Korea (grant number: HV22C0233). The funders had no role in study design, data collection, data analysis, data interpretation, or writing of the report.

---

### **Ethics Approval**

The CHS data were anonymous, and the study protocol was approved by the Institutional Review Board of Kyung Hee University (KHUH 2022-06-042) and Korea Disease Control and Prevention Agency.

---

### **Informed Consent**

Every participant provided written informed consent, and the study protocol was performed in accordance with the Declaration of Helsinki.

---

### **Authors' Contribution**

Dr Dong Keon Yon had full access to all of the data in the study and took responsibility for the integrity of the data and the accuracy of the data analysis. All authors approved the final version before submission. Study concept and design: Hakyoun Kim, Minji Kim, and Dong Keon Yon; Acquisition, analysis, or interpretation of data: Hakyoun Kim, Minji Kim, and Dong Keon Yon; Drafting of the manuscript: Hakyoun Kim, Minji Kim, and Dong Keon Yon; Critical revision of the manuscript for important intellectual content: Hakyoun Kim, Minji Kim, Sang Youl Rhee, Ai Koyanagi, Lee Smith, Min Seo Kim, Guillaume Fond, Laurent Boyer, Sunyoung Kim, Jae Il Shin, Louis Jacob, Jinseok Lee, Masoud Rahmati, Seung Geun Yeo, Dong Keon Yon; Statistical analysis: Hakyoun Kim, Minji Kim, and Dong Keon Yon; Study supervision: Masoud Rahmati, Seung Geun Yeo, and Dong Keon Yon. Dong Keon Yon supervised the study and is guarantor for this study. Dong Keon Yon is a senior author. The corresponding author attests that all listed authors meet authorship criteria and that no others meeting the criteria have been omitted.

---

### **Availability of Data and Materials**

Data are available on reasonable request. Study protocol, statistical code: available from Dong Keon Yon (email: yon-

kkang@gmail.com). Data set: available from the Korean Disease Control and Prevention Agency (KDCA) through a data use agreement.

### ORCID ID

Hakyong Kim: 0009-0009-8180-1208  
 Minji Kim: 0000-0003-0293-0570  
 Sang Youl Rhee: 0000-0003-0119-5818  
 Ai Koyanagi: 0000-0002-9565-5004  
 Lee Smith: 0000-0002-5340-9833  
 Min Seo Kim: 0000-0003-2115-7835  
 Guillaume Fond: 0000-0003-3249-2030  
 Laurent Boyer: 0000-0003-1229-6622  
 Sunyoung Kim: 0000-0003-4115-4455  
 Jae Il Shin: 0000-0003-2326-1820  
 Louis Jacob: 0000-0003-1071-1239  
 Jinseok Lee: 0000-0002-8580-490X  
 Masoud Rahmati: 0000-0003-4792-027X  
 Seung Geun Yeo: 0000-0001-8021-1024  
 Dong Keon Yon: 0000-0003-1628-9948

