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Abstract

The novel coronavirus disease 2019 (COVID-19) spread rapidly worldwide. Nursing home (NH) residents are the most vulnerable high-risk population to infection. Professional registered nurses' (RNs') infection control is irreplaceable. We used a secondary data analysis method using the government's senior citizen welfare department large data set about all NHs (N = 3,389) across Korea between January 20 and October 20, 2020. Bed size positively associated with the mortality rate (No. of COVID-19 resident deaths / No. of total residents) ($p = .048$). When the proportion of RNs to total nursing staff was higher, the infection rate was 0.626% lower ($p = .049$), the mortality rate was 0.088% lower ($p = .076$), the proportion of confirmed COVID-19 cases per resident out of the total number of NHs was 44.472% lower ($p = .041$), and the proportion of confirmed COVID-19 deaths per resident out of the total number of NHs was 6.456% lower ($p = .055$). This study highlighted nurse staffing criteria and suggests that increasing RNs in NHs will reduce infection and mortality rates during the COVID-19 pandemic. We strongly suggest NHs hire at least one RN per day to properly function, and a minimum of four RNs to provide a fully competent RN workforce in long-term care settings in Korean NHs.

Keywords

COVID-19, nursing homes, nurse staffing

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Introduction

The novel coronavirus disease 2019 (COVID-19) spread rapidly worldwide. On March 11, 2020, the World Health Organization (WHO) declared COVID-19 a global pandemic, which is the highest level of the WHO's infectious disease alert state (WHO, 2020). The COVID-19 pandemic has infected about 115,561,120 global citizens with 2,570,19 deaths worldwide. In Korea—one of the closest countries to China—about 152,545 people are infected with COVID-19 with 2,007 deaths reported from COVID-19 as of June 23, 2021 (Korea Centers for Disease Control & Prevention, 2021). COVID-19 spread mainly through close contact from person-to-person, and signs of infection include fever, cough, shortness of breath, sputum, and a sore throat (Korea Centers for Disease Control & Prevention, 2020). The COVID-19 outbreak's mortality rate promptly increases for those older than 65, and worsens with existing gerontological diseases including cardiovascular and Parkinson disease (Kim, 2020). Nursing homes (NHs) are considered healthcare settings where elders with chronic or gerontological diseases stay steadily with limited activities of daily living (ADLs), and residents

are very susceptible to any kind of infection (Kovaleva et al., 2018).

In Korea, 163,484 people reside in 3,389 NHs, comprising 2.21% of the total elderly population (Korean National Health Insurance Corporation, 2019). Most residents require assistance when performing ADLs and suffer from chronic disease (i.e., dementia: 94.7%, hypertension: 68.4%, diabetes: 31.6%, neurological disease: 29.8%, and osteoporosis: 19.3%; Shin et al., 2020). Respiratory infections are reported in 23.5% of residents, urinary tract infections in 11.4%, and skin infections in 7.4% (Park et al., 2018; Shin et al., 2020). When treating infected residents with COVID-19, elderly residents must be isolated, which

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may worsen their psychosocial health including delirium, depression, and anxiety (Barasteh et al., 2020). Beyond the health condition of elderly residents, the physical NH environment that places many residents in the same room or area and their relatively out-of-date information system can help quickly spread the virus (Agency for Healthcare Research & Quality, 2020). The spread of the virus is typically very severe as residents share the physical environment (Nicolle, 2014).

The Korean government distributed COVID-19 control manuals to prevent and manage the COVID-19 pandemic in February 2020. Registered nurses (RNs) are critical and the only healthcare providers who meet the government manual's criteria to prevent the spread of COVID-19. The manual provides guidelines that include equipping nurses with personal protection equipment (PPE) such as hand sanitizer and masks to control the spread of infections, restricting visits and leaves, excluding workers with a recent travel history to affected regions, taking temperatures, checking workers and residents for pneumonia, and notifying suspected cases to the Public Health authorities (Ministry of Health & Welfare-Centers for Disease Control & Prevention [MHOW-CDC], 2020). Also, tentative scenarios for each situation (i.e., if NH workers and residents came into contact with a confirmed case of COVID-19; if workers and residents interacted with a suspected case of COVID-19; and if workers and residents have a confirmed case of COVID-19) were developed and distributed in February 2020 (MHOW-CDC, 2020). These scenarios provide detailed guidance on step-by-step response procedures, workers' and residents' (residents' families) actions, public health center actions, NH actions (partial or full closure), and residents' transfer actions (MHOW-CDC, 2020).

