

Understanding the factors associated with nurse employment in clinics: Experiences in Taiwan

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Abstract

Background: The shortage and distribution of nurses affect healthcare access in aging societies. Limited research has explored the nursing workforce in clinics, which is vital for healthcare delivery. This study aimed to investigate the shortage and distribution of nurses in clinics in Taiwan, considering geographical, institutional, and specialty variations.

Methods: We conducted a cross-sectional analysis of the national nursing workforce in Western medicine clinics in Taiwan using open government data. The nursing practice rate (NPR) was calculated. The ratio of clinics employing nurses (RCN) was determined by calculating the percentage of clinics with nurses in each category. A logistic regression model was fitted to examine the factors associated with nurse employment, including urbanization level and different specialty clinics. Adjusted odds ratios (OR) and 95% CIs were calculated.

Results: The study revealed an overall NPR as low as 59.1%, and a decreasing trend with age. Among the 11 706 clinics in the study, nearly a quarter did not employ nurses, with an overall RCN of 72.3%. Urbanization level and clinic specialty were associated with nurse employment ($p < 0.05$). After adjusting for urbanization level, the fitted regression model identified the top three specialties as plastic surgery (OR = 11.37, RCN = 96.8%), internal medicine (OR = 1.94, RCN = 84.1%), and orthopedics (OR = 1.89, RCN = 83.6%), while the bottom three were otolaryngology (OR = 0.59, RCN = 61.5%), psychiatry (OR = 0.49, RCN = 57.1%), and rehabilitation medicine (OR = 0.30, RCN = 45.2%). Nurses were more likely to be employed in areas at urbanization level 1 (OR = 1.17), 3 (OR = 1.37), and 6 (OR = 1.48), which represent highly urbanized areas within the urban, suburban, and rural categories, respectively, than in urbanization level 4.

Conclusion: Clinics in Taiwan showed nursing shortages and maldistribution, with 72.3% RCN and variations based on urbanization and specialty. These factors may be considered in nursing research conducted in other countries to inform future workforce planning.

Keywords: Ambulatory care; Health policy; Health workforce; Nursing; Taiwan

1. INTRODUCTION

Nursing workforce sustainability, shortages, and distribution are critical health policy issues in aging societies because of

their effects on the access, delivery, and complexity of care.¹⁻⁶ Considering the global nursing shortage, proper allocation of nurses and clarification of their professional scope of practice have become public health concerns.⁵ With restricted workforce planning in developed countries, the future supply of nurses is fragile.⁷ One of the challenges that all income countries face is ensuring that the data used to determine national health policies are valid, reliable, and easily accessible to human health resources.^{8,9} National health workforce data at the subnational level should be available to address regional variations.¹⁰⁻¹² In addition to nursing shortages, the distribution of nurses in community settings is a key issue with implications for patient outcomes, healthcare costs, and healthcare disparities. The distribution of nursing staff can be divided into geographical divisions or by medical institutions.^{4,13} Previous research has demonstrated the maldistribution of the nursing workforce in different countries, which has mostly included nurses employed in various types of medical institutions, with rural-urban disparities often playing a pivotal role.^{4,14-16} However, what is not yet understood is the nursing workforce in clinics.

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Taiwan's healthcare system faces challenges from the country's rapidly aging population and shortages in the nursing workforce. Taiwan had entered an aged society in 2018 and is expected to reach a super-aged society with 20% of the population being over 65 years of age by 2025.¹⁷ Therefore, policies must be implemented to sustain the supply of and meet the growing demand for nursing personnel.⁷ As one of the countries with universal health coverage, Taiwan provides timely and accessible health care through a single-payer system, the National Health Insurance (NHI).¹⁸ The existing salary structure has contributed to a migration of nurses to medical centers and urban areas, potentially leading to shortages and uneven distribution of nurses.^{1,3} Furthermore, although the issue may be particularly critical in clinics, it has generally gone unrecognized in these settings. However, few studies have examined the effects of the NHI system on nursing shortages and distribution, resulting in disparities in the nursing workforce across levels of medical institutions, especially in clinics, which requires further research.

This study aimed to investigate the nursing workforce distribution and shortages in clinics in Taiwan. We further explored the sustainability of nursing staff and their distribution in terms of geographical location and medical institutions by examining the rural-urban disparities and different specialties in clinics. Taiwan's experience can serve as a reference for other countries for workforce allocation and health policies to address the challenges posed by an aging population and health system.

2. METHODS

2.1. Data sources

We accessed datasets via open data platforms under the Ministry of Health and Welfare in Taiwan to extract information on the types of medical institutions, counties and townships, addresses, specialties, and medical staff.¹⁹ The analysis included medical staff such as physicians, registered nurses (RNs), licensed practical nurses (LPN), and midwives. RNs, LPNs, and midwives were defined as a broad spectrum of nurses. Data on the number of male and female members of the nursing workforce registered with the Health Bureau and the total number of licensed nurses issued by the Ministry of Health and Welfare were downloaded from the Taiwan Nursing Workforce Statistics.²⁰ The Monthly Bulletin of Interior Statistics was used as the source for information on the fundamental characteristics of 368 townships in Taiwan.²¹

According to the legislation on personal data privacy in Taiwan and regulations of the institutional review board at Taipei Veterans General Hospital, the use of publicly available data is exempt from approval.