### References

- Sartorius N. The meanings of health and its promotion. *Croat Med J* 2006; 47: 662-664.
- GBD 2019 Ageing Collaborators. Global, regional, and national burden of diseases and injuries for adults 70 years and older: systematic analysis for the Global Burden of Disease 2019 Study. *BMJ* 2022; 376: e068208.
- Monk BJ, Tewari KS, Dubot C, Caceres MV, Hasegawa K, Shapira-Frommer R, Salman P, Yañez E, Gümüş M, Hurtado de Mendoza MO, Samouëlian V, Castonguay V, Arkhipov A, Tekin C, Li K, Martin Nguyen A, Monberg MJ, Colombo N, Lorusso D. Health-related quality of life with pembrolizumab or placebo plus chemotherapy with or without bevacizumab for persistent, recurrent, or metastatic cervical cancer (KEYNOTE-826): a randomised, double-blind, placebo-controlled, phase 3 trial. *Lancet Oncol* 2023; 24: 392-402.
- Kaplan RM, Hays RD. Health-Related Quality of Life Measurement in Public Health. *Annu Rev Public Health* 2022; 43: 355-373.
- Payakachat N, Ali MM, Tilford JM. Can The EQ-5D Detect Meaningful Change? A Systematic Review. *Pharmacoeconomics* 2015; 33: 1137-1154.
- Cha Y, Jung W, Seo M, Rahmati M. The emerging pandemic recent: SARS-CoV-2. *Life Cycle* 2023; 3: e2.
- Anderson RM, Heesterbeek H, Klinkenberg D, Hollingsworth TD. How will country-based mitigation measures influence the course of the COVID-19 epidemic? *Lancet* 2020; 395: 931-934.
- Shin H, Park S, Yon H, Ban CY, Turner S, Cho SH, Shin YH, Shin JU, Koyanagi A, Jacob L, Smith L, Min C, Lee YJ, Kim SY, Lee J, Kwon R, Koo MJ, Fond G, Boyer L, Hahn JW, Kim N, Rhee SY, Shin JI, Woo HG, Park H, Kim HJ, Lee Y, Kim MS, Lefkir E, Hadalin V, Choi J, Lee SW, Yon DK, Kim S. Estimated prevalence and trends in smoking among adolescents in South Korea, 2005-2021: a nationwide serial study. *World J Pediatr* 2023; 19: 366-377.
- Rahmati M, Yon DK, Lee SW, Butler L, Koyanagi A, Jacob L, Shin JI, Smith L. Effects of COVID-19 vaccination during pregnancy on SARS-CoV-2 infection and maternal and neonatal outcomes: A systematic review and meta-analysis. *Rev Med Virol* 2023; 33: e2434.
- Lee SW, Yuh WT, Yang JM, Cho YS, Yoo IK, Koh HY, Marshall D, Oh D, Ha EK, Han MY, Yon DK. Nationwide Results of COVID-19 Contact Tracing in South Korea: Individual Participant Data From an Epidemiological Survey. *JMIR Med Inform* 2020; 8: e20992.
- Lee SW, Yang JM, Moon SY, Kim N, Ahn YM, Kim JM, Shin JI, Suh DI, Yon DK. Association between mental illness and COVID-19 in South Korea: a post-hoc analysis. *Lancet Psychiatry* 2021; 8: 271-272.
- Daly M, Robinson E. Depression and anxiety during COVID-19. *Lancet* 2022; 399: 518.
- Fancourt D, Steptoe A, Bu F. Trajectories of anxiety and depressive symptoms during enforced isolation due to COVID-19 in England: a longitudinal observational study. *Lancet Psychiatry* 2021; 8: 141-149.
- Pierce M, McManus S, Hope H, Hotopf M, Ford T, Hatch SL, John A, Kontopantelis E, Webb RT, Wessely S, Abel KM. Mental health responses to the COVID-19 pandemic: a latent class trajectory analysis using longitudinal UK data. *Lancet Psychiatry* 2021; 8: 610-619.
- Tison GH, Barrios J, Avram R, Kuhar P, Bostjancic B, Marcus GM, Pletcher MJ, Olgin JE. Worldwide physical activity trends since COVID-19 onset. *Lancet Glob Health* 2022; 10: e1381-e1382.
- Tison GH, Avram R, Kuhar P, Abreau S, Marcus GM, Pletcher MJ, Olgin JE. Worldwide Effect of COVID-19 on Physical Activity: A Descriptive Study. *Ann Intern Med* 2020; 173: 767-770.
- Azizi A, Achak D, Aboudi K, Saad E, Nejari C, Noura Y, Hilali A, Youlyouz-Marfak I, Marfak A. Health-related quality of life and behavior-related lifestyle changes due to the COVID-19 home confinement: Dataset from a Moroccan sample. *Data Brief* 2020; 32: 106239.
- Hay JW, Gong CL, Jiao X, Zawadzki NK, Zawadzki RS, Pickard AS, Xie F, Crawford SA, Gu NY. A US Population Health Survey on the Impact of COVID-19 Using the EQ-5D-5L. *J Gen Intern Med* 2021; 36: 1292-1301.
- Tamson M, Reile R, Sokurova D, Innos K, Nurk E, Laidra K, Vorobjov S. Health-Related Quality of Life and Its Socio-Demographic and Behavioural Correlates during the COVID-19 Pandemic in Estonia. *Int J Environ Res Public Health* 2022; 19.
- Wong EL, Li J, Yuen S, Lai AH, Cheung AW, Yau PS, Yeoh EK. Vulnerable populations during