Very limited research due to the characteristics of the very new and novel COVID-19 virus reported that NHs with greater numbers of RNs showed fewer cases and deaths of COVID-19 (Harrington et al., 2020; Li et al., 2020). Research in the United States reported that NHs with worse California Department of Public Health, quality ratings and public ratings (CMS ratings) had more confirmed cases of COVID-19 (He et al., 2020). As such, public rating has been confirmed to be related to COVID-19 in the United States, but no such research has been conducted in Korea yet. In Korea, NH rating evaluations are conducted every 3 years for all NHs to improve residents' health outcomes by improving the NHs' quality of care, and the evaluation rating is divided into five grades (Korean National Health Insurance Service, 2021).

Research in the United States reported that NHs with less non-White residents had more confirmed cases of COVID-19 (Abrams et al., 2020; Gorges & Konetzka, 2020; He et al., 2020; Moore et al., 2020). For-profit NHs compared with not-for-profit NHs or government-operated NHs provided less staffing input and also were related with more confirmed cases of COVID-19 (He et al., 2020; Stall et al., 2020). The

public reporting results from state department of health were not significant factors in some studies (Abrams et al., 2020; Chatterjee et al., 2020; Tulloch et al., 2021); it may be biased in measuring quality measures as they used a secondary dataset. Unmeasured confounding factors may remain about the relationship between measures of NH quality using secondary data and COVID-19 incidences and mortality, and a lower quality rating may simply indicate another measure of inferiority (Williams et al., 2021). Larger NHs and higher occupancy rates also showed more COVID-19 cases (Abrams et al., 2020; Harrington et al., 2020; He et al., 2020). Areas with larger populations where NHs are located also had more risk of having COVID-19 cases (Chatterjee et al., 2020).

With the Korean government's effort to control the COVID-19 outbreak, the importance of professional RNs' infection control is irreplaceable. Inadequate RN staffing levels were reported in many NHs prior to the spread of COVID-19 (Harrington et al., 2020; Li et al., 2020; Zimmerman et al., 2020). Lower RN staffing levels are related to higher pneumonia cases (Hutt et al., 2008), urinary tract infections (UTIs; Carter and Porell, 2005; Dorr et al., 2005; Horn et al., 2005; Shin et al., 2020), and kidney infections (Carter & Porell, 2005). More nursing staff, especially RNs, should be deployed to prevent the spread of infectious diseases (Lee et al., 2014) because RNs lead in virtually almost every aspect of care in NHs, including the assessment, treatment, evaluation, and management of residential conditions and infection control. However, there are not enough RNs available to flexibly respond to infection crises in Korean NHs (Ahn, 2020). Previous research suggests there are not enough RNs employed to respond to infection crises in Korean NHs (Ahn, 2020). Korea's long-term care law requires NHs to have only one RN or certified nursing assistant (CNA) for every 25 residents (Korean Ministry of Government Legislation, 2020) based on the number of each staffing category, rather than using hours per resident day (HPRD) of each nursing staff. Also, the ratio of care workers (CWs) to Korean NH residents is 1:2.5 (Korean Ministry of Government Legislation, 2020). The staffing mix in Korean NHs comprises of RNs, CNAs, and CWs (Lee et al., 2015). The education and training levels between RNs and CNAs are very different in terms of the required credits (103 college-level credits plus 100 clinical hours for RNs vs. only 1,520 h (740 classroom hours) for CNAs) without any restriction on educational background (Lee et al., 2015). CWs, with the requirement of education of only 240 h of training (including in class and practice), are in charge of providing services such as physical support and daily life activity support to residents in Korean NHs, and the job description of CWs is similar to that of CNAs in the United States (Lee et al., 2015; Lee et al., 2020). Nursing staff in Korean NHs have a big problem in that the staff consist heavily of CWs (88.1%), followed by CNAs(1.9%)

and RNs (10%) (Korean National Health Insurance Service, 2020). Basically, RNs must supervise CNAs or CWs (Lee et al., 2015). However, many administrators have hired CNAs instead of RNs to reduce costs and only 22% of NHs deploy RNs (Korean National Health Insurance Corporation, 2019). This study examined the organizational factors and characteristics of NH staffing including the proportion of RNs to nursing staff and the ratio of staff to residents, which relate to the COVID-19 outbreak and number of NH resident deaths during the COVID-19 pandemic's peak.

Methods

We used a large dataset from the government's senior citizen welfare department as our secondary data-analysis method in this study. NHs with COVID-19 residents are required to report COVID-19-confirmed cases to the public health center in the district level (each division of the 249 administrative districts; rural area, 20,000 < population < 50,000) to which they belong. Each division's office manages these COVID-19 data, and we used these data in this study. Specifically, this study included data about all NHs (N = 3,389) across Korea and we identified NHs that reported COVID-19 infections and deaths among residents between January 20 (the day of the first confirmed COVID-19 case in Korea) and October 20, 2020.