2.2. Study design and variables

This descriptive cross-sectional study was conducted in 2021 to explore the nationwide nursing workforce in clinics. The current study focused on Western medicine clinics in Taiwan. Clinics were divided based on whether they provided nursing staff. The ratio of clinics employing nurses (RCN) was calculated as the percentage of clinics employing nurses among all clinics in this category.

2.2.1. Determination of clinic specialties

Clinics were classified as either single-specialty or multispecialty clinics based on government declarations. The nursing workforce in clinics with different specialties was also surveyed. We

excluded clinics with a single specialty of neurosurgery, radiology, emergency, or anesthesiology because of the relatively small number of clinics in each group.

2.2.2. Classifications of urbanization levels

The National Health Research Institutes in Taiwan have classified 368 townships into seven urbanization levels.²² In this study, we categorized levels 1 and 2 as urban; levels 3, 4, and 5 as suburban; and levels 6 and 7 as rural.

2.3. Statistical analysis

To demonstrate the sustainability of the nursing workforce, we stratified the total number of practicing and certified nurses by age groups. The proportion of practicing nurses actively employed in nursing was represented as the nursing practice rate (NPR). Reduction in NPR was calculated as the difference in the practice rate between two adjacent age groups divided by the older age group. We used the Chi-square test to examine the differences in NPR across age groups.

The Gini coefficient was used to measure the inequality in the distribution of nurses and physicians across clinics.^{23–25} The Gini coefficient ranges between 0 and 1, denoting complete equality and inequality, respectively. Degrees of inequality were determined as follows: Gini coefficient of <0.2 represented absolute equality, 0.2 to 0.3 relative equality, 0.3 to 0.4 proper inequality, 0.4 to 0.5 large inequality, and above 0.5 severe inequality.²⁶ The inequality in physician distribution was represented using the same procedure. We used a bootstrap method to calculate CIs for Gini coefficients.^{27,28} We repeated the simulation process 1000 times and obtained 95% CIs using the percentile method.

We created a geographic distribution map to illustrate the spatial distribution of nurses and urbanization levels. A logistic regression model was fitted to identify influential factors, such as urbanization level and specialty, for clinics that employed nursing staff. The adjusted odds ratio (OR) and 95% CIs for each factor were used to represent the effect size on the probability of clinics employing nursing staff. A two-tailed *p* value <0.05 indicated statistical significance. All statistical analyses were performed with Stata 17.0 software (StataCorp, College Station, TX).

3. RESULTS

3.1. Number of practicing and certified nurses and NPR stratified by age group in Taiwan

In Taiwan, the total number of licensed nurses was found to be approximately 300 000; however, only 180 000 were practicing nurses, resulting in an NPR as low as 59.1% (Fig. 1 and Table 1). Practicing and certified nurses were found to be predominantly female. Further categorized by gender, the NPR of male nurses was 71.1%, whereas that of female nurses was much lower (58.7%). In terms of practice rate of nurses by age stratification, a decreasing trend with age was observed. The most significant reduction in the overall NPR was a marked decrease of 16.7% for those aged 21 to 30 and 31 to 40 years, apart from the effect of retirement.

3.2. Distribution of nurses and physicians in clinics

Fig. 2 shows the distribution of nurses and physicians in clinics as Lorenz curves. The Gini coefficient of nurses in clinics was 0.625 (95% CI, 0.619–0.630), indicating high inequality. In contrast, the Gini coefficient of physicians in clinics was 0.275 (95% CI, 0.270–0.279), showing relative equality. The Gini

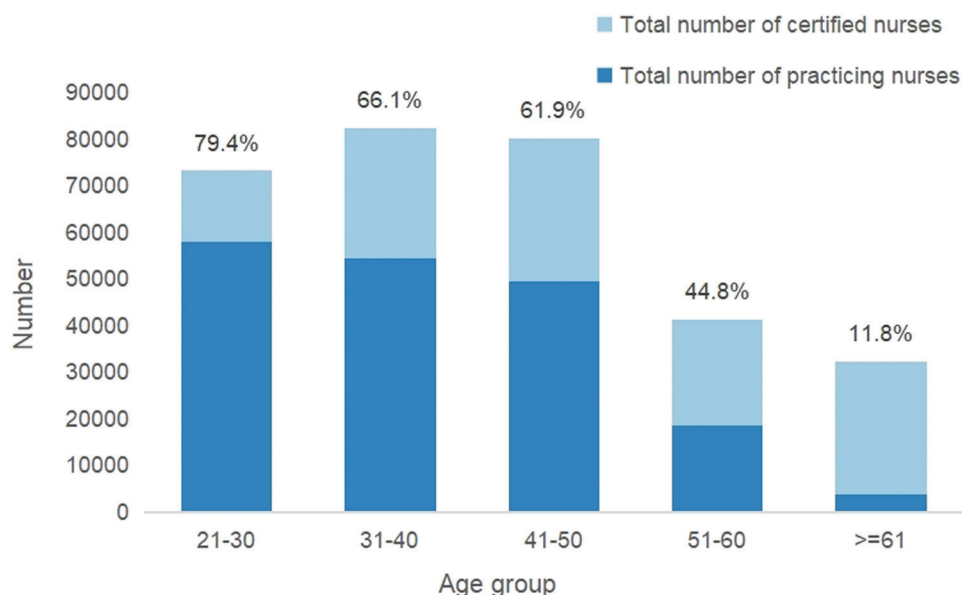


Fig. 1 NPR and numbers of practicing and certified nurses by age groups. NPR was calculated by percentage of practicing/certified nurses. NPR = nursing practice rate.

coefficient difference between nurses and physicians in clinics was statistically significant.

