

Estimation of Excess Mortality among Older People in Nursing Homes Amidst the COVID-19 Pandemic in South Korea

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Abstract

Older people in nursing homes are particularly vulnerable to infectious diseases, yet studies quantifying the impact of the COVID-19 pandemic on their mortality remain limited. To estimate excess mortality among older nursing home residents during the pandemic, we analyzed mortality data from Statistics Korea for individuals aged ≥ 65 years who died in social welfare facilities between 2015 and 2022. A seasonal autoregressive integrated moving average model fitted to 2015–2019 data was applied to estimate expected deaths for 2020–2022, which were compared with observed deaths. Excess mortality during 2020–2022 was estimated at 6,992 deaths (95% confidence interval [CI]=142.7–15,027.4), approximately 15% above the expected level, and was concentrated in 2022 (6,191.2, 95% CI=2,899.6–10,057.6). Significant excesses were observed for “not elsewhere classified” (R00-R99, 3,089.2, 95% CI=1,422.1–4,775.9), neoplasms (734.4, 95% CI=604.0–865.9), and diseases of the genitourinary system (139.6, 95% CI=78.8–201.1), whereas deaths from mental and behavioral disorders and from external causes were lower than expected. These findings are consistent with indirect pandemic effects, such as healthcare system strain and disrupted chronic disease management, although studies linking healthcare utilization data are required to disentangle the mechanisms.

Keywords: Death, Cause of Death, Nursing Homes, Social Welfare, COVID-19

알기 쉬운 요약

이 연구는 왜 했을까? 코로나19 유행이 요양시설 노인의 사망에 미친 영향을 오미크론 변이 우세시기를 포함하여 정량화한 연구는 제한적이다. 본 연구는 코로나19 팬데믹 전 기간에 걸쳐 이들의 초과 사망을 추정하고, 성별·연령군·사인별 분포를 파악하고자 하였다.

새롭게 밝혀진 내용은? 2020~2022년 초과 사망은 6,992명(95% 신뢰구간 142.7–15,027.4)으로 오미크론 변이가 우세했던 2022년에 집중되었다. 사인별로는 달리 분류되지 않은 증상 및 임상소견, 신생물·비노생식계 질환에서 유의한 초과 사망이 확인된 반면, 정신 및 행동장애와 외인에 의한 사망은 기대보다 적었다.

앞으로 무엇을 해야 하나? 초과 사망의 양상은 의료체계 부담과 만성질환 관리의 어려움 등 팬데믹의 간접적 영향과 부합하나 사망 자료만으로는 그 기전을 확인할 수 없으므로 의료 이용 자료를 연계한 후속 연구가 필요하다. 아울러 감염병 대응과 만성질환 진료를 함께 수행할 수 있도록 의료체계의 회복력을 강화하여 향후 공중보건 위기에 대비할 필요가 있다.

The authors have no conflicts of interest to declare for this study.

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I. Introduction

Older people in nursing homes are particularly vulnerable to infectious diseases due to their underlying health conditions and communal living arrangements. Globally, increased mortality in nursing homes substantially contributed to the overall rise in deaths early in the COVID-19 pandemic. In many developed countries, nursing home residents experienced massive outbreaks and high mortality rates (Comas-Herrera et al., 2020; Kemenesi et al., 2020; Thompson et al., 2020).

Despite initial success in controlling COVID-19 transmission, South Korea (hereafter, Korea) also faced extensive outbreaks and numerous casualties in nursing homes during the later stages of the pandemic. This was particularly evident when the Omicron variant became dominant (Ahn et al., 2022). Although the Omicron variant had a lower case-fatality rate than the Delta variant (K. Kim et al., 2023), its high infectivity led to a substantial increase in COVID-19 outbreaks within nursing homes. However, previous studies had limitations in elucidating the extent of excess mortality during the COVID-19 pandemic among older nursing home residents, while primarily focusing on the general population or failing to encompass the Omicron variant dominant period (Han, 2022; Shin et al., 2021; J. H. Kim et al., 2022).

During the COVID-19 pandemic, excess mortality has frequently been employed as a summary measure to assess the overall impact, encompassing both direct and indirect effects attributable to COVID-19. However, interpreting such estimates requires a more detailed analysis of their distribution (Beaney et al., 2020), including the timing and magnitude of the excess, the groups most affected, and the leading causes of death. We aimed to quantify excess mortality among older residents in nursing homes during the COVID-19 pandemic and to describe its distribution by sex, age group, and cause of death. Our findings are intended to inform policies for protecting those aged 65 and above, who are at higher risk during infectious disease outbreaks such as COVID-19.

II. Methods

1. Data

To quantify excess death counts among older nursing home residents during the COVID-19 pandemic, we obtained anonymous individual-level mortality data spanning from 2015 to 2022 from the cause-of-death statistics available on the MicroData Integrated Service (MDIS, <https://mdis.kostat.go.kr>) provided by Statistics Korea. Mortality data in Korea are compiled from mandatory civil registration records. This dataset includes details of the deceased, such as age at the time of death (grouped into five-year intervals ranging from 0 to 1-4, 5-9 to 80-84, and ≥ 85 years), gender (men and women), residential address, the date and place of death, and causes of death. The place of death was categorized into social welfare facilities such as nursing homes and orphanages, homes, medical facilities, public facilities, roads, commercial and service facilities, farms, on the way to the hospital, other places, and unknown. Causes of death comprised 104 disease categories (Supplementary material 1). For privacy protection, deaths attributed to COVID-19 were only

identifiable from 2021 onward due to concerns that individuals could potentially be re-identified given the relatively small number of COVID-19 deaths in 2020. Fatalities due to COVID-19 (N=950) in 2020 were aggregated into the group of ‘certain infectious and parasitic diseases’ (classified under the Korean Standard Classification of Diseases [hereafter, KCD]: A00–B99, Supplementary material 2).

We specifically focused on deaths occurring in social welfare facilities among individuals aged 65 and above to assess the extent of excess death counts among older adults in nursing homes during the COVID-19 pandemic. Individuals aged 65 or older who died in social welfare facilities were included, with those missing age or death location information excluded. The number of deaths was aggregated by week, referred to as epidemiological week (hereafter, epiweek; Centers for Disease Control and Prevention [CDC], 2011). We calculated the average number of deaths per epiweek both before and after 2020 (spanning from 2015 to 2019 and from 2020 to 2022), considering that the first case of COVID-19 in Korea was reported in January 2020.

2. Statistical analysis

To provide basic information, we summarized death counts and their proportions by year, based on gender, age group (65–69, 70–74, 75–79, 80–84, ≥85 years), month of death, and cause of death. We visualized the weekly number of deaths using a heatmap and additively decomposed time series to identify trends and seasonal patterns.

To ensure comparability across years, the case counts for the 53rd week of 2015–2019 and 2021 were synthesized. The case count of the 53rd week was calculated by averaging the case count of the 52nd week of the corresponding year and the 1st week of the following year. The year 2020 naturally contained 53 epidemiological weeks, and our observation period concluded at the 52nd week of 2022.

In this study, excess mortality refers to the difference between observed and expected death counts. We utilized the Seasonal Autoregressive Integrated Moving Average (hereafter, SARIMA) model to account for seasonality, autocorrelation, and non-stationarity in the occurrence of deaths. This approach relies solely on historical event counts and does not require explicit population denominators. Because the model captures and extrapolates the underlying trend in the training period, gradual growth in the resident population is already reflected in the expected deaths for 2020–2022. This assumes that the pace of growth remained stable. The SARIMA framework thus offers a practical approach to the structural unavailability of accurate denominator data.

The general model follows the form $ARIMA(p,d,q)(P,D,Q)[S]$, where p , d , and q represent non-seasonal autoregressive order, differencing, and moving average order respectively, and P , D , and Q denote the seasonal autoregressive order, differencing, and moving average order respectively, with S indicating the period of the repeating seasonal pattern ($S=53$). To identify the optimal parameters, we employed the `auto.arima()` function from the `forecast` package, which selects the best-fitting model by minimizing the Akaike Information Criterion (AIC, Hyndman & Khandakar, 2008). To validate the model, the residuals were examined using the Ljung-Box test, wherein the null hypothesis assumes the absence of significant autocorrelation (Box & Pierce, 1970; Ljung & Box, 1978). Because a model was selected independently for each series, the fitted

orders and diagnostic results differ across subgroups.