We retrieved data from the following two formal Information Disclosure system sources: the Information Disclosure system, and the Korean National Health Insurance Corporation website. We collected data about the actual number of NH residents with confirmed COVID-19 cases and associated deaths by each division of the 249 administrative districts and the organizational and resident characteristics of NHs. Korea developed the Information Disclosure system in 1998, which permits that information prepared or acquired by any public institution must be disclosed to the requester in the form of perusal at the request of a requester (available for general citizens, corporations, organizations, and foreigners) in Korea (Information Disclosure, 2020). This system is designed to ensure the public's right to know and encourage participation in state administration based on more information (Information Disclosure, 2020). We requested the necessary information (the number of NH residents with confirmed COVID-19 cases and associated deaths by each division of the 249 administrative districts) using the system's website. The senior citizens' welfare officer in charge of each division of the 249 administrative districts disclosed the related information in the form of an Excel or Word document (Information Disclosure, 2020).

The process of collecting data related to COVID-19 in NHs by each division of the 249 administrative districts is as follows. One person is in charge of reviewing NH infections and they immediately report to the public health

center if a suspected resident or employee are detected through periodic monitoring (temperature, respiratory symptoms such as cough, sore throat, difficulty breathing, or other). The public health center staff collect samples from NH residents suspected of having an infection and count the number of confirmed residents. This information is aggregated in each administrative district (Korea Centers for Disease Control & Prevention, 2020). Additionally, we used the Korean National Health Insurance Corporation website (<http://www.longtermcare.or.kr/npbs/index.jsp>) as a secondary data source to obtain information about the organizational and resident characteristics of NHs. The 2018 long-term care institution evaluation results offered the most current available data, detailing residents' characteristics (gender, average residence duration, grade of long-term care insurance) and NH characteristics (bed size, occupancy rate, ownership form, public reporting, skill mix, ratio of staff to residents, the proportion of shared rooms) from the open-access Korean National Health Insurance Corporation (Korean National Health Insurance Corporation, 2019). Among them, we selected the proportion of RN/RN + CNA, ratio of staff to residents, and facility evaluation in each division of the 249 administrative districts to analyze the data. We merged those two datasets to examine the association between NH characteristics and the likelihood of having confirmed COVID-19 cases and deaths in NH residents.

Analysis

We conducted descriptive statistics such as frequency, ratio, average, and percentage to examine NHs' and residents' characteristics and COVID-19 cases and deaths. We compared NHs with COVID-19-confirmed residents to those without COVID-19-confirmed residents. Independent variables were bed size, skill mix (proportion of RN/RN + CNA), ratio of staff to residents, and facility evaluation.

We used an ordinary least-squared (OLS) regression with a fixed-effects method to analyze the data. We analyzed the relationship between NH characteristics (staffing, results of public reporting) and the proportion of NH residents' COVID-19 infections and deaths in each district level. We estimated the coefficient with robust standard errors and found variables with coefficients that satisfy p values at the .05. All statistical analyses were performed using SAS software version 9.3 (SAS Institute, Cary, NC, USA).

Results

Table 1 shows the characteristics of residents and NHs in Korea. A total of 3,396 NHs in Korea cared for 118,315 residents in 2019. About 78.9% were female residents. The average residence duration was 2 years and 10 months. Of residents, 38.8% were grade 3 long-term care insurances (elderly people who are partially dependent on daily activities). The

Table 1. Characteristics of Residents and Nursing Homes in Korea.

Characteristics	Frequency or ratio	%	Mean(SD)
Resident characteristics (2019) N = 118,315			
Male residents	25,009	21.1	
Female residents	93,306	78.9	
Average residence duration (year)			2.8
Long-term care grade (acuity score)			
Grade 1 ¹	12,901	10.9	
Grade 2 ²	28,069	23.7	
Grade 3 ³	45,952	38.8	
Grade 4 ⁴	29,677	25.1	
Grade 5 ⁵	1,626	1.4	
Grade Cognitive Assistant ⁶	90	0.1	
Nursing home characteristics (2019) N = 3,389 in 249 geographical districts			
Bed size			48.24(32.5)
Occupancy rate, %		83.1	
Ownership form			
For-profit	2,650	78.2	
Not-for-profit	739	21.8	
Facility quality evaluation by Korean National Health Insurance Corporation			
A grade ^a	702	20.7	
B grade ^b	827	24.4	
C grade ^c	827	24.4	
D grade ^d	915	27.0	
E grade ^e	125	3.7	
Characteristics			
Skill mix (proportion of RN/RN + CNA), %	15.87		Mean(SD)
Ratio of staff to residents			
RN:residents	1:111		
CNA:residents	1:20		
CW:residents	1:2		
Physician:residents	1:75		
Physical therapist:residents	1:84		
Dietitian:residents	1:151		
Shared rooms			
Residents in private (1-person) rooms, %	3.3		
Residents in shared (2 or more people) rooms, %	96.7		