3.3. Association between urbanization levels and clinics employing nurses

We found that less than three-quarters of the clinics in Taiwan employed nurses, with an RCN of 72.3%. Nursing employment varied across clinics at different urbanization levels, with the highest RCN at level 6 and the lowest at level 4, ranging from 69.9% to 77.9% (Table 2). Furthermore, most nurses practicing in clinics worked in urban (64.9%) or suburban areas (28.8%). Of all the clinics in the study, 94.4% were located in urban (65.1%) or suburban areas (29.2%). In Taiwan, the number of nurses in rural areas, most of which are mountainous, was relatively small compared to that in urban areas. Geographic distribution maps are shown in Fig. 3 to further visualize the spatial distribution of nurses in Taiwan.

After adjusting for specialty, the fitted regression model showed a significant association between urbanization level and nurse employment ($p < 0.05$; Table 3). Nurses were more likely to be employed in clinics at urbanization level 1 (OR = 1.17, 95% CI, 1.02-1.34), 3 (OR = 1.37, 95% CI, 1.17-1.60), and 6 (OR = 1.48, 95% CI, 1.10-1.99), corresponding to the highly urbanized areas within the urban, suburban, and rural categories, as compared to urbanization level 4.

Table 1

Number of practicing and certified NPR stratified by age group in Taiwan

Age, y/o	Certified nurses Total, f/m	Practicing nurses Total, f/m	NPR, f/m
21-30	73 250 (67 109/6141)	58 154 (53 640/4514)	79.4 (79.9/73.5)
31-40	82 375 (80 102/2273)	54 454 (52 824/1630)	66.1 (66.0/71.7)
41-50	80 135 (79 151/984)	49 598 (48 956/642)	61.9 (61.9/65.2)
51-60	41 425 (41 090/335)	18 550 (18 361/189)	44.8 (44.7/56.4)
≥61	32 313 (32 233/80)	3824 (3818/6)	11.8 (11.8/7.5)
Total	309 498 (299 685/9813)	183 010 (176 034/6976)	59.1 (58.7/71.1)

f/m = female/male; NPR = nursing practice rate.

3.4. Association between specialties and clinics employing nurses

Among 11 706 clinics, 10 026 (85.6%) were single-specialty practices and 1680 (14.4%) were multispecialty practices. No statistical difference in RCN was observed between single-specialty and multispecialty clinics. The average percentage of single-specialty clinics with nurses was 72.1%, which was close to the average of multispecialty clinics (72.9%) ($p = 0.79$) (Fig. 4).

After adjusting for urbanization level, the fitted regression model revealed significant associations between specialties and the likelihood of employing nurses ($p < 0.05$; Table 3).

Compared to general medicine, the three specialties most likely to employ nurses were plastic surgery (OR = 11.37, RCN = 96.8%), internal medicine (OR = 1.94, RCN = 84.1%), and orthopedics (OR = 1.89, RCN = 83.6%; Table 3, Fig. 4). In contrast, the bottom three specialties with a lower likelihood of employing nurses were otolaryngology (OR = 0.59, RCN = 61.5%), psychiatry (OR = 0.49, RCN = 57.1%), and rehabilitation medicine (OR = 0.30, RCN = 45.2%), while the remaining specialties had close to an average RCN of 72.3%.

4. DISCUSSION

The proper allocation and distribution of nurses in clinics is crucial to addressing the global nursing shortage, particularly in the context of complex care needs and an aging population; however, research on the nursing workforce in clinics remains scarce. Open government data were used to demonstrate the shortage and distribution of nursing personnel in Taiwan. Of the 11 706 clinics in the study, 72.3% employed nurses, with disparities between urbanization levels and specialty. Notably, the top three specialty clinics with the highest RCNs were plastic surgery, internal medicine, and orthopedics, whereas the bottom three were otolaryngology, psychiatry, and rehabilitation medicine. These findings on nursing workforce allocation are vital for policymakers and healthcare administrators to optimize clinic staffing and workforce planning.

Our results demonstrated an age-related decline in the NPR. Previous research has shown that the nursing workforce is aging