Using the fitted SARIMA model, we forecasted death counts from 2020 to 2022 and compared the observed values against the predicted total, minimum, maximum, mean counts. Finally, to accurately estimate the 95% confidence interval for the cumulative predicted and excess deaths, while appropriately incorporating the uncertainty propagated over the multi-year forecast horizon (158 weeks), we employed a Monte Carlo path simulation approach with 100,000 iterations (COVID-19 Excess Mortality Collaborators, 2022; Hyndman & Athanasopoulos, 2021).

Subgroup analyses were conducted based on gender, age groups, and causes of death by 22 primary categories of the KCD (Supplementary material 2), excluding COVID-19, to explore differential impacts and possible explanations for the observed excess mortality. To accurately capture the unique baseline trends and seasonal variations inherent to each group, independent SARIMA models were fitted to each subgroup. This independent modeling approach naturally leads to numerical discrepancies, meaning that the sum of the predicted and excess death counts from the subgroups may not exactly equal the total values for the overall population. Subgroup estimates therefore indicate the direction and relative magnitude of the excess within each stratum rather than an additive decomposition of the overall total. For statistical stability, only subgroups with over 100 death cases from 2015 to 2019, according to KCD categories, were included. Sensitivity analysis was conducted using death count data with 52 epiweek framework. The data was created by averaging the 53rd week case count of 2020 with that of the 52nd week. Statistical analysis was performed using R version 4.2.2 (R Foundation, Vienna, Austria, <https://cran.r-project.org>).

3. Ethics statement

The Institutional Review Board (IRB) of the National Medical Center approved this study and waived informed consent due to the absence of personal identification information in the dataset (IRB number: NMC-2023-10-112). This study adhered to the Declaration of Helsinki.

III. Results

Out of 2,431,753 deaths recorded between January 1, 2015, and December 31, 2022, a total of 113,085 individuals aged 65 or older, whose place of death was a social welfare facility, were included in the descriptive analysis after excluding cases with missing data on age and place of death, as well as those under 65 years of age or who did not die in social welfare facilities (61,242 deaths in 2015–2019; 51,843 deaths in 2020–2022). Because the 2020-1 epiweek began on December 29, 2019, 118 deaths occurring in late December 2019 were assigned to the 2020-2022 series, and 98 deaths belonging to the 2014-53 epiweek were excluded. After adding the synthesized 53rd week counts, the final adjusted dataset of 116,638 cases was included in the time-series modeling (63,905 cases in 2015-2019; 52,733 cases in 2020-2022, Figure 1).

Table 1 presents the basic characteristics of the study population who died in nursing homes at ≥ 65

years of age. Death cases increased by 108.6% from 10,437 in 2015 to 21,772 in 2022. The average number of deaths per epiweek in 2015–2022 was 271.0, which increased from 234.7 in 2015–2019 to 331.0 in 2020–2022 (Supplementary material 3 Table S1). The proportion of nursing home deaths among ≥ 65 age group also increased from 5.1% (10,437/205,603) in 2015 to 7.2% (21,772/303,447) in 2022 (Supplementary material 3 Table S1).