Note. SD = standard deviation; RN = Registered nurse; CAN = Certified nursing assistants; CW = Care worker; ¹ Elders who are completely dependent for activities of daily living with a score of over 95 in the evaluation; ² Elders who are mostly dependent for activities of daily living with a score of between 75 and 95 in the evaluation; ³ Elders who are partially dependent for activities of daily living with a score of between 60 and 75 in the evaluation; ⁴ Elders who have limited dependence for activities of daily living with a score of between 51 and 60 in the evaluation; ⁵ Elders who dementia with a score of between 45 and 51 in the evaluation; ⁶ Elders who dementia with a score under 45 in the evaluation; ^a Score of 90 or more, and 70 points or more of each major classification area; ^b Score of 80 or more, and 60 points or more of each major classification area; ^c Score of 70 or more, and 50 points or more of each major classification area; ^d Score of 60 or more, and 40 points or more of each major classification area; ^e Score of 59 or less, and 39 points or less in each major classification area.

average number of beds for all NHs in Korea is 48.24 (SD = 32.5) with a high occupancy rate (83.1%). Almost all NH residents in Korea were more likely to reside in shared rooms (96.7%). Most Korean NHs are for profit (78.2%). About 20.7% received a superior grade in public reporting. The mean skill mix of nursing staff was 15.87% for RNs/RNs + CNAs. The ratios of staff to residents are as follows: RNs:residents is 1:111, CNAs:residents is 1:20, CWs:residents is 1:2, visiting physicians (part-time physicians who visit once a month):residents is 1:75, physical therapists:residents is 1:84, and dietitians:residents is 1:151.

Table 2 provides the result of the descriptive statistic of the characteristics of Korean NHs (administrative district classification) with and without COVID-19 residents. The average number of beds in NHs with a COVID-19 outbreak was 46.87, which was smaller than the average number of beds (48.24) for NHs without COVID-19 outbreaks. The proportion of RNs in NHs with COVID-19 outbreaks was lower than that of NHs that did not experience COVID-19 outbreaks (13.63% vs 15.90%). In other words, NHs with residents infected by COVID-19 had lower numbers of RNs than other NHs in Korea. The ratio of RNs to residents in NHs with

Table 2. Characteristics of NHs With and Without Covid-19 Residents (District Level).

	Nursing Homes Located in 249 Geographical Districts					
	With COVID-19 residents N = 26			Without COVID-19 residents N = 223		
	Frequency or ratio	%	Mean(SD)	Frequency or ratio	%	Mean(SD)
Bed size			46.87(35.31)			48.52(11.08)
Skill mix (proportion of RN/RN + CNA), %		13.63			15.90	
Ratio of staff to residents						
RN:residents	1:132			1:113		
CNA:residents	1:19			1:21		
CW:residents	1:2			1:2		
Physician:residents	1:60			1:58		
Physical therapist:residents	1:87			1:84		
Dietitian:residents	1:184			1:146		
Facility quality evaluation by Korean National Health Insurance Corporation						
A grade ^a	78	18.4		468	21.1	
B grade ^b	104	24.6		539	24.3	
C grade ^c	105	24.8		538	24.3	
D grade ^d	125	29.6		587	26.5	
E grade ^e	11	2.6		86	3.8	

Note. SD = standard deviation; RN = Registered nurse; CAN = Certified nursing assistants; CW = Care worker, ^a Score of 90 or more, and 70 points or more of each major classification area; ^b Score of 80 or more, and 60 points or more of each major classification area; ^c Score of 70 or more, and 50 points or more of each major classification area; ^d Score of 60 or more, and 40 points or more of each major classification area; ^e Score of 59 or less, and 39 points or less in each major classification area.

Table 3. COVID-19 Cases and Deaths Among Korean NH Residents (District Level).