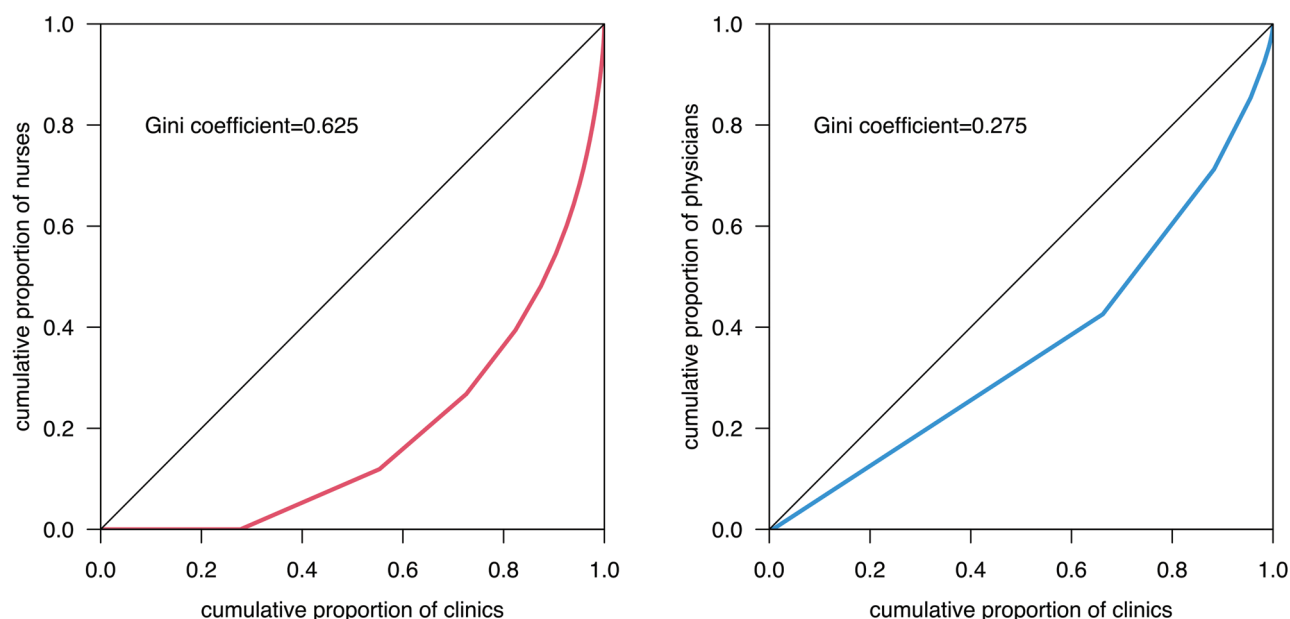


Fig. 2 Lorenz curve of the distribution of nurses and physicians in clinics.

Table 2

Distribution of nursing workforce in clinics in urban, suburban, and rural areas in Taiwan

Urbanization level	No. of townships	No. of nurses	No. of nurses in clinics	No. of clinics	% of clinics with nurses
Urban					
Level 1	27	47 904	8487	3558	72.0
Level 2	42	60 922	9115	4064	71.3
Suburban					
Level 3	57	16 302	4265	1812	75.5
Level 4	87	19 270	3189	1476	69.9
Level 5	35	418	350	136	75.0
Rural					
Level 6	61	1749	814	299	77.9
Level 7	59	2089	922	361	72.6
Total	368	148 654	27 142	11 706	72.3

and the young nursing workforce is less stable.^{29,30} This is consistent with our finding that the highest NPR in Taiwan is in the 20 to 30-year age group, with NPR decreasing with age. The NPR in Taiwan is <60% (59.1%), which is substantially different from the rates in other countries. In a survey conducted by the International Council of Nurses, only 33% of nurses in Taiwan were very likely to remain in the profession, showing a large gap compared to the average of 53% in 11 other countries.³¹ The average age of inactive nurses in Taiwan is 38.75 years, which is much younger than the 52.90 years reported in a US study.^{32,33} The annual income of nurses in Taiwan is less than half that in the top ten countries globally; however, on average, each nursing staff member in Taiwan cares for approximately 135 residents.³⁴ Similar to Taiwan, the UK has a single-payer healthcare system.¹⁸ In the UK, the number of inhabitants per nurse is approximately 130; however, the remuneration is more than twice that in Taiwan.³⁴ The imbalance between wages and workloads has caused an exodus among nursing staff in Taiwan.³²

The willingness of clinics to employ nurses was associated with their urbanization level and specialty. Plastic surgery, internal

medicine, orthopedics, and surgery-related clinics were found to employ more nurses than other specialties. Nurse employment in different specialty clinics is influenced by variations in patient characteristics and healthcare needs. Outpatient operating rooms and observation beds should be staffed with a nurse. The global scope of nursing practice in clinics is difficult to define because of the diversity of nursing policies across countries and organizations.⁵ Previous studies have reported that the common clinical responsibilities of nurses in community settings include medication administration, vaccination, suture removal, dressing changes, and first aid.^{35–37} In addition, nurse staffing contributes to chronic disease management and assists in the clinical care of patients with diabetes, chronic obstructive pulmonary disease, and congestive heart failure.^{38–40} In Taiwan, nursing personnel are responsible for assessing health problems, providing healthcare and prevention measures, giving instructions and counseling, and offering medical assistance as instructed by a physician.⁴¹ The scope of medical assistance includes assisting in invasive examinations and treatments, operations, and medication administration as well as monitoring and assessing patients' vital signs.⁴² One factor that may drive clinics to hire nurses may be the prescription of injections, a technique that requires nurses to perform. Several studies have reported overprescription of injections, especially antibiotics and corticosteroids, in Asian countries.^{43–46}

Certain specialty clinics, including rehabilitation medicine, psychiatry, and otolaryngology clinics, were found to be less likely to employ nurses. This can be attributed to these clinics' unique operational requirements and the relatively independent roles of physicians in patient care or assistance from healthcare professionals other than nurses.^{47,48} For example, the main business of a rehabilitation clinic is to assist in patients with their rehabilitation, which requires physiotherapists or occupational therapists and has a low demand for nursing staff. Similarly, clinics where doctors can work independently also employ a relatively lower percentage of nurses, such as psychiatrists who interview patients with mental illnesses and otolaryngologists who use equipment to treat patients independently. In addition, this study identified an uneven distribution of nurses in clinics, highlighting the role of geographic factors. Clinics located