Figure 1. Flowchart of study subject selection

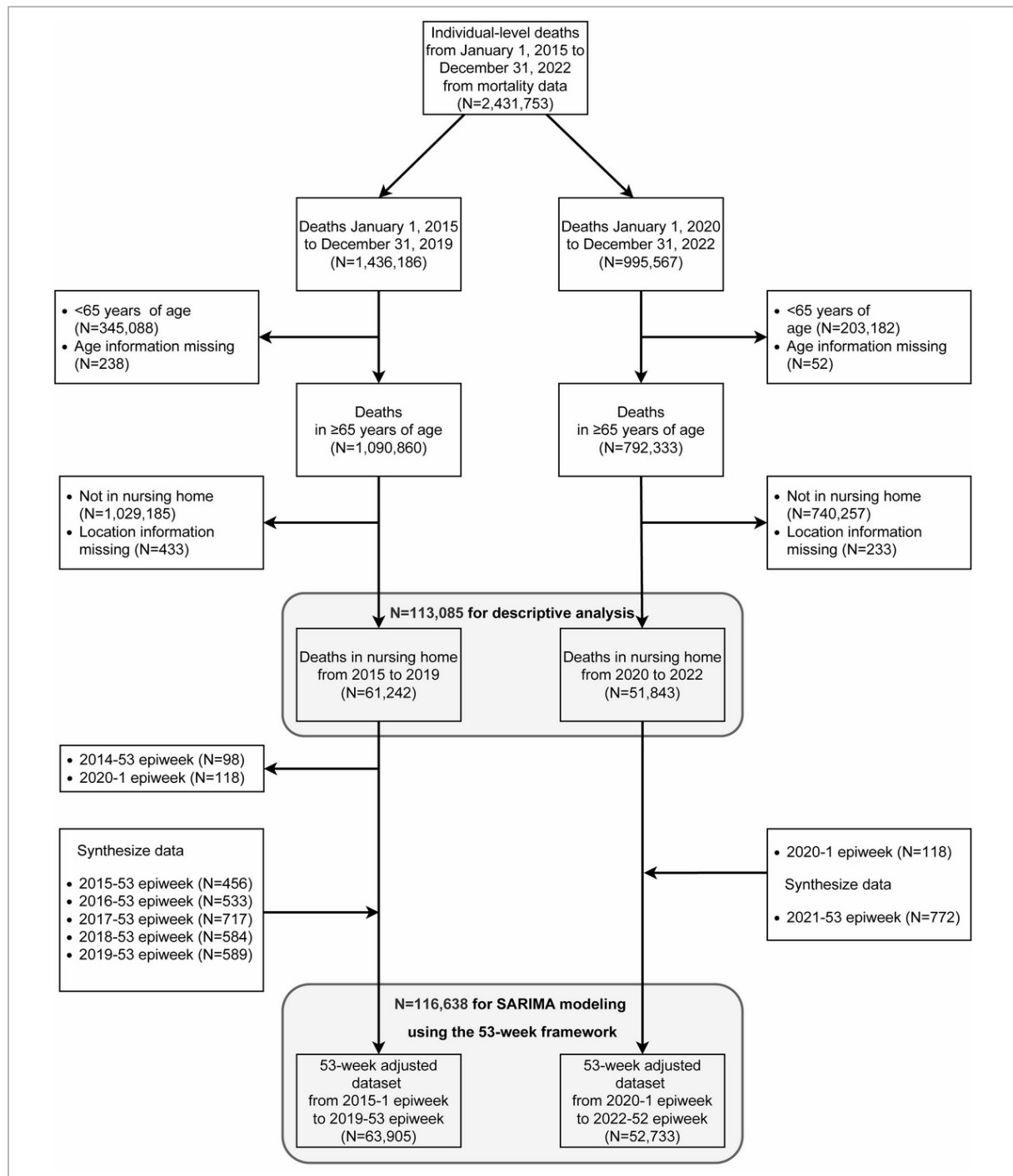


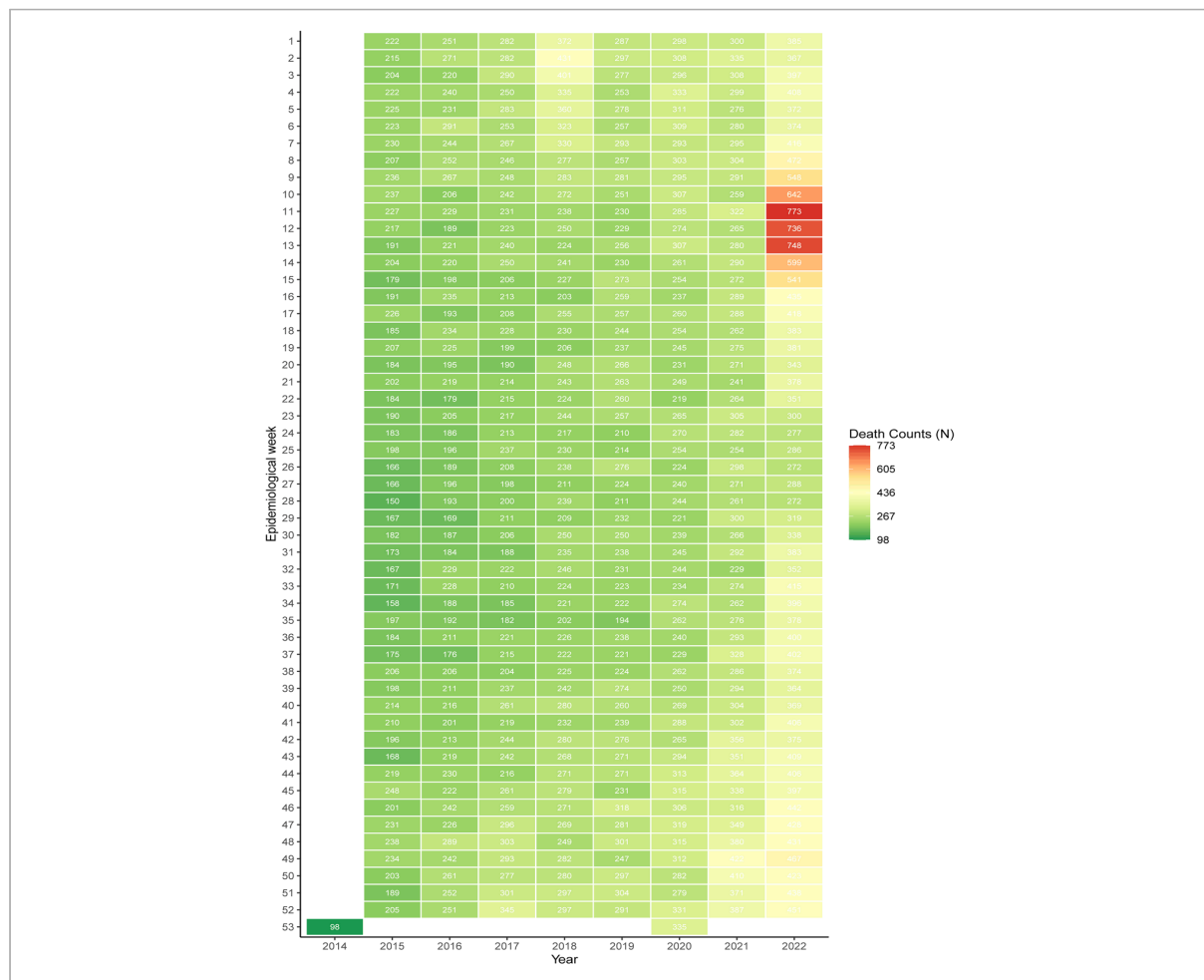
Table 1. General characteristics of the study population by year, expressed in death counts and its percentage

	2015 (N=10,437, 9.2%)	2016 (N=11,486, 10.2%)	2017 (N=12,381, 10.9%)	2018 (N=13,632, 12.1%)	2019 (N=13,306, 11.8%)	2020 (N=14,326, 12.7%)	2021 (N=15,745, 13.9%)	2022 (N=21,772, 19.3%)	2015–2022 (N=113,085, 100.0%)
Gender									
Men	2,906 (27.8)	3,091 (26.9)	3,357 (27.1)	3,577 (26.2)	3,603 (27.1)	3,884 (27.1)	4,346 (27.6)	6,005 (27.6)	30,769 (27.2)
Women	7,531 (72.2)	8,395 (73.1)	9,024 (72.9)	10,055 (73.8)	9,703 (72.9)	10,442 (72.9)	11,399 (72.4)	15,767 (72.4)	82,316 (72.8)
Age group (years of age)									
65–69	256 (2.5)	264 (2.3)	227 (1.8)	266 (2.0)	252 (1.9)	247 (1.7)	265 (1.7)	396 (1.8)	2,173 (1.9)
70–74	645 (6.2)	579 (5.0)	521 (4.2)	497 (3.6)	500 (3.8)	480 (3.4)	504 (3.2)	692 (3.2)	4,418 (3.9)
75–79	1,343 (12.9)	1,422 (12.4)	1,379 (11.1)	1,483 (10.9)	1,288 (9.7)	1,231 (8.6)	1,292 (8.2)	1,540 (7.1)	10,978 (9.7)
80–84	2,150 (20.6)	2,384 (20.8)	2,548 (20.6)	2,741 (20.1)	2,726 (20.5)	2,833 (19.8)	2,857 (18.1)	3,959 (18.2)	22,198 (19.6)
≥85	6,043 (57.9)	6,837 (59.5)	7,706 (62.2)	8,645 (63.4)	8,540 (64.2)	9,535 (66.6)	10,827 (68.8)	15,185 (69.7)	73,318 (64.8)
Month of Death									
January	961 (9.2)	1,082 (9.4)	1,242 (10.0)	1,696 (12.4)	1,241 (9.3)	1,400 (9.8)	1,392 (8.8)	1,701 (7.8)	10,715 (9.5)
February	885 (8.5)	1,064 (9.3)	1,023 (8.3)	1,248 (9.2)	1,085 (8.2)	1,228 (8.6)	1,159 (7.4)	1,671 (7.7)	9,363 (8.3)
March	997 (9.6)	972 (8.5)	1,036 (8.4)	1,102 (8.1)	1,076 (8.1)	1,290 (9.0)	1,238 (7.9)	3,141 (14.4)	10,852 (9.6)
April	858 (8.2)	906 (7.9)	944 (7.6)	995 (7.3)	1,097 (8.2)	1,062 (7.4)	1,230 (7.8)	2,165 (9.9)	9,257 (8.2)
May	859 (8.2)	955 (8.3)	922 (7.4)	1,012 (7.4)	1,139 (8.6)	1,064 (7.4)	1,167 (7.4)	1,639 (7.5)	8,757 (7.7)
June	801 (7.7)	818 (7.1)	936 (7.6)	999 (7.3)	1,017 (7.6)	1,088 (7.6)	1,201 (7.6)	1,258 (5.8)	8,118 (7.2)
July	737 (7.1)	822 (7.2)	911 (7.4)	1,004 (7.4)	1,017 (7.6)	1,053 (7.4)	1,221 (7.8)	1,346 (6.2)	8,111 (7.2)
August	747 (7.2)	909 (7.9)	856 (6.9)	1,001 (7.3)	972 (7.3)	1,123 (7.8)	1,167 (7.4)	1,693 (7.8)	8,468 (7.5)
September	817 (7.8)	865 (7.5)	944 (7.6)	990 (7.3)	1,025 (7.7)	1,043 (7.3)	1,279 (8.1)	1,674 (7.7)	8,637 (7.6)
October	873 (8.4)	940 (8.2)	1,061 (8.6)	1,178 (8.6)	1,165 (8.8)	1,286 (9.0)	1,461 (9.3)	1,731 (8.0)	9,695 (8.6)
November	966 (9.3)	1,027 (8.9)	1,151 (9.3)	1,148 (8.4)	1,215 (9.1)	1,345 (9.4)	1,489 (9.5)	1,783 (8.2)	10,124 (9.0)
December	936 (9.0)	1,126 (9.8)	1,355 (10.9)	1,259 (9.2)	1,257 (9.4)	1,344 (9.4)	1,741 (11.1)	1,970 (9.0)	10,988 (9.7)

Throughout the entire period, deaths were more prevalent among women (82,316, 72.8%) than men (30,769, 27.2%). Those aged 85 and above (73,318, 64.8%) had the highest number of deaths, with death counts increasing with age. From 2015 through 2022, December had the highest number of deaths (10,988, 9.7%), followed by March (10,852, 9.6%), January (10,715, 9.5%), and November (10,124, 9.0%). A peak in deaths was consistently observed during the winter season (November–January) from 2015 to 2021, whereas in 2022, the highest number of deaths occurred in March (3,141, 14.4%).