	Frequency	Mean	Standard Deviation	Min-Max
Confirmed COVID-19 resident cases	268			
COVID-19 resident deaths	40			
COVID-19 infection rate (%)		0.180	1.322	0–14.815
COVID-19 mortality rate (%)		0.028	0.207	0–2.273
COVID-19 fatality rate (%)		15.001	3.322	0–66.672
No. of COVID-19 resident /No. of total nursing home (%)		10.936	90.802	0–1000
No. of COVID-19 death resident /No. of total nursing home (%)		1.721	14.115	0–160

Note. COVID-19 infection rate = No. of residents infected with COVID-19 in each administrative district / No. of total NH resident in each administrative district; COVID-19 mortality rate = No. of COVID-19 residents who died of COVID-19 in each administrative district / No. of total resident in each administrative district; COVID-19 fatality rate = No. of COVID-19 residents who died of COVID-19 / No. of residents infected with COVID-19 in each administrative district.

COVID-19 outbreaks was 1:132, whereas that of NHs without COVID-19 outbreaks was 1:113. The ratio of CNAs to residents in NHs with COVID-19 outbreaks was 1:19, whereas that of NHs without COVID-19 outbreaks was 1:21. The ratios of CWs to residents in NHs with COVID-19 outbreaks and without COVID-19 outbreaks were the same at 1:2. About 18.4% of NHs with COVID-19-positive residents received a superior grade in public reporting. However, 21.1% of NHs without COVID-19-positive residents in Korea received a superior grade in this evaluation. NHs with COVID-19 outbreaks had a lower proportion of superior grades than those without COVID-19-positive residents.

Table 3 provides the results of COVID-19 cases and deaths among NH residents. The total confirmed COVID-19 cases among Korean NH residents was 268, COVID-19 deaths totaled 40, and the number of NH outbreaks was 40. The mean resident infection rate of COVID-19 was 0.180 per each NH, the mean mortality rate was 0.028, and the mean fatality rate was 15.001. The proportion of confirmed COVID-19 resident cases out of the total number of NHs was 10.936 and the proportion of confirmed COVID-19 resident deaths out of the total number of NHs was 1.721.

Table 4 shows the relationships between COVID-19 cases and deaths of residents and selected staffing variables with selected NH characteristics. In this study, bed size positively associated with the mortality rate (No. of COVID-19 resident deaths / No. of total residents) ($p = .048$). When the proportion of RNs in the total nursing staff was higher than the sample median, the infection rate (No. of

COVID-19-infected residents / No. of total residents) was 0.626% lower ($p = .049$), the mortality rate was 0.088% lower ($p = .076$), the proportion of confirmed COVID-19 resident cases out of the total number of NHs was 44.472% lower ($p = .041$), and the proportion of confirmed COVID-19 resident deaths out of the total number of NHs was 6.456% lower ($p = .055$). The ratios of CWs to residents positively associated with the infection rate ($p = .033$), the mortality rate ($p = .033$), the proportion of confirmed COVID-19 resident cases out of the total number of NHs ($p = .030$), and the proportion of confirmed COVID-19 resident deaths out of the total number of NHs ($p = .029$). The job descriptions of NH CWs in Korea are equivalent to CNAs in the United States (Lee et al., 2015).

These results are consistent with our hypothesis. However, the ratios of CNAs to residents, visiting physicians to residents, physical therapists to residents, dietitian to residents, and the result of public reporting did not significantly associate with the likelihood of residents' COVID-19 infection and mortality rates, the proportion of confirmed COVID-19 resident cases out of the total number of NHs, and the proportion of confirmed COVID-19 resident deaths out of the total number of NHs.

Discussion

Throughout the world, NHs are severely suffering from the spread of COVID-19, which NH staff and residents have never experienced. This study was conducted to investigate the impact of organizational factors and staffing characteristics on NHs that had COVID-19 infections and deaths among residents in Korea between January 20, 2020 and October 20, 2020. The NHs with more RNs among the total nursing staff were likely to have fewer COVID-19 infections and resident deaths, and a lower proportion of confirmed COVID-19 residents and deaths out of the total number of NHs.

This result is not surprising, considering that RNs are the only licensed healthcare workers in Korean NHs. Some recent studies reported that the lack of RNs in NHs increases the likelihood of COVID-19 outbreaks in NHs (Barasteh et al., 2020), which relates to the role of professional nurses in long-term care settings (Barasteh et al., 2020). RNs undertake physical assessments, comprehensive health evaluations, and make critical decisions for NH residents (Davidson & Szanton, 2020). In terms of infection control, RNs are responsible for assessing and recording residents' infection statuses and transferring residents who are suspected to or have an infectious disease to the hospital (Harrington et al., 2020; Park et al., 2018). Also, RNs educate and supervise residents' families to wear PPE such as gloves, masks, and gowns to prevent the spread of infectious diseases and to comply with isolation guidelines based on infection routes such as droplet and contact caution (Ahn, 2020). In addition, RNs are responsible for requesting medical treatment and determining isolation of suspected