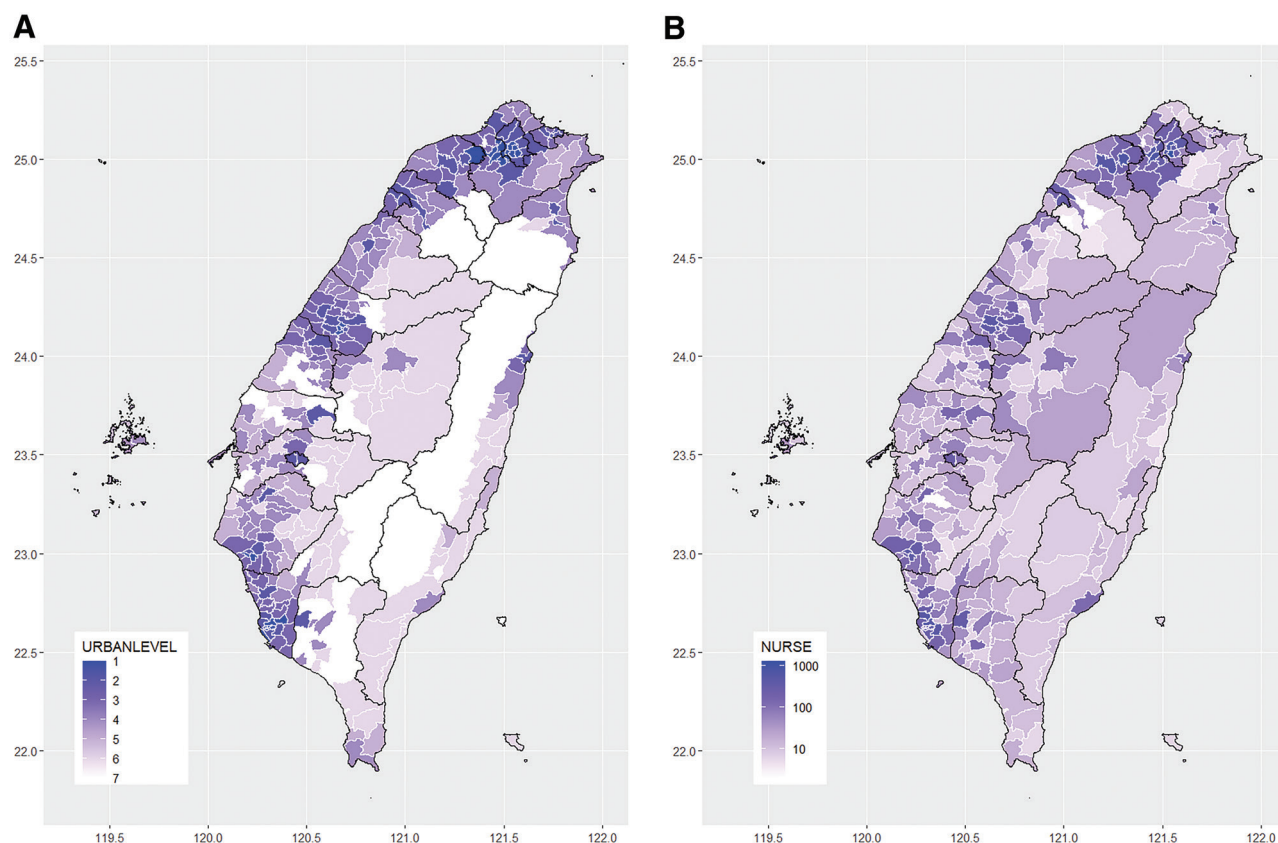


Fig. 3 Distribution of nurses across townships in Taiwan. A, Stratified by urbanization level 1 to 7. B, Number of nurses.

in highly urbanized areas, regardless of their classification as urban, suburban, or rural, demonstrated higher RCNs. These findings provide valuable insights for healthcare administrators and policymakers to enhance the effective utilization of nurses in clinics. By understanding the specific needs and operational dynamics of different specialty clinics, healthcare organizations can tailor their recruitment and staffing strategies accordingly. Additionally, considering the geographic context can help address disparities in nurse distribution and ensure equitable access to nursing services across regions.

The shortage of nursing staff in Taiwan has detrimental effects on both the workload of existing healthcare professionals and the quality and efficiency of public health services. This study revealed that the uneven distribution and shortage of nursing staff in clinics, particularly in remote areas, may affect healthcare service equity and availability.^{3,4} This issue could lead to longer wait times for patients, hinder timely diagnosis and treatment, and limit the implementation of disease prevention and health promotion activities.^{40,49} Previous research on nursing shortages in Taiwan has primarily focused on hospitals.^{32,50,51} The government has also promoted a strategy for nursing workforce preparation that places greater emphasis on measures at the hospital level.⁵² However, the findings of this study suggest that the government and relevant organizations should consider policies and incentives that focus on recruitment, retention, and staff allocation in clinics to protect the nursing workforce.² Addressing this gap is essential to strengthen the future workforce for sustainable care, safeguard the quality of care and patient safety, and improve health outcomes across communities. Moreover, in developing strategies for nursing workforce management, flexibility in retirement age is crucial to consider. Nurses do not necessarily have to retire at age 55; instead, policies should