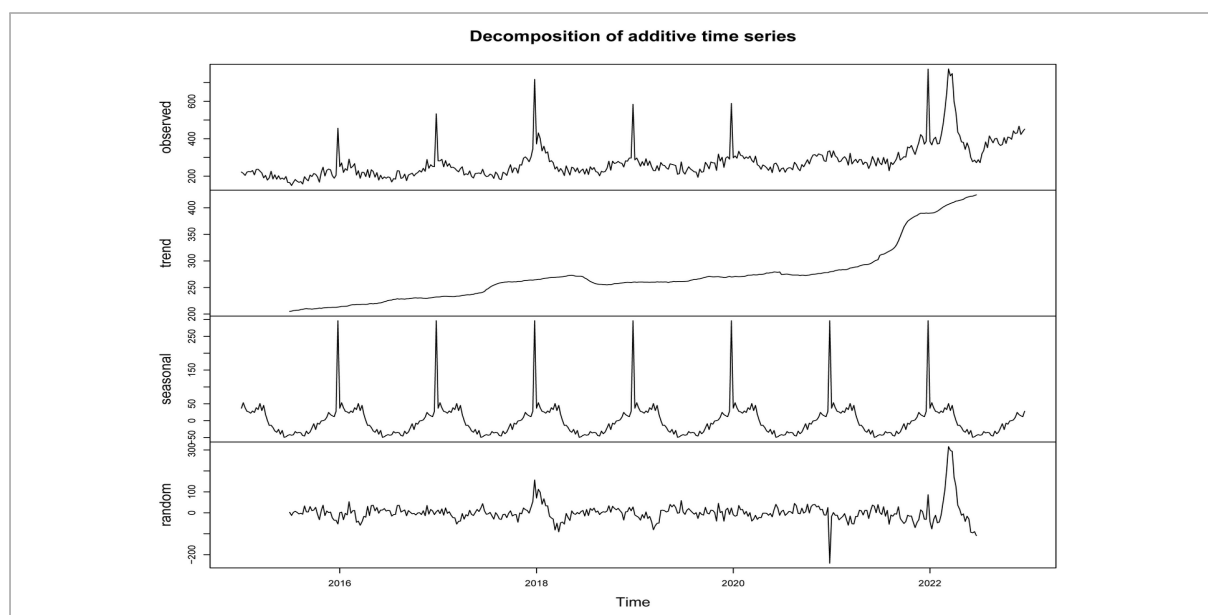
The heatmap (Figure 2) and additive decomposition of the time series (Figure 3) revealed a consistent increase in deaths from 2015 to 2022, with a pattern of winter seasonality persisting until 2021. However, in 2022, a marked upsurge was observed during the spring period, specifically between epiweek 9 and 15.

Figure 2. Heatmap of weekly death counts of the study population in 2015-2022



Notes: Death counts are depicted as a gradient from dark green at the lowest value to dark red at the highest value.

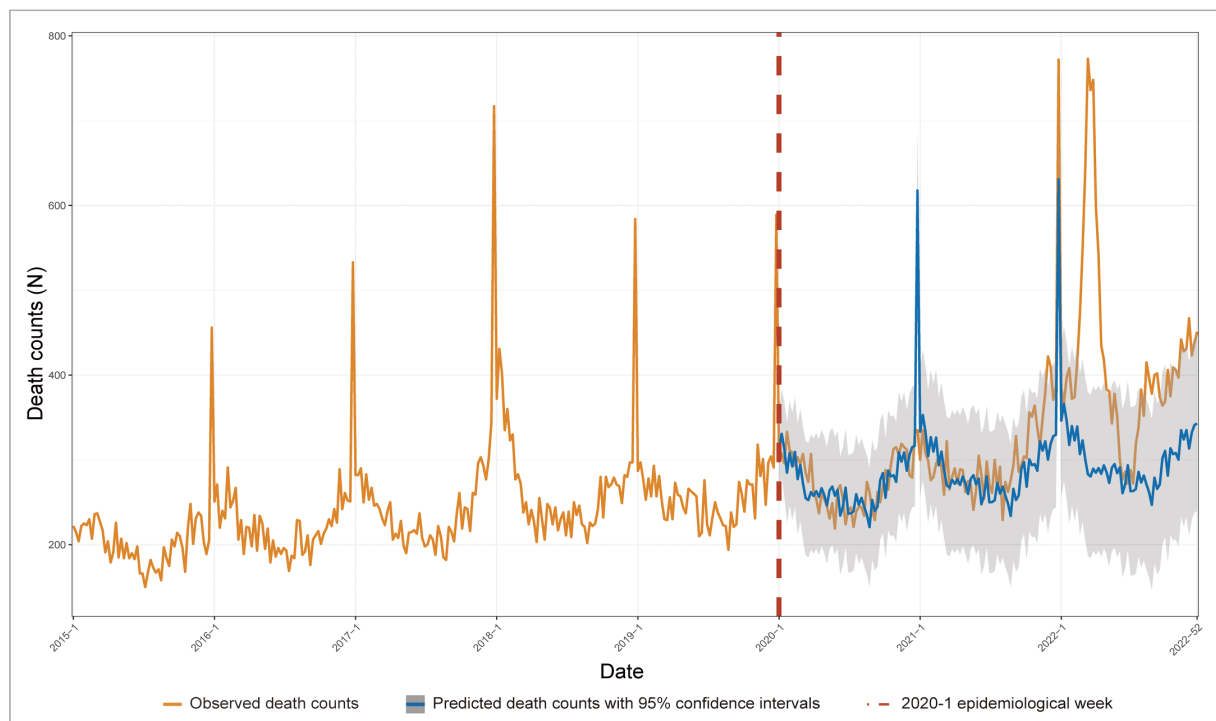
Figure 3. Results of decomposition of additive time series model for weekly death numbers



The SARIMA model based on the death counts of 2015–2019 was fitted as $ARIMA(1,1,3)(0,1,1)[53]$ and yielded a p-value of 0.2141 in the Ljung-Box test, indicating the absence of autocorrelation. Figure 4 illustrates congruence between the observed and predicted deaths up until mid-2021, except a significant surge in observed deaths in early 2021. However, from the latter half of 2021 through 2022, observed deaths sharply escalated compared to the predicted values. Particularly notable surges in deaths were observed during the winter of 2021 and the spring of 2022.

Observed deaths from 2020 to 2022 exceeded the estimated counts by 6,992.0 (95% confidence interval [CI]=142.7–15,027.4, Table 2). When stratified by epidemiological year, the highest and significant excess mortality was observed in 2022, with 6,191.2 deaths (95% CI=2,899.6–10,057.6), followed by excess deaths in 2021 (975.4, 95% CI=-1,544.9–3,877.8). In contrast, 2020 exhibited a deficit in excess mortality, recorded at -174.6 (95% CI=-1,910.1–1,729.3). Neither the 2021 excess nor the 2020 deficit reached statistical significance.

Figure 4. Predicted and observed numbers of deaths during the COVID-19 pandemic



Notes: The orange line refers to observed death counts. The blue line refers to predicted death counts. The grey band refers to 95% confidence intervals of the predicted death counts. The red dashed line refers to 2020-1 epidemiological week.

To investigate how the excess was distributed, we categorized the excess deaths according to gender, age group, and causes of death by major classification of the KCD (Table 2). Separate models were selected for each subgroup series, and residual autocorrelation was detected in three of them (men, women, and R00-R99; $p < 0.05$). Men exhibited excess death counts (2,167.1, 95% CI=1,101.0–3,247.1) while the estimate of women was not significant (13,492.8, 95% CI=-19,133.7–46,484.7). The 65–69 age group had significant excess death counts (143.6, 95% CI=79.2–208.6), while estimates for other age groups were not

significant.

According to the major KCD classification, there were no deaths recorded from 2015 to 2022 attributed to diseases of the eye and adnexa (KCD-code: H00–H59), pregnancy, childbirth, and the puerperium (O00–O99), conditions originating in the perinatal period (P00–P96), injury, poisoning, and certain other consequences of external causes (S00–T98), nor factors influencing health status and contact with health services (Z00–Z99). To ensure analytical robustness, causes of death with fewer than 100 deaths before 2019 were excluded, such as diseases of the blood and blood-forming organs and certain disorders involving the immune mechanism (D50–D89, N=64), diseases of the ear and mastoid process (H60–H95, N=2), diseases of the skin and subcutaneous tissue (L00–L99, N=68), and congenital malformations, deformations, and chromosomal abnormalities (Q00–Q99, N=2).

Among the causes of death, “not elsewhere classified” (R00–R99) showed the largest statistically significant excess (3,089.2, 95% CI=1,422.1–4,775.9). Neoplasms (C00–D48, 734.4, 95% CI=604.0–865.9) and diseases of the genitourinary system (N00–N99, 139.6, 95% CI=78.8–201.1) also exhibited a higher number of observed deaths than predicted between 2020 and 2022. Diseases of the circulatory system showed the largest absolute excess of any category (3,786.6) and diseases of the nervous system also showed a substantial excess (1,341.1), but neither reached significance (95% CI=–2,789.0–10,430.8 and –211.7–2,910.3, respectively).

Conversely, certain categories of causes had more predicted deaths than observed, including mental and behavioral disorders (F00–F99, –446.3, 95% CI=–800.9 to –89.3) and external causes of morbidity and mortality (V01–Y98, –58.0, 95% CI=–106.9 to –8.6). Deaths from diseases of the respiratory system were lower than predicted without reaching significance (–684.5, 95% CI=–1,756.4–399.7).