infectious disease residents, and restricting visits (Park et al., 2020). RNs instruct and supervise workers to disinfect their rooms and surroundings of infectious disease residents (Kim, 2020). Previous studies reported that higher RN staffing is a key factor in decreasing COVID-19 outbreaks (Figueroa et al., 2020; Harrington et al., 2020; Li et al., 2020) and infectious diseases in NHs (Carter & Porell, 2005; Dorr et al., 2005; Horn et al., 2005; Hutt et al., 2008; Shin et al., 2020). Li et al. (2020) reported that providing about RN 0.33 HPRD (20 min) correlates to 22% fewer confirmed COVID-19 cases and 26% mortality. NHs that failed to provide at least 0.75 RN HPRD (equivalent to 45 min per the U.S. federal government's NH staffing guideline) were twice more likely to have confirmed cases of COVID-19 than NHs that adhered to government guidelines (Harrington et al., 2020). Also, lower HPRD of RNs and total nurse staffing were more susceptible to the COVID-19 infection (Figueroa et al., 2020). Also, lower HPRD of RNs and total nurse staffing were more susceptible to the COVID-19 outbreak (Figueroa et al., 2020). Our results of a negative relationship existing between RN staffing and the COVID-19 infection and mortality rate of NH residents are consistent with findings of these previous studies (Figueroa et al., 2020; Harrington et al., 2020; Li et al., 2020). Furthermore, McGilton et al. (2020) suggested relocating and training RNs at other medical facilities, such as hospitals, to work in NHs to increase RN staffing levels during a pandemic. These findings highlight the important role professional RNs play in reducing COVID-19 outbreaks in NHs. However, more than 70% of Korean NHs had no RNs (Bakerjian et al., 2021). Thus, the Korean government should benchmark U.S. regulations and experts' recommendations on NHs to hire at least one RN per day with a specialty of geriatric nursing and leadership and ensure appropriate working conditions and compensation to realize NH residents' best care (Bakerjian et al., 2021).

Comparing the staffing standards of the U.S. and South Korea, U.S. NHs provide a total of 4.1 HPRD to residents (RN: 0.75 HPRD, licensed vocational or licensed practical nurse (LPN): 0.55 HPRD, CNA: 2.78 HPRD; (Lee et al., 2015) whereas Korean NHs provide a total of 3.52 HPRD to residents (RN or CNA: 0.32 HPRD, CW: 3.2 HPRD; Ministry of Health and Welfare, 2021). More seriously, Korea not only has a smaller total of HPRD than the U.S., but also has no mandatory-placement regulations for RNs in NHs.

Other than RN staffing, three major factors impacted the COVID-19 outcomes in previous research: for-profit NHs, NH size, and resident ethnicity. Spurlock and Elgazzar (2020) reported that smaller NHs are more effective in controlling COVID-19 than larger NHs. This outcome is consistent our result. The average bed size of NHs in Korea is 48.2 and most NHs in Korea did not provide single rooms for each resident (Korean National Health Insurance Corporation, 2019). To prevent the spread of infections, including

Table 4. Effects of Staffing and NH Characteristics on Outcomes (District Level).

	COVID-19 infection rate (%)			COVID-19 mortality rate (%)			No. of COVID-19 resident infections in each administrative district/ No. of total nursing homes in each administrative district(%)			No. of COVID-19 resident deaths in each administrative district/ No. of total nursing homes in each administrative district(%)		
	Coeff	Std error	p-value	Coeff	Std error	p-value	Coeff	Std error	p-value	Coeff	Std error	p-value
Intercept	-5.701	3.583	0.115	-1.049	0.561	0.065	-383.220	245.894	0.122	-66.516	38.091	0.084
Bed size	1.094	0.640	0.090	0.201	0.100	0.048*	73.180	43.886	0.098	12.680	6.798	0.065
Skill mix (proportion of RN/RN + CNA)	-0.626	0.313	0.049*	-0.088	0.049	0.076	-44.472	21.504	0.041*	-6.456	3.331	0.055
Ratio of Care workers/ residents	9.270	4.299	0.033*	1.458	0.673	0.033*	647.979	294.974	0.030*	101.292	45.694	0.029*
Ratio of Physician/ residents	-12.512	19.477	0.522	-1.236	3.050	0.686	-728.209	1336.522	0.587	-81.779	207.040	0.694
Ratio of Physical therapist/ residents	-83.019	54.596	0.131	-12.669	8.550	0.142	-5319.798	3746.351	0.159	-817.962	580.347	0.162
Facility quality evaluation by Korean National Health Insurance Corporation												
A grade ^a	0.221	0.301	0.464	0.025	0.047	0.591	16.019	20.666	0.440	2.119	3.201	0.509
B grade ^b	-0.896	0.288	0.200	-0.158	0.045	0.100	-62.033	19.751	0.200	-10.433	3.060	0.100
C grade ^c	-0.038	0.285	0.895	-0.013	0.045	0.770	0.577	19.570	0.977	-0.245	3.032	0.936
D grade ^d	-0.526	0.262	0.470	-0.085	0.041	0.420	-37.305	17.984	0.410	-5.881	2.786	0.370
E grade ^e	0.226	0.315	0.475	0.035	0.049	0.483	11.577	21.615	0.593	1.778	3.348	0.597
Province-fixed effects		Yes			Yes			Yes			Yes	
R-squared		0.131			0.125			0.129			0.125	
F-statistic		0.628			0.593			0.613			0.594	