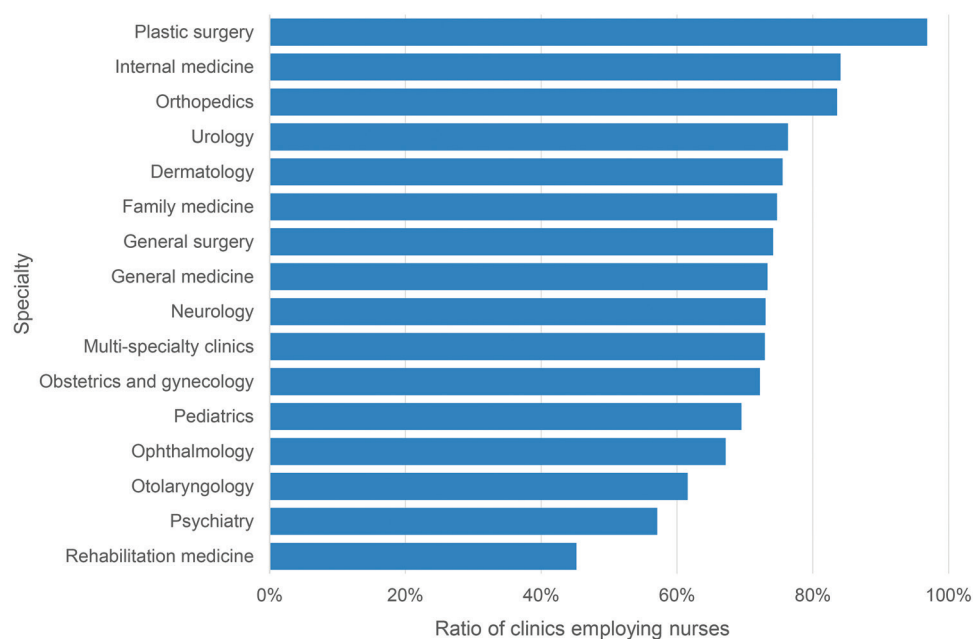
encourage those who reach retirement age but wish to continue working to remain in the workforce. This approach will help to address the challenges of replacing labor in an aging society.

This study had some limitations. First, unmeasurable biases, including factors such as clinic turnover or size as well as the influence of various social factors on the local salary of nurses in clinics, such as local policies and regulations, remain inaccessible to the public due to limitations in data availability. Further research and data collection are necessary to fully understand and ascertain the effects of these factors on nurse employment in clinics. Second, RCNs may have been underestimated because the dataset did not capture individuals with multiple roles, and the inclusion of part-time nurses can lead to imprecision in the data calculation. An accurate assessment of the degree of underestimation requires additional data sources and methodologies. Third, the cross-sectional design of our study limited our ability to establish causality or determine the directionality of the observed associations, thereby affecting the interpretation of the results. Fourth, the current study may not be generalizable to other periods or future contexts, as it focused on a specific time frame and set of conditions. Based on more accessible data, the impact of the coronavirus disease 2019 (COVID-19) pandemic on the distribution of the nursing workforce in clinics warrants investigation. Finally, the generalizability of the results is limited to Western medicine clinics and may not be applicable to other types, such as dental and Chinese medicine clinics.

In conclusion, the nursing workforce in Taiwan's clinics faces the challenges of shortage and maldistribution, which are not fully understood. Among all clinics in Taiwan, the RCN was 72.3%, with variations observed by urbanization level and specialty. Given the high demand for nurses

Table 3**Distribution of the nationwide nursing workforce in clinics, stratified by urbanization level and specialty group**

Factors	Number of clinics employing		Number of clinics not employing		Adjusted odds ratio for clinics employing nurses		
	Nurses		Nurses		OR	95% CI	p
Total ^a	8458	(100.00)	3248	(100.00)			
Urbanization level							
Urban							
1	2562	(30.29)	996	(30.67)	1.17	(1.02–1.34)	0.023
2	2899	(34.28)	1165	(35.87)	1.11	(0.98–1.27)	0.11
Suburban							
3	1368	(16.17)	444	(13.67)	1.37	(1.17–1.60)	<0.001
4	1032	(12.20)	444	(13.67)	–ref–		
5	102	(1.21)	34	(1.05)	1.25	(0.83–1.87)	0.288
Rural							
6	233	(2.75)	66	(2.03)	1.48	(1.10–1.99)	0.01
7	262	(3.10)	99	(3.05)	1.12	(0.86–1.45)	0.4
Specialty of clinic							
Plastic surgery	214	(2.53)	7	(0.22)	11.37	(5.33–24.28)	<0.001
Internal medicine	919	(10.87)	174	(5.36)	1.94	(1.62–2.33)	<0.001
Orthopedics	168	(1.99)	33	(1.02)	1.89	(1.29–2.77)	0.001
Urology	29	(0.34)	9	(0.28)	1.19	(0.56–2.53)	0.65
Dermatology	340	(4.02)	110	(3.39)	1.15	(0.91–1.44)	0.251
Family medicine	807	(9.54)	273	(8.41)	1.07	(0.91–1.25)	0.425
General surgery	175	(2.07)	61	(1.88)	1.06	(0.78–1.44)	0.694
General medicine	2149	(25.41)	782	(24.08)	–ref–		
Neurology	46	(0.54)	17	(0.52)	1.01	(0.57–1.77)	0.978
Multispecialty clinics	1225	(14.48)	455	(14.01)	0.99	(0.86–1.13)	0.875
Obstetrics and gynecology	382	(4.52)	147	(4.53)	0.96	(0.78–1.18)	0.688
Pediatrics	615	(7.27)	270	(8.31)	0.84	(0.71–0.99)	0.037
Ophthalmology	474	(5.60)	232	(7.14)	0.75	(0.63–0.90)	0.002
Otolaryngology	605	(7.15)	378	(11.64)	0.59	(0.50–0.68)	<0.001
Psychiatry	165	(1.95)	124	(3.82)	0.49	(0.38–0.63)	<0.001
Rehabilitation medicine	145	(1.71)	176	(5.42)	0.30	(0.24–0.38)	<0.001

^aA total of 12 clinics specializing in neurosurgery, radiology, emergency, and anesthesiology were excluded from the analysis due to the relatively small number of clinics.**Fig. 4** The RCNs in different specialties. RCNs = ratio of clinics employing nurses.

worldwide, these factors may be considered in future nursing research conducted in other countries and may inform future workforce planning.