Table 2. Estimated numbers of excess mortality during the COVID-19 pandemic

	Death counts			Excess death counts, 2020–2022 (95% CI)
	Observed, 2015–2019	Observed, 2020–2022	Predicted, 2020–2022 (95% CI)	
Total	63,905	52,733	45,741.0 (37,705.6– 52,590.3)	6,992.0 (142.7–15,027.4)
Gender				
Men	17,186	14,477	12,309.9 (11,229.9–13,376.0)	2,167.1 (1,101.0–3,247.1)
Women	46,719	38,256	24,763.2 (–8,228.7–57,389.7)	13,492.8 (–19,133.7–46,484.7)
Age group (years of age)				
65–69	1,312	925	781.4 (716.4–845.8)	143.6 (79.2–208.6)
70–74	2,843	1,696	1,530.9 (1,118.8–1,938.4)	165.1 (–242.4–577.2)
75–79	7,172	4,130	4,213.5 (3,656.8–4,766.4)	–83.5 (–636.4–473.2)
80–84	13,085	9,793	9,626.7 (9,024.6–10,225.0)	166.3 (–432.0–768.4)
≥85	39,493	36,189	24,424.7 (–917.2–49,498.4)	11,764.3 (–13,309.4–37,106.2)
Cause of death (KCD-code)				
Certain infectious and parasitic diseases (A00–B99)	607	359	361.9 (323.1–400.3)	–2.9 (–41.3–35.9)
Neoplasms (C00–D48)	4,012	3,126	2,391.6 (2,260.1–2,522.0)	734.4 (604.0–865.9)

	Death counts			Excess death counts, 2020–2022 (95% CI)
	Observed, 2015–2019	Observed, 2020–2022	Predicted, 2020–2022 (95% CI)	
Endocrine, nutritional, and metabolic diseases (E00–E90)	2,350	1,664	1,732.5 (530.3–2,922.5)	-68.5 (-1,258.5–1,133.7)
Mental and behavioral disorders (F00–F99)	3,525	1,665	2,111.3 (1,754.3–2,465.9)	-446.3 (-800.9 to -89.3)
Diseases of the nervous system (G00–G99)	4,113	4,905	3,563.9 (1,994.7–5,116.7)	1,341.1 (-211.7–2,910.3)
Diseases of the circulatory system (I00–I99)	14,726	10,347	6,560.4 (-83.8–13,136.0)	3,786.6 (-2,789.0–10,430.8)
Diseases of the respiratory system (J00–J99)	5,392	3,088	3,772.5 (2,688.3–4,844.4)	-684.5 (-1,756.4–399.7)
Diseases of the digestive system (K00–K93)	588	368	349.9 (313.3–386.2)	18.1 (-18.2–54.7)
Diseases of the musculoskeletal system and connective tissue (M00–M99)	280	163	154.4 (106.0–202.4)	8.6 (-39.4–57.0)
Diseases of the genitourinary system (N00–N99)	648	524	384.4 (322.9–445.2)	139.6 (78.8–201.1)
Symptoms, signs, and abnormal clinical and laboratory findings, not elsewhere classified (R00–R99)	26,648	24,563	21,473.8 (19,787.1–23,140.9)	3,089.2 (1,422.1–4,775.9)
External causes of morbidity and mortality (V01–Y98)	872	464	522.0 (472.6–570.9)	-58.0 (-106.9 to -8.6)

Notes: The sum of predicted and excess deaths from subgroups may not exactly equal the overall total, as independent SARIMA models were fitted to each subgroup. Subgroup estimates should be interpreted as indicating direction rather than as an additive decomposition of the total.

Abbreviations: CI, Confidence interval; KCD-code, The Korean Standard Classification of Diseases code.

In the sensitivity analysis using a 52-epiweek framework, the total excess was larger in magnitude but not statistically significant (10,205.8, 95% CI=-34,335.7–55,314.1; Supplementary material 3 Table S2 and Figure S1). Under this framework, the prediction interval extended below zero from about the second quarter of 2021 onward (Figure S1), a range inadmissible for count data. Five findings were reproduced across both frameworks, comprising significant excesses in the 65–69 age group (154.0, 95% CI=96.5–211.6), neoplasms (766.0, 95% CI=677.8–854.5), and diseases of the genitourinary system (146.4, 95% CI=106.8–186.0), together with significant deficits in mental and behavioral disorders (-376.4, 95% CI=-652.9 to -98.2) and external causes (-43.7, 95% CI=-89.1 to -1.8). Three findings differed. The sex-specific significance was reversed, with women showing a significant excess (6,041.1, 95% CI=109.9–12,059.2) and men not (3,202.6, 95% CI=-6,031.5–12,559.1). The ≥85 age group reached significance (7,373.4, 95% CI=2,024.3–12,806.9). The excess in “not elsewhere classified” cause lost significance (4,008.6, 95% CI=-8,471.3–16,652.8) while that in diseases of the nervous system gained it (1,595.2, 95% CI=145.8–3,066.3).

IV. Discussion

To the best of our knowledge, this is the first study to quantify excess mortality among older people in nursing homes during the COVID-19 pandemic, including the Omicron period, and to conduct a stratified analysis by gender, age group, and causes of death. Our results revealed significant excess mortality in nursing home residents from 2020 to 2022, with 6,992.0 (95% CI=142.7–15,027.4) more observed deaths than predicted, approximately 15% above the expected level. The sensitivity analysis using a 52-epiweek framework yielded a larger point estimate that did not reach significance (10,205.8, 95% CI=-34,335.7–55,314.1). Imposing a 52-week seasonal period on an observation period that contained 53-week years leaves part of the seasonal pattern unexplained, which inflates the residual variance and widens the forecast interval. Confidence intervals were also wide for several subgroups, as forecast uncertainty accumulated over the 158-week horizon.

Excess mortality varied across different years. In 2020, deaths were slightly lower than expected, although the estimate did not reach significance (-174.6, 95% CI=-1,910.1–1,729.3). This direction is nonetheless consistent with previous studies suggesting that a decline in mortality during the early stages of the pandemic was likely attributable to strict public health measures and decreased exposure to other infectious diseases (J. H. Kim et al., 2022; Shin et al., 2021). The estimate for 2021 was positive but also did not reach significance (975.4, 95% CI=-1,544.9–3,877.8), whereas a significant excess was observed in 2022 (6,191.2, 95% CI=2,899.6–10,057.6), when the Omicron variant, with higher transmissibility but lower fatality than the Delta variant (K. Kim et al., 2023), became dominant. This suggests that the sheer volume of infections may have exceeded healthcare capacity, despite the lower lethality of the variant (A. R. Kim et al., 2023).

However, COVID-19 alone could not fully explain the excess mortality among nursing home residents in Korea. Stratified results by gender, age group, and causes of death suggest that factors beyond COVID-19 may have contributed. Men had significant excess death counts (2,167.1, 95% CI=1,101.0–3,247.1), while the estimate for women was not significant (13,492.8, 95% CI=-19,133.7–46,484.7). However, a difference in significance does not by itself establish a difference between the estimates, as the sensitivity analysis reversed the pattern, which likely reflects the greater variance of the series for women, who accounted for 72.8% of deaths in our study population. Our data therefore preclude a firm conclusion about which gender experienced the larger excess. Previous studies reported more excess deaths among men in Korea (Oh et al., 2022) and Italy (Rizzi et al., 2022), and among women aged ≥ 85 (Kye, 2023). This underscores the need for further research to understand gender-specific vulnerabilities in such settings (Rizzi et al., 2022).

Differences in excess deaths across age groups suggest several possible explanations. Excess deaths did not increase monotonically with age. Only the 65-69 group showed a significant excess (143.6, 95% CI=79.2–208.6), whereas the 70-74, 75-79, and 80-84 groups showed small and non-significant estimates, and the largest number of excess deaths was concentrated in the ≥ 85 group without reaching significance (11,764.3, 95% CI=-13,309.4–37,106.2). Similar patterns were also reported in the general population of Korea (Kye, 2023). We propose that admission to a nursing home at a relatively young age generally implies substantial functional impairment, so that residents aged 65-69 may already be comparable in frailty to much older residents. On this view, frailty and disability, rather than chronological age alone, would shape the

distribution of excess deaths in this setting (Modig et al., 2021), and the possibility that frail residents respond differently to vaccination has also been raised (Chen, 2021; Wyller et al., 2021). These interpretations should be read with caution, as the excess in the 65-69 group is smaller than that in the ≥ 85 group and its narrow interval reflects the greater stability of this series rather than a more reliable excess. Testing them would require data on functional status and vaccination that our dataset does not contain, which we suggest as a direction for further research.