Note. RN = Registered nurse; CNA = Certified nursing assistants; Coeff = coefficient; Std error = standard error; ^aScore of 90 or more, and 70 points or more of each major classification area; ^bScore of 80 or more, and 60 points or more of each major classification area; ^cScore of 70 or more, and 50 points or more of each major classification area; ^dScore of 60 or more, and 40 points or more of each major classification area; ^eScore of 59 or less, and 39 points or less in each major classification area; *p < 0.05; COVID-19 infection rate = No. of residents infected with COVID-19 in each administrative district / No. of total NH resident in each administrative district; COVID-19 mortality rate = No. of COVID-19 residents who died of COVID-19 in each administrative district / No. of total NH resident in each administrative district.

COVID-19, the physical NH environment should only allow a small number of residents, allowing wide space for distance among residents and employees (Spurlock & Elgazzar, 2020). Subsequent studies should identify the relationship between NH size, its physical structural design, and COVID-19 outbreaks. In this study, the result of public reporting did not have a significant relationship with COVID-19 outbreaks, but NHs with COVID-19 outbreaks had a lower proportion of superior grades in public reporting than all Korean NHs (18.44% vs 20.67%). This finding is consistent with Abrams et al. (2020) and Chatterjee et al. (2020), but it is not consistent with other previous studies (Harrington et al., 2020; Li et al., 2020). Compared with 1- to 3-star NHs, 4- or 5-star NHs had 13% fewer confirmed COVID-19 cases (Li et al., 2020) and higher Center for

Medicare and Medicaid 5-star total staffing ratings were less likely to have COVID-19-positive residents (Harrington et al., 2020). This result is because NHs with higher ratings that comply with regulations and perform them are also able to manage the COVID-19 control regulations well, and higher ratings mean they are well equipped with resources such as staffing and materials to deal with COVID-19 (Li et al., 2020). Since over 99% of South Koreans' ethnicity is Korean, it is impossible to identify the residents' ethnicities, but most of them are expected to be Korean. We could not test the health inequity among race groups, whereas some research mentioned that the African American or Latin residents had more confirmed cases of COVID-19 (Abrams et al., 2020; Harrington et al., 2020).

This study reported that smaller NHs were more effective in controlling COVID-19 than larger NHs in their mortality rate. This result is consistent with one previous study (Spurlock & Elgazzar, 2020) and not consistent with another previous study (Abrams et al., 2020). NHs with small bed sizes have more difficulty isolating COVID-positive residents than NHs with large bed sizes (Abrams et al., 2020). However, Spurlock and Elgazzar (2020) reported that NHs with large bed sizes (>99) had greater COVID-19 case and death rates than NHs with small bed sizes (<66). This is because NHs with large bed sizes present larger opportunities for staff to transmit COVID-19 viruses among residents (Spurlock & Elgazzar, 2020). Considering these findings, the effective method of preventing COVID-19 infections in NHs is that NH administrators and policymakers should establish a manual for preventing dissemination of infections and ensure education on infection control for NH staff. Also, they should structurally reduce the number of residents per unit area and increase the rate of private rooms (Spurlock & Elgazzar, 2020).