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REFERENCES

- MacLean L, Hassmiller S, Shaffer F, Rohrbaugh K, Collier T, Fairman J. Scale, causes, and implications of the primary care nursing shortage. *Annu Rev Public Health* 2014;35:443–57.
- Aston J. The future of nursing in primary care. *Br J Gen Pract* 2018;68:312–3.
- Drennan VM, Ross F. Global nurse shortages—the facts, the impact and action for change. *Br Med Bull* 2019;130:25–37.
- Boniol M, McCarthy C, Lawani D, Guillot G, McIsaac M, Diallo K. Inequal distribution of nursing personnel: a subnational analysis of the distribution of nurses across 58 countries. *Hum Resour Health* 2022;20:22.
- Norful A, Martsolf G, de Jacq K, Poghosyan L. Utilization of registered nurses in primary care teams: a systematic review. *Int J Nurs Stud* 2017;74:15–23.
- Ball J, Maben J, Griffiths P. Practice nursing: what do we know? *Br J Gen Pract* 2015;65:10–1.
- Buchan J, Twigg D, Dussault G, Duffield C, Stone PW. Policies to sustain the nursing workforce: an international perspective. *Int Nurs Rev* 2015;62:162–70.
- Cometto G, Buchan J, Dussault G. Developing the health workforce for universal health coverage. *Bull World Health Organ* 2020;98:109–16.
- Pozo-Martin F, Nove A, Lopes SC, Campbell J, Buchan J, Dussault G, et al. Health workforce metrics pre- and post-2015: a stimulus to public policy and planning. *Hum Resour Health* 2017;15:14.
- Nomura S, Sakamoto H, Glenn S, Tsugawa Y, Abe SK, Rahman MM, et al. Population health and regional variations of disease burden in Japan, 1990–2015: a systematic subnational analysis for the Global Burden of Disease Study 2015. *Lancet* 2017;390:1521–38.
- Costa C, Freitas A, Stefanik I, Krafft T, Pilot E, Morrison J, et al. Evaluation of data availability on population health indicators at the regional level across the European Union. *Popul Health Metr* 2019;17:11.
- Burström B, Burström K, Nilsson G, Tomson G, Whitehead M, Winblad U. Equity aspects of the Primary Health Care Choice Reform in Sweden—a scoping review. *Int J Equity Health* 2017;16:29.
- Morioka N, Tomio J, Seto T, Kobayashi Y. The association between higher nurse staffing standards in the fee schedules and the geographic distribution of hospital nurses: a cross-sectional study using nationwide administrative data. *BMC Nurs* 2017;16:25.
- Lu H, Hou L, Zhou W, Shen L, Jin S, Wang M, et al. Trends, composition and distribution of nurse workforce in China: a secondary analysis of national data from 2003 to 2018. *BMJ Open* 2021;11:e047348.
- Winkelmann J, Muench U, Maier CB. Time trends in the regional distribution of physicians, nurses and midwives in Europe. *BMC Health Serv Res* 2020;20:937.
- Izutsu M, Suzuki E, Izutsu Y, Doi H. Trends in geographic distribution of nursing staff in Japan from 2000 to 2010: a multilevel analysis. *Acta Med Okayama* 2014;68:101–10.
- Lin YY, Huang CS. Aging in Taiwan: building a society for active aging and aging in place. *Gerontologist* 2016;56:176–83.
- Cheng TM. Reflections on the 20th anniversary of Taiwan's single-payer National Health Insurance System. *Health Aff (Millwood)* 2015;34:502–10.
- Taiwan Open Government Data. Medical institutions and basic information. Available at <https://data.gov.tw/>. Accessed December 30, 2021.
- Taiwan Union of Nurses Association. Statistics of nursing staff in Taiwan. Available at <https://www.nurse.org.tw/publicUI/H/H10201.aspx?arg=8D9CEAEF1B70AF9021>. Accessed January 16, 2022.
- Taiwan Ministry of the Interior. Monthly bulletin of interior statistics 1.7 population for township and district and by urban area. Available at https://www.moi.gov.tw/files/site_stuff/321/1/month/month_en.html. Accessed January 16, 2022.
- Liu CY, Hung YT, Chuang YL, Chen YJ, Weng WS, Liu JS, et al. Incorporating development stratification of Taiwan townships into sampling design of large scale health interview survey. *J Health Manag* 2006;4:1–22.
- Anand S. *Measuring health workforce inequalities: methods and application to China and India*. Geneva: World Health Organization; 2010.
- Theodorakis PN, Mantzavinis GD, Rumbullaku L, Lionis C, Trell E. Measuring health inequalities in Albania: a focus on the distribution of general practitioners. *Hum Resour Health* 2006;4:5.
- Shinjo D, Aramaki T. Geographic distribution of healthcare resources, healthcare service provision, and patient flow in Japan: a cross sectional study. *Soc Sci Med* 2012;75:1954–63.
- Ren Z, Song P, Chang X, Wang J, An L. Inequality of obstetric and gynaecological workforce distribution in China. *Int J Equity Health* 2018;17:3.
- Abeles J, Conway DJ. The Gini coefficient as a useful measure of malaria inequality among populations. *Malaria J* 2020;19:1–18.
- Asada Y. Assessment of the health of Americans: the average health-related quality of life and its inequality across individuals and groups. *Popul Health Metr* 2005;3:7.
- Maré M, Bartosiewicz A, Burzyńska J, Chmiel Z, Januszewicz P. A nursing shortage—a prospect of global and local policies. *Int Nurs Rev* 2019;66:9–16.
- Nirel N, Riba S, Reicher S, Toren O. Registered nurses in Israel-workforce employment characteristics and projected supply. *Isr J Health Policy Res* 2012;1:11.
- DeCola PR, Riggins P. Nurses in the workplace: expectations and needs. *Int Nurs Rev* 2010;57:335–42.
- Yu HY, Tang FI, Chen IJ, Yin TJ, Chen CC, Yu S. Inactive nurses in Taiwan: human capital, intention to return to hospital nursing, and incentives for returning. *J Nurs Manag* 2016;24:347–56.
- Skillman SM, Palazzo L, Hart LG, Keepnews D. The characteristics of registered nurses whose licenses expire: why they leave nursing and implications for retention and re-entry. *Nurs Econ* 2010;28:181–9.
- International Institute for Management Development (IMD). *IMD World Competitiveness Yearbook*. 2021. Lausanne, Switzerland: IMD International; 2021.
- Anderson DR, St Hilaire D, Flinter M. Primary care nursing role and care coordination: an observational study of nursing work in a community health center. *Online J Issues Nurs* 2012;17:3.
- Joyce CM, Piterman L. The work of nurses in Australian general practice: a national survey. *Int J Nurs Stud* 2011;48:70–80.
- Walker L, Clendon J, Nelson K. Nursing roles and responsibilities in general practice: three case studies. *J Prim Health Care* 2015;7:236–43.
- Lukewich J, Edge DS, VanDenKerkhof E, Tranmer J. Nursing contributions to chronic disease management in primary care. *J Nurs Adm* 2014;44:103–10.
- Griffiths P, Maben J, Murrells T. Organisational quality, nurse staffing and the quality of chronic disease management in primary care: observational study using routinely collected data. *Int J Nurs Stud* 2011;48:1199–210.
- Smolowitz J, Speakman E, Wojnar D, Whelan EM, Ulrich S, Hayes C, et al. Role of the registered nurse in primary health care: meeting health care needs in the 21st century. *Nurs Outlook* 2015;63:130–6.
- Laws and Regulation Database of Taiwan, Ministry of Justice. Nursing Personnel Act. Available at <https://law.moj.gov.tw/ENG/LawClass/LawAll.aspx?pcode=L0020166>. Accessed December 17, 2022.
- Ministry of Health and Welfare. Explanations of Nursing Personnel Act. Available at <https://nhplatform.mohw.gov.tw/dl-847-b554e4c-7c9554a66b78cdb281c7e9a9b.html>. Accessed December 17, 2022.
- Li Y, Xu J, Wang F, Wang B, Liu L, Hou W, et al. Overprescribing in China, driven by financial incentives, results in very high use of antibiotics, injections, and corticosteroids. *Health Aff (Millwood)* 2012;31:1075–82.
- Dong L, Wang D, Gao J, Yan H. Doctor's injection prescribing and its correlates in village health clinics across 10 provinces of Western China. *J Public Health (Oxf)* 2011;33:565–70.
- Lee IH, Park S, Lee EK. Sociodemographic factors influencing the use of injections in South Korean outpatient care. *Pharmacoepidemiol Drug Saf* 2014;23:51–9.
- Meskarpour-Amiri M, Dopeykar N, Mehdizadeh P, Ayoubian A, Motaghd Z. A study on the factors affecting the prescription of