Lastly, stratified results by cause of death highlight the healthcare system's performance in Korea. Deaths categorized as "not elsewhere classified" (R00-R99) showed the largest significant excess (3,089.2, 95% CI=1,422.1-4,775.9). This category already accounted for 41.8% of deaths in this population before the pandemic and rose to 47.9% during 2020-2022 (Table 2), so the excess represents a further increase in an already high baseline. Two explanations are compatible with this pattern. Assignment to R00-R99 occurs when the underlying cause cannot be determined, which is more likely when death is not preceded by clinical evaluation, so the increase may reflect reduced contact with medical services during the pandemic (Health Insurance Review & Assessment Service [HIRA], 2024). Alternatively, the frequency of these codes reflects how deaths are investigated and certified, not only the deaths themselves. Where deaths of unclear cause are routinely examined by forensic autopsy, as in Finland, R00-R99 coding is far less common than where they are not, as in Denmark (Ylijoki-Sørensen et al., 2014). In Korea, postmortem examination certificates for deaths outside hospitals are issued by emergency physicians under considerable time pressure (Lim et al., 2020), and deterioration in certification quality under health system overload has been documented elsewhere during the pandemic (França et al., 2022). We have no information on the circumstances of certification, but the two explanations are not mutually exclusive and both trace back to strain on the health system during the pandemic.

Significant excess deaths were also observed for neoplasms (734.4, 95% CI=604.0-865.9) and diseases of the genitourinary system (139.6, 95% CI=78.8-201.1), both of which require continuity of treatment. Diseases of the circulatory system showed the largest number of excess deaths of any category (3,786.6) and diseases of the nervous system also showed a substantial excess (1,341.1), although neither reached significance (95% CI=-2,789.0-10,430.8 and -211.7-2,910.3, respectively). In contrast, deaths from mental and behavioral disorders (-446.3, 95% CI=-800.9 to -89.3) and external causes of morbidity and mortality (-58.0, 95% CI=-106.9 to -8.6) were significantly lower than predicted, and reduced mobility and restricted movement within facilities may have lowered the incidence of falls and related deaths. Estimates for the remaining categories, including diseases of the respiratory system, did not reach significance. Overall, this pattern is consistent with disruptions in the management of chronic conditions during the pandemic (Singh et al., 2022), although our data cannot establish this link directly.

We utilized all available information from the mortality database. However, certain limitations must be acknowledged. First, COVID-19 deaths could not be distinguished in 2020 owing to the data's intrinsic characteristics, which may underestimate its contribution, although the overall death count in 2020 was low. Second, our ecological design precludes causal conclusions, and the explanations discussed above should be regarded as possible rather than established. Third, we estimated excess deaths as counts rather than rates. Our study population consisted of deaths that occurred in social welfare facilities, and no population

at risk corresponds to this definition. Statistics on long-term care beneficiaries cannot serve as a denominator either, as admission to residential facilities is not restricted to those certified for such benefits. Long-term care capacity in Korea expanded throughout the study period, so part of the observed increase may reflect growth in the resident population. However, the SARIMA model was fitted to 2015-2019, when this expansion was already under way, so the corresponding trend is reflected in the expected deaths, and the observed excess was concentrated in a six-week window in the spring of 2022 rather than accumulating gradually. Fourth, defining the study population by the place of death introduces bias in both directions. Residents transferred to hospitals before dying were not captured, leading to underestimation, whereas restrictions on transfer during the pandemic may have shifted deaths into facilities, leading to overestimation. The net direction remains uncertain. Fifth, the Ljung-Box test indicated residual autocorrelation in three of the fitted series. Autocorrelation of this kind tends to understate forecast uncertainty, so the intervals for these subgroups may be narrower than warranted. This applies to the significant estimates for men and for deaths categorized as “not elsewhere classified”, although the lower bounds of both intervals lie well above zero. Sixth, the lack of individual-level information on infection history, vaccination status, and underlying health conditions, as well as facility-level information, limited our ability to examine the explanations discussed above. Linkage with healthcare utilization data would permit a more direct assessment and is needed in future research. Despite these limitations, our study offers a detailed understanding of the pandemic's impact on nursing home residents by utilizing recent national mortality data and examining the causes of death.

In conclusion, excess mortality among older residents in nursing homes during the COVID-19 pandemic was concentrated in 2022, when the Omicron variant became dominant, and the largest significant excess was observed for deaths categorized as “not elsewhere classified” (R00-R99). This pattern is consistent with indirect effects of the pandemic on the delivery of care, although our data cannot establish the mechanisms involved. It underscores the critical need to bolster healthcare system resilience to manage both pandemic response and chronic disease care effectively, ensuring better preparedness for future public health crises.

김지현은 고려대학교에서 보건학 학·석·박사학위를 받았으며, 국립중앙의료원에서 과제연구원으로 근무 중이다. 주요 관심 분야는 역학, 건강형평성, 공간역학이다.

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이은후는 연세대학교에서 보건학 석사학위를 받았으며, 국립중앙의료원에서 재직 중이다. 주요 관심 분야는 공공의료, 지역격차, 간호학이다.

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Supplementary material 1

Cause of death (104 disease categories)

The cause of death refers to all diseases, conditions, injuries, accidents, or acts of violence recorded in the death certificate that either caused or contributed to the death (Statistics Korea, 2024). In accordance with WHO recommendations, the reported causes of death from death notification forms and death certificates are reviewed, classified according to the Korean Standard Classification of Diseases (KCD), and aggregated into the International Statistical Classification of Diseases and Related Health Problems, 10th revision (ICD-10) mortality tabulation list 2 provided by the World Health Organization (WHO) to compile statistics on the underlying causes of death (Statistics Korea, 2024). The underlying cause of death is defined as either the disease or injury directly leading to a series of events resulting in death or the circumstances of an accident or violence causing fatal injury (Statistics Korea, 2024).

Until 2020, Statistics Korea utilized the WHO-recommended General Mortality Tabulation List (103 items) for statistical table compilation (WHO, 2016). In 2020, deaths attributed to COVID-19 (KCD=U07.1, U07.2) were included to the death by “Certain infectious and parasitic diseases (KCD=A00–B99).” However, since 2021, deaths due to COVID-19 have been separately categorized, employing a total of 104 categories. These categories are detailed below.

Cause of death	WHO category ¹⁾	KCD code
Certain infectious and parasitic diseases	1-001	A00–B99
Cholera	1-002	A00
Other gastroenteritis and colitis of infectious and unspecified origin	1-003	A09
Other intestinal infectious diseases	1-004	A01–A08
Respiratory tuberculosis	1-005	A15–A16
Other tuberculosis	1-006	A17–A19
Plague	1-007	A20
Tetanus	1-008	A33–A35
Diphtheria	1-009	A36
Whooping cough	1-010	A37
Meningococcal infection	1-011	A39
Septicaemia	1-012	A40–A41
Infections with a predominantly sexual mode of transmission	1-013	A50–A64
Acute poliomyelitis	1-014	A80
Rabies	1-015	A82
Yellow fever	1-016	A95
Other arthropod-borne viral fevers and viral haemorrhagic fevers	1-017	A90–A94, A96–A99
Measles	1-018	B05
Viral hepatitis	1-019	B15–B19
Human immunodeficiency virus [HIV] disease	1-020	B20–B24
Malaria	1-021	B50–B54
Leishmaniasis	1-022	B55