This study highlighted the importance of policy making and recommendations in Korea, which has been ranked the world's second-largest Middle East Respiratory Syndrome (MERS) resident country since the 2015 outbreak and 2003 severe acute respiratory syndrome (SARS) outbreak. Korea has raised the need of standards for nurse staffing to strengthen infection control among NH residents (Kim, 2015). In the MERS and SARS situations, RNs provided other nursing staff with information on how to wear personal protective equipment (PPE), screen and quarantine residents, clean and disinfect the hospital environment, dispose of medical waste, and supervise laundry management. In addition, this outbreak emphasized the importance of the contribution of RNs who are mainly responsible for infection control in NHs and play a key role in preventing the further spread of disease (Choi & Kim, 2016). Nevertheless, there has been no change in the standards for NH nurse staffing and mandatory placement of RNs with infection specialties. Korea now has 402 infection-special NPs (Korean accreditation board of nursing education, 2021). Current NH nurse staffing criteria in Korea allows CNAs to replace RNs. The criteria has failed to reflect the differences in the roles and responsibilities of RNs (licensed by the Korean Ministry of Health and Welfare) and CNAs (certified by the Korean Ministry of Health and Welfare) in NHs (Korean Ministry of Government Legislation, 2021). It is time to prepare for the postpandemic world beyond overcoming COVID-19 cases in NHs. To ensure safe NH environments for the elderly, policy considerably matters to mandate appropriate RN staffing levels in NHs and infection-special NPs as Korea has prepared 402 over 18 years (McGregor & Harrington, 2020; Korean accreditation board of nursing education, 2021). This study confirmed the important role RNs play in controlling the COVID-19 outbreak in Korea. We strongly suggest that each Korean

NH hires at least one RN to function properly, not permitting substitutions with CNAs. Furthermore, as a stronger regulation, one RN should be assigned to each duty (day, evening, night), and four nurses per NH should be required to account for RNs' days off. Furthermore, policy should reflect NH working conditions, health and sick-leave benefits, and violations of staffing requirements (Spurlock & Elgazzar, 2020).

Furthermore, the Korean government must collect more concrete data on NH staffing and infections. Although the Korean government has the Information Disclosure system and Korean National Health Insurance Corporation website, it was impossible to get data on COVID-19 outbreaks per each NH. The units of data in this study were broken down by each administrative district rather than by each NH, and we expect to conduct ongoing research using microlevel units of analysis. Furthermore, consumers should have easy access to information on the ongoing test numbers with results, confirmed cases of residents with infectious diseases, NH staff or family members, and volunteers about each specific NH (Spurlock & Elgazzar, 2020). In addition, information regarding RNs' HPRD and the appropriate supply of PPE should be released to the public. Fortunately, the supply of PPE was stable during the pandemic in Korea, and the impact of supply was controlled in this study. Nevertheless, the worst seasonal pandemic threatened Korea's long-term care settings in late 2020 and early 2021. National efforts are needed to supply sufficient PPE considering that PPE is the most fundamental factor in controlling the COVID-19 outbreak. Also, support such as staff education and training for proper PPE use is needed to mitigate COVID-19 transmission (Li et al., 2020; McGilton et al., 2020).

Limitations

This study has several limitations. First, concrete data about confirmed COVID-19 cases and deaths could not be collected for each NH; instead, we could only get aggregated data of NHs according to each administrative district. Furthermore, concrete data on nurse staffing including HPRD was not available; instead, we could only get the number of staff at each NH. Further research is definitely necessary to examine the related variables at each NH to have more valid evidence. Second, there may be unrecognized COVID-19 cases. The method of testing residents in Korean NHs for COVID-19 was as follows. In some NHs, COVID-19 tests were conducted on all residents as a preemptive test; whereas in other NHs, only residents with active fevers and respiratory symptoms were regularly checked (Ministry of Health & Wellness, 2021). There may have been a COVID-19 case in an asymptomatic person that was not confirmed at the time of data collection. Third, to identify confirmed COVID-19 cases we had to rely on NH administrators' self-reports to the public health center and Korea Centers for Disease Control and Prevention

(KCDC). Therefore, this led to an increased probability in delays with the district's collection of data and incomplete data. Fourth, matching those two different datasets was challenging. The most current available data about the organizational factors were from 2018 (the new result is coming out in 2021, which provides a 3-year base), while data on COVID-19 was collected from January to July 2020. Finally, when NH residents are on the brink of death or when serious health conditions occur in NHs, residents are transferred to hospitals, so no deaths linked to COVID-19 have been recorded in NHs (Kim, 2020), which results in fewer COVID-19 deaths in NHs.

Conclusion

NH residents are always vulnerable to infectious pathogens due to their physiological characteristics and surrounding environmental factors. This study confirmed the important role RNs play in controlling the COVID-19 outbreak in Korea. NHs with higher numbers of RNs in the total nursing staff have the potential to better control the spread of COVID-19 and reduce deaths. This study highlighted nurse staffing criteria and suggests that increasing RNs in NHs will reduce infection and mortality rates during the COVID-19 pandemic. We strongly suggest NHs hire at least one RN to function, and four RNs to provide a fully competent RN workforce in long-term care settings in Korean NHs.

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