- COVID-19 response: Health-related quality of life among Chinese population and its influence due to socio-demographic factors and loneliness. *Front Public Health* 2022; 10: 857033.
- 21) Ishikawa H, Kato M, Kiuchi T. Declines in health literacy and health-related quality of life during the COVID-19 pandemic: a longitudinal study of the Japanese general population. *BMC Public Health* 2021; 21: 2180.
  - 22) Kang YW, Ko YS, Kim YJ, Sung KM, Kim HJ, Choi HY, Sung C, Jeong E. Korea Community Health Survey Data Profiles. *Osong Public Health Res Perspect* 2015; 6: 211-217.
  - 23) Yoo IK, Marshall DC, Cho JY, Yoo HW, Lee SW. N-Nitrosodimethylamine-contaminated ranitidine and risk of cancer in South Korea: a nationwide cohort study. *Life Cycle* 2021; 1: e1.
  - 24) Ban CY, Shin H, Eum S, Yon H, Lee SW, Choi YS, Shin YH, Shin JU, Koyanagi A, Jacob L, Smith L, Min C, Yeniova A, Kim SY, Lee J, Yeo SG, Kwon R, Koo MJ, Fond G, Boyer L, Acharya KP, Kim S, Woo HG, Park S, Shin JI, Rhee SY, Yon DK. 17-year trends of body mass index, overweight, and obesity among adolescents from 2005 to 2021, including the COVID-19 pandemic: a Korean national representative study. *Eur Rev Med Pharmacol Sci* 2023; 27: 1565-1575.
  - 25) Eum S, Rhee SY. Age, ethnic, and sex disparity in body mass index and waist circumference: a bi-national large-scale study in South Korea and the United States. *Life Cycle* 2023; 3: e4.
  - 26) Eum S, Son JW, Min C, Cho W, Kim S, Woo HG, Kwon R, Lee KN, Han KD, Yon DK, Rhee SY. Ethnic and sex differences in the distributions of body mass index and waist circumference among adults: a binationally representative study in South Korea and the United States. *Eur Rev Med Pharmacol Sci* 2023; 27: 1889-1903.
  - 27) Kim MJ, Lee KH, Lee JS, Kim N, Song JY, Shin YH, Yang JM, Lee SW, Hwang J, Rhee SY, Yon DK, Shin JI, Choi YJ. Trends in body mass index changes among Korean adolescents between 2005-2020, including the COVID-19 pandemic period: a national representative survey of one million adolescents. *Eur Rev Med Pharmacol Sci* 2022; 26: 4082-4091.
  - 28) Oh K, Kim Y, Kweon S, Kim S, Yun S, Park S, Lee YK, Kim Y, Park O, Jeong EK. Korea National Health and Nutrition Examination Survey, 20th anniversary: accomplishments and future directions. *Epidemiol Health* 2021; 43: e2021025.
  - 29) Lee YK, Nam HS, Chuang LH, Kim KY, Yang HK, Kwon IS, Kind P, Kweon SS, Kim YT. South Korean time trade-off values for EQ-5D health states: modeling with observed values for 101 health states. *Value Health* 2009; 12: 1187-1193.
  - 30) Lee SW. Regression analysis for continuous independent variables in medical research: statistical standard and guideline of Life Cycle Committee. *Life Cycle* 2022; 2: e3.
  - 31) Lee SW. Methods for testing statistical differences between groups in medical research: statistical standard and guideline of Life Cycle Committee. *Life Cycle* 2022; 2: e1.
  - 32) Ping W, Zheng J, Niu X, Guo C, Zhang J, Yang H, Shi Y. Evaluation of health-related quality of life using EQ-5D in China during the COVID-19 pandemic. *PLoS One* 2020; 15: e0234850.
  - 33) Lim SL, Woo KL, Lim E, Ng F, Chan MY, Gandhi M. Impact of COVID-19 on health-related quality of life in patients with cardiovascular disease: a multi-ethnic Asian study. *Health Qual Life Outcomes* 2020; 18: 387.
  - 34) Kwon HY, Kim Y, Lee SY, Kim CB. Quarantining: a mentally distressful but physically comfortable experience in South Korea. *Health Qual Life Outcomes* 2022; 20: 144.
  - 35) Lubetkin EI, Long D, Haagsma JA, Janssen MF, Bonsel GJ. Health inequities as measured by the EQ-5D-5L during COVID-19: Results from New York in healthy and diseased persons. *PLoS One* 2022; 17: e0272252.
  - 36) Hamdan A, Ghanim M, Mosleh R. COVID-19 confinement and related well being measurement using the EQ-5D questionnaire: A survey among the Palestinian population. *Int J Clin Pract* 2021; 75: e14621.
  - 37) Bratić M, Radivojević A, Stojiljković N, Simović O, Juvan E, Lesjak M, Podovšovnik E. Should I Stay or Should I Go? Tourists' COVID-19 Risk Perception and Vacation Behavior Shift. *Sustainability* 2021; 13: 3573.
  - 38) Guzelhan Y. Mental health in pre-COVID-19 and during the COVID-19 pandemic: a comparative study using symptom checklist-90-R. *Eur Rev Med Pharmacol Sci* 2022; 26: 6382-6390.
  - 39) Lee SW, Lee J, Moon SY, Jin HY, Yang JM, Ogi-no S, Song M, Hong SH, Abou Ghayda R, Kronbichler A, Koyanagi A, Jacob L, Dragioti E, Smith L, Giovannucci E, Lee IM, Lee DH, Lee KH, Shin YH, Kim SY, Kim MS, Won HH, Ekelund U, Shin JI, Yon DK. Physical activity and the risk of SARS-CoV-2 infection, severe COVID-19 illness and COVID-19 related mortality in South Korea: a nationwide cohort study. *Br J Sports Med* 2022; 56: 901-912.
  - 40) Lazar J. Managing digital accessibility at universities during the COVID-19 pandemic. *Univers Access Inf Soc* 2022; 21: 749-765.
  - 41) Barbosa Junior JG, Barbosa de Lira CA, Vancini RL, Puccinelli PJ, Seffrin A, Vivan L, Ribeiro Dos Anjos V, Weiss K, Knechtle B, Andrade MS. Comparison of the levels of depression and anxiety during the first and fourth waves of coronavirus disease-2019 pandemic in Brazil. *Eur Rev Med Pharmacol Sci* 2022; 26: 4148-4157.
  - 42) Cho JK, Yang H, Park J, Lee H, Nguyen A, Kattih M, Rahmati M, Yon DK. Association between allergic rhinitis and despair, suicidal ideation, and suicide attempts in Korean adolescents: a nationally representative study of one million adolescents. *Eur Rev Med Pharmacol Sci* 2023; 27: 9248-9256.