Cause of death	WHO category ¹⁾	KCD code
Trypanosomiasis	1-023	B56-B57
Schistosomiasis	1-024	B65
Remainder of certain infectious and parasitic diseases	1-025	A21-A32, A38, A42-A49, A65-A79, A81, A83-A89, B00-B04, B06-B09, B25-B49, B58-B64, B66-B94, B99
Neoplasms	1-026	C00-D48
Malignant neoplasms of lip, oral cavity and pharynx	1-027	C00-C14
Malignant neoplasm of oesophagus	1-028	C15
Malignant neoplasm of stomach	1-029	C16
Malignant neoplasms of colon, rectum and anus	1-030	C18-C21
Malignant neoplasms of liver and intrahepatic bile ducts	1-031	C22
Malignant neoplasm of pancreas	1-032	C25
Malignant neoplasm of larynx	1-033	C32
Malignant neoplasms of trachea, bronchus and lung	1-034	C33-C34
Malignant melanoma of skin	1-035	C43
Malignant neoplasm of breast	1-036	C50
Malignant neoplasm of cervix uteri	1-037	C53
Malignant neoplasms of other and unspecified parts of uterus	1-038	C54-C55
Malignant neoplasm of ovary	1-039	C56
Malignant neoplasm of prostate	1-040	C61
Malignant neoplasm of bladder	1-041	C67
Malignant neoplasms of meninges, brain and other parts of central nervous system	1-042	C70-C72
Non-Hodgkin's lymphoma	1-043	C82-C86
Multiple myeloma and malignant plasma cell neoplasms	1-044	C90
Leukaemia	1-045	C91-C95
Remainder of malignant neoplasms	1-046	C17, C23-C24, C26-C31, C37-C41, C44-C49, C51-C52, C57-C60, C62-C66, C68-C69, C73-C81, C88, C96-C97
Remainder of neoplasms	1-047	D00-D48
Diseases of the blood and blood-forming organs and certain disorders involving the immune mechanism	1-048	D50-D89
Anaemias	1-049	D50-D64
Remainder of diseases of the blood and blood-forming organs and certain disorders involving the immune mechanism	1-050	D65-D89
Endocrine, nutritional and metabolic diseases	1-051	E00-E88
Diabetes mellitus	1-052	E10-E14
Malnutrition	1-053	E40-E46
Remainder of endocrine, nutritional and metabolic diseases	1-054	E00-E07, E15-E34, E50-E88
Mental and behavioural disorders	1-055	F01-F99

Cause of death	WHO category ¹⁾	KCD code
Mental and behavioural disorders due to psychoactive substance use	1-056	F10-F19
Remainder of mental and behavioural disorders	1-057	F01-F09, F20-F99
Diseases of the nervous system	1-058	G00-G98
Meningitis	1-059	G00, G03
Alzheimer's disease	1-060	G30
Remainder of diseases of the nervous system	1-061	G04-G25, G31-G98
Diseases of the eye and adnexa	1-062	H00-H57
Diseases of the ear and mastoid process	1-063	H60-H93
Diseases of the circulatory system	1-064	I00-I99
Acute rheumatic fever and chronic rheumatic heart diseases	1-065	I00-I09
Hypertensive diseases	1-066	I10-I13
Ischaemic heart diseases	1-067	I20-I25
Other heart diseases	1-068	I26-I51
Cerebrovascular diseases	1-069	I60-I69
Atherosclerosis	1-070	I70
Remainder of diseases of the circulatory system	1-071	I71-I99
Diseases of the respiratory system	1-072	J00-J98
Influenza	1-073	J09-J11
Pneumonia	1-074	J12-J18
Other acute lower respiratory infections	1-075	J20-J22
Chronic lower respiratory diseases	1-076	J40-J47
Remainder of diseases of the respiratory system	1-077	J00-J06, J30-J39, J60-J98
Diseases of the digestive system	1-078	K00-K92
Gastric and duodenal ulcer	1-079	K25-K27
Diseases of the liver	1-080	K70-K76
Remainder of diseases of the digestive system	1-081	K00-K22, K28-K66, K80-K92
Diseases of the skin and subcutaneous tissue	1-082	L00-L98
Diseases of the musculoskeletal system and connective tissue	1-083	M00-M99
Diseases of the genitourinary system	1-084	N00-N98
Glomerular and renal tubulo-interstitial diseases	1-085	N00-N15
Remainder of diseases of the genitourinary system	1-086	N17-N98
Pregnancy, childbirth, and the puerperium	1-087	O00-O99
Pregnancy with abortive outcome	1-088	O00-O07
Other direct obstetric deaths	1-089	O10-O92
Indirect obstetric deaths	1-090	O98-O99
Remainder of pregnancy, childbirth, and the puerperium	1-091	O95-O97
Certain conditions originating in the perinatal period	1-092	P00-P96
Congenital malformations, deformations, and chromosomal abnormalities	1-093	Q00-Q99
Symptoms, signs, and abnormal clinical and laboratory findings, not elsewhere classified	1-094	R00-R99
External causes of mortality	1-095	V01-Y89
Transport accidents	1-096	V01-V99
Falls	1-097	W00-W19

Cause of death	WHO category ¹⁾	KCD code
Accidental drowning and submersion	1-098	W65-W74
Exposure to smoke, fire, and flames	1-099	X00-X09
Accidental poisoning by and exposure to noxious substances	1-100	X40-X49
Intentional self-harm	1-101	X60-X84
Assault	1-102	X85-Y09
All other external causes	1-103	W20-W64, W75-W99, X10-X39, X50-X59, Y10-Y89
COVID-19 ²⁾	-	U07.1, U07.2

¹⁾ Category based on World Health Organization tabulation list 1.

²⁾ The category for COVID-19 was included for “Certain infectious and parasitic diseases” category in 2020 and separated from 2021.

Abbreviations: WHO, World Health Organization; KCD, Korean Standard Classification of Diseases.

References

- Statistics Korea. (2024). *Korean standard classification of diseases*. https://kssc.kostat.go.kr:8443/ksscNew_web/ekssc/main/main.do#
- World Health Organization. (2016). *International statistical classification of diseases and related health problems: 10th revision* (5th ed., Vol. 1: Tabular list). <https://icd.who.int>

Supplementary material 2

Korean Standard Classification of Diseases (KCD) code

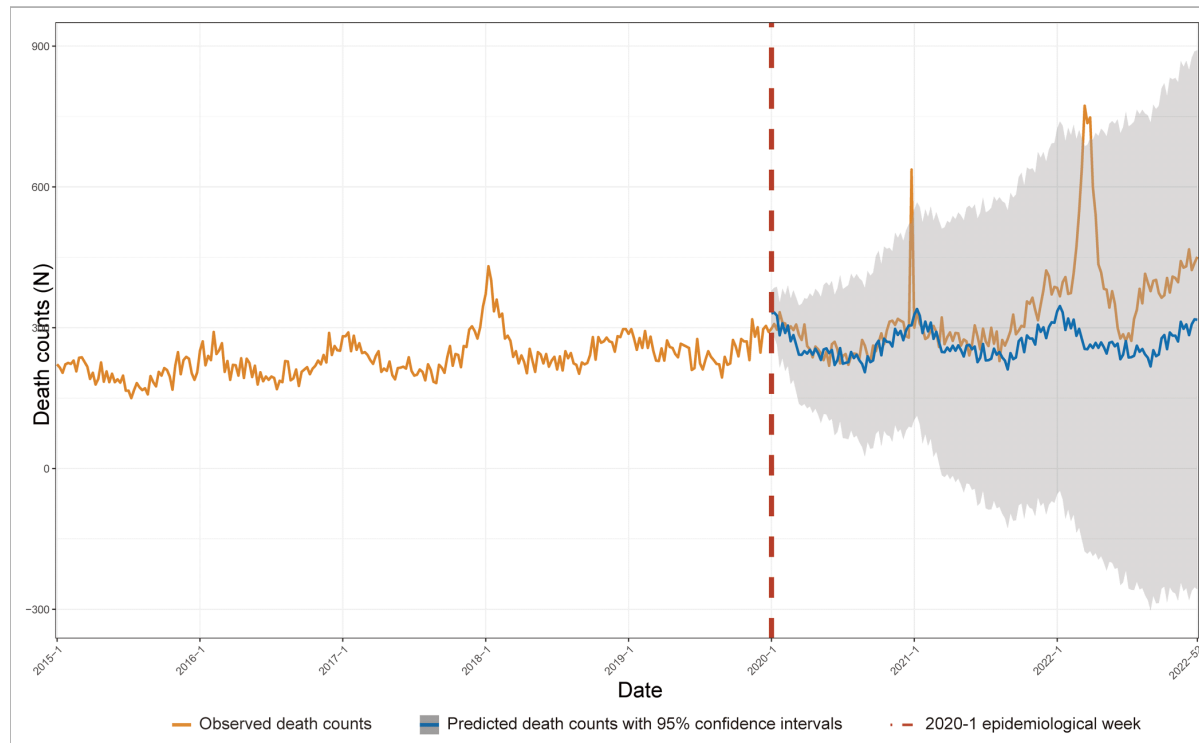
The Korean Standard Classification of Diseases (KCD) code is a systematic categorization for disease infection and death data according to the similarity of their features (Statistics Korea, 2024). The main category of KCD was selected to subgroup the causes of death because the code could provide standardized criteria which could result in consistency and comparative results (Statistics Korea, 2024). The main category is divided as follows (Statistics Korea, 2024):