- injection medicines in Iran: a policy making approach. *Glob J Health Sci* 2015;7:291–7.
47. Schot E, Tummers L, Noordegraaf M. Working on working together. A systematic review on how healthcare professionals contribute to inter-professional collaboration. *J Interprof Care* 2020;34:332–42.
 48. Paxino J, Denniston C, Woodward-Kron R, Molloy E. Communication in interprofessional rehabilitation teams: a scoping review. *Disabil Rehabil* 2022;44:3253–69.
 49. Lukewich J, Asghari S, Marshall EG, Mathews M, Swab M, Tranmer J, et al. Effectiveness of registered nurses on system outcomes in primary care: a systematic review. *BMC Health Serv Res* 2022;22:440.
 50. Liang YW, Chen WY, Lee JL, Huang LC. Nurse staffing, direct nursing care hours and patient mortality in Taiwan: the longitudinal analysis of hospital nurse staffing and patient outcome study. *BMC Health Serv Res* 2012;12:44.
 51. Lin CF, Huang CI, Yang CM, Lu MS. The relationship between work environment satisfaction and retention intention among nursing administrators in Taiwan. *J Nurs Res* 2019;27:e43.
 52. Executive Yuan, Republic of China (Taiwan). Supply and demand analysis and policy preparation for nursing manpower in Taiwan. Available at <https://www.ey.gov.tw/Page/448DE008087A1971/66247489-47d4-4f90-a4b7-ad46a0820c51>. Accessed April 16, 2024.