- Certain infectious and parasitic diseases (KCD: A00–B99)
- Neoplasms (KCD: C00–D48)
- Diseases of the blood and blood-forming organs and certain disorders involving the immune mechanism (KCD: D50–D89)
- Endocrine, nutritional, and metabolic diseases (KCD: E00–E90)
- Mental and behavioral disorders (KCD: F00–F99)
- Diseases of the nervous system (KCD: G00–G99)
- Diseases of the eye and adnexa (KCD: H00–H59)
- Diseases of the ear and mastoid process (KCD: H60–H95)
- Diseases of the circulatory system (KCD: I00–I99)
- Diseases of the respiratory system (KCD: J00–J99)
- Diseases of the digestive system (KCD: K00–K93)
- Diseases of the skin and subcutaneous tissue (KCD: L00–L99)
- Diseases of the musculoskeletal system and connective tissue (KCD: M00–M99)
- Diseases of the genitourinary system (KCD: N00–N99)
- Pregnancy, childbirth, and the puerperium (KCD: O00–O99)
- Certain conditions originating in the perinatal period (KCD: P00–P96)
- Congenital malformations, deformations, and chromosomal abnormalities (KCD: Q00–Q99)
- Symptoms, signs, and abnormal clinical and laboratory findings, Not Else Classified (KCD: R00–R99)
- Injury, poisoning, and certain other consequences of external causes (KCD: S00–T98)
- Codes for special purposes (KCD: U00–U99)
- External causes of morbidity and mortality (KCD: V01–Y98)
- Factors influencing health status and contact with health services (KCD: Z00–Z99)

References

Statistics Korea. (2024). *Korean standard classification of diseases*. https://kssc.kostat.go.kr:8443/ksscNew_web/ekssc/main/main.do#

Supplementary material 3

Figure S1. Predicted and observed numbers of death during the COVID-19 pandemic using 52 epidemiological week framework

Notes: The orange line refers to observed death counts. The blue line refers to predicted death counts. The grey band refers to 95% confidence intervals of the predicted death counts. The red dashed line refers to 2020-1 epidemiological week.

Table S1. Background information for main analysis

	Individuals who died at ≥65 years of age	Individuals who died in social welfare facilities aged ≥65 years of age
Total number of deaths by year		
2015	205,603	10,437 (5.1%)
2016	210,716	11,486 (5.5%)
2017	217,703	12,381 (5.7%)
2018	229,764	13,632 (5.9%)
2019	227,074	13,306 (5.9%)
2020	237,831	14,326 (6.0%)
2021	251,055	15,745 (6.3%)
2022	303,447	21,772 (7.2%)
Average number of deaths by year		
2015–2019	218,172.0	12,248.4 (5.6%)
2020–2022	264,111.0	17,281.0 (6.5%)
2015–2022	235,399.1	14,135.6 (6.0%)

	Individuals who died at ≥65 years of age	Individuals who died in social welfare facilities aged ≥65 years of age
Average number of deaths per epiweek ¹⁾		
2015–2019	4,180.4	234.7 (5.6%)
2020–2022	5,060.6	331.0 (6.5%)
2015–2022	4,511.8	271.0 (6.0%)
COVID-19 death counts (2020-53 epiweek–2022-52 epiweek)		
Total	33,087	1,393 (4.2%)
Weekly average	315.1	13.3 (4.2%)

¹⁾ Calculated after excluding 2014-53 epidemiological week.
Abbreviations: Epiweek, Epidemiological week.

Table S2. Estimated numbers of excess mortality during the COVID-19 pandemic using 52 epidemiological week framework

	Death counts			Excess death counts, 2020–2022 (95% CI)
	Observed, 2015–2019	Observed, 2020–2022	Predicted, 2020–2022 (95% CI)	
Total	61,026.0	51,932.0	41,726.2 (-3,382.1–86,267.7)	10,205.8 (-34,335.7–55,314.1)
Gender				
Men	16,466	14,272	11,069.4 (1,712.9–20,303.5)	3,202.6 (-6,031.5–12,559.1)
Women	44,560	37,660	31,618.9 (25,600.8–37,550.1)	6,041.1 (109.9–12,059.2)
Age group (years of age)				
65–69	1,260	910	756.0 (698.4–813.5)	154.0 (96.5–211.6)
70–74	2,736	1,677	1,490.2 (1,096.3–1,879.8)	186.8 (-202.8–580.7)
75–79	6,887	4,077	4,065.0 (3,632.9–4,494.0)	12.0 (-417.0–444.1)
80–84	12,501	9,676	9,618.2 (4,242.9–14,916.2)	57.8 (-5,240.2–5,433.1)
≥85	37,642	35,592	28,218.6 (22,785.1–33,567.7)	7,373.4 (2,024.3–12,806.9)
Cause of death (KCD-code)				
Certain infectious and parasitic diseases (A00–B99)	587.0	356.0	352.2 (314.7–389.7)	3.8 (-33.7–41.3)
Neoplasms (C00–D48)	3,841.0	3,071.0	2,305.0 (2,216.5–2,393.2)	766.0 (677.8–854.5)
Endocrine, nutritional, and metabolic diseases (E00–E90)	2,276.0	1,644.0	1,579.1 (438.9–2,702.3)	64.9 (-1,058.3–1,205.1)
Mental and behavioral disorders (F00–F99)	3,358.0	1,647.0	2,023.4 (1,745.2–2,299.9)	-376.4 (-652.9 to -98.2)

	Death counts			Excess death counts, 2020-2022 (95% CI)
	Observed, 2015-2019	Observed, 2020-2022	Predicted, 2020-2022 (95% CI)	
Diseases of the nervous system (G00-G99)	3,917.0	4,827.0	3,231.8 (1,760.7-4,681.2)	1,595.2 (145.8-3,066.3)
Diseases of the circulatory system (I00-I99)	14,088.0	10,208.5	9,479.5(2,280.1-16,581.3)	729.0(-6,372.8-7,928.4)
Diseases of the respiratory system (J00-J99)	5,132.0	3,040.0	3,464.7(2,546.6-4,373.3)	-424.7(-1,333.3-493.4)
Diseases of the digestive system (K00-K93)	563.0	362.0	337.5(304.5-370.5)	24.5(-8.5-57.5)
Diseases of the musculoskeletal system and connective tissue (M00-M99)	265.0	159.0	105.2(-3.9-213.0)	53.8(-54.0-162.9)
Diseases of the genitourinary system (N00-N99)	611.0	513.0	366.6(327.0-406.2)	146.4(106.8-186.0)
Symptoms, signs, and abnormal clinical and laboratory findings, not elsewhere classified (R00-R99)	25,414.0	24,153.5	20,144.9(7,500.7-32,624.8)	4,008.6(-8,471.3-16,652.8)
External causes of morbidity and mortality (V01-Y98)	838.0	460.0	503.7(458.2-549.1)	-43.7(-89.1 to -1.8)

Notes: The sum of predicted and excess deaths from subgroups may not exactly equal the overall total, as independent SARIMA models were fitted to each subgroup. Subgroup estimates should be interpreted as indicating direction rather than as an additive decomposition of the total.

Abbreviations: CI, Confidence interval; KCD-code, The Korean Standard Classification of Diseases code

코로나19 팬데믹 기간 한국 요양시설 노인의 초과 사망 추정

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| 초 록 |

본 연구는 통계청 사망원인 통계자료(2015-2022년, 65세 이상)를 이용하여 SARIMA 모형을 구축하고 코로나19 팬데믹 기간 요양시설 노인의 초과 사망을 추정하였다. 2020-2022년 초과 사망은 6,992명(95% 신뢰구간 142.7-15,027.4)이었으며, 2022년에 집중되었다(6,191.2명, 95% 신뢰구간 2,899.6-10,057.6). 사인별로는 달리 분류되지 않은 증상 및 임상소견(3,089.2명, 95% 신뢰구간 1,422.1-4,775.9), 신생물(734.4명, 95% 신뢰구간 604.0-865.9), 비노생식계 질환(139.6명, 95% 신뢰구간 78.8-201.1)에서 유의한 초과 사망이 관찰된 반면, 정신 및 행동장애와 외인에 의한 사망은 기대보다 적었다. 이는 의료 체계 부담 및 만성질환 관리의 어려움 등 팬데믹의 간접적 영향과 부합하나, 기전 규명을 위한 의료이용 자료와의 연계 등 후속 연구가 필요하다.

주요 용어: 사망, 사망원인, 요양시설, 사회복지, 코로나19