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Distribution disparities among medical specialists in Thailand: an equity analysis of the national health workforce database (2015–2024)

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ABSTRACT

Objectives Ensuring equity in medical specialist distribution is essential for achieving universal health coverage (UHC). This study explored the changes in the availability and distribution of medical specialists in Thailand from 2015 to 2024 and assessed the equity impacts on workforce.

Design A retrospective longitudinal analysis of national administrative workforce data.

Setting Public and private hospitals across Thailand, covering 1471 facilities in 77 provinces.

Primary outcome and explanatory variables The primary outcomes were specialist-to-population ratios and geographical equity measured using the Gini coefficient (G), where values closer to 0 indicate greater equity. Explanatory variables included specialty type, geographical region and the timing of major workforce policies, including mandatory service and specialty-specific legislative interventions.

Results Between 2015 and 2024, the GPs and specialists in Thailand expanded significantly, with improvements in both density and distribution. The Gini coefficient for GPs showed the largest equity improvement (G=0.42 in 2015 and G=0.22 in 2024), reflecting the impact of mandatory service programme and rural recruitment programmes. Among specialists, emergency and family medicine have shown rapid growth and significant reductions in distribution inequity, reflecting the success of legislative policies. Sustainability of workforce policies was challenged by the 'leaking stock' phenomenon due to attraction of career opportunities and economic drives.

Conclusion Workforce targeted interventions have led to improvements in the availability and equitable distribution of GPs and medical specialists over the past decade. Further policy, such as retention incentives and assisted technology, is needed to achieve equitable distribution across all specialties, particularly in low-density fields. Thailand's experience offers the lessons for other low- and middle-income countries as the evidence-based and equity-focused workforce policies for UHC advancement.

STRENGTHS AND LIMITATIONS OF THIS STUDY

⇒ Our study applies an equity-focused, longitudinal approach to workforce analysis in Thailand, demonstrating the practical use of real-world data to inform policy decision-making.
⇒ Our study introduces the methodology to identify and impute human data-entry errors, enhancing data reliability.
⇒ The 10-year period of analysis provides sufficient granularity to observe distinct trends and policy influences across each specialty area.
⇒ Our study has some limitations, as it focuses solely on quantitative and retrospective policy analysis, while the underlying policy agendas and implementation mechanisms within the system were not explored through qualitative methods.

BACKGROUND

A well-distributed and sufficient health workforce is the backbone of a functional healthcare system and a foundation for achieving universal health coverage (UHC).[1–3] While many countries have made efforts to expand their health workforce capacity through training and education, projections estimate a 10 million global shortfall by 2030, especially in low- and middle-income countries (LMICs).[4] In response, the WHO implemented the National Health Workforce Accounts (NHWA) aimed at advocating and monitoring the progression of workforce production and governance.[5] However, despite the initiatives, gaps remain in workforce availability and equitable distribution to ensure the accessibility to a high-quality workforce and lower the disparities between the resource-concentrated and underserved areas within the nations.[6 7]

Among healthcare professionals, medical doctors play a crucial role in patient care and health systems performance.[8] However, policy decision-making on physician availability and distribution mainly relied on crude numbers of physicians and failed to

Table 1 Number of physicians over 10 years (2015–2024)

Numbers	Year 2015	Year 2024	Average annual change
Physicians, N	22 868	46 854	+10.9
Public, n (%)	17 978 (79)	35 896 (77)	+11.8
Private, n (%)	4890 (21)	10 958 (23)	+9.6
GPs, N	2011	5945	+18.5
Public, n (%)	1673 (83)	5058 (85)	+20.5
Private, n (%)	338 (17)	887 (15)	+12.6
Specialists, N	14 058	35 980	+11.9
Public, n (%)	10 392 (74)	26 821 (75)	+12.4
Private, n (%)	3666 (26)	9159 (25)	+11.2
Ratio of medical doctors to 100 000 population in public hospitals	0.274	0.544	
Ratio of specialists to GPs in public hospitals (median)	6:1	5:1	

*The sum of GPs and specialists does not equal the total number of physicians due to under-reporting in some cases for either specialist or GP categories.
GPs, general practitioners.

address the heterogeneity in medical specialities.[9 10] Some studies indicated that the imbalance of specialists impacts the accessibility and quality of care, such as the imbalance of surgical specialists and anaesthesiologists.[11] Additionally, services delivered by different specialists might result in different outcomes, such as how internal medicine specialists and family physicians manage patients with non-communicable chronic diseases, which can influence long-term patient outcomes and health system efficiency.[12] Nonetheless, studies on the availability and distribution of medical specialists are limited, particularly in LMICs.

As the frontier of UHC in LMICs, Thailand could provide a case study to examine the availability and distribution of medical specialists towards the impact of workforce policies. Over the decades, Thailand has implemented multiple policies to leverage the production and distribution of general practitioners (GPs) and specialist groups. A key strategy has been the mandatory 3 year service programme for newly graduated medical students to serve as GPs in nationwide public hospitals before pursuing residency training.[13 14]

Additionally, Thailand has introduced targeted policies to increase rural workforce retention. The Collaborative Project to Increase Production of Rural Doctors (CPIRD) and the One-District-One-Doctor (ODOD) programme have annually recruited students from underserved areas and require them to return to their hometowns on graduation.[15–17] Apart from GP-focused policies, specific legislation has targeted the production of particular specialists, such as the Emergency Medicine Act BE 2551 (AD 2008)[18] and Primary Health Systems Act BE 2562 (AD 2019),[19] which promote the production of emergency physicians and family medicine physicians, respectively. Investigating whether sufficient and equitable distribution of each specialist as the impact of workforce interventions is needed.

Given these policy initiatives, this study aims to explore changes in the number and density of medical specialists in Thailand per 100 000 population, the equitable distribution in 13 health regions and 77 provinces between 2015 and 2024, and the impacts of policies targeting the equitable distribution of medical specialists.

MATERIALS AND METHODS

Data sources

Multiple datasets were used for the analysis. Data on the number of full-time physicians currently employed in hospitals throughout the country were extracted from http://gishealth.moph.go.th/, which is Ministry of Public Health's (MOPH's) open-access platform. This dataset included information on the number of physicians and specialists, which we categorised into GPs and 16 distinct groups of medical specialists.

Physician distribution was measured by the number of specialists per 100 000 population.[20 21] Regional Thai populations were retrieved from the National Population Registry Database, which is regularly produced and updated by the Bureau of Registration Administration, Ministry of Interior, Thailand.

Additionally, data on all hospitals operating in Thailand were sourced from the Health Facility Registry dataset maintained by the Office of the Permanent Secretary (MOPH). This dataset includes comprehensive information about the location, type (including public and private), and administrative hierarchy for the healthcare facilities and health regions in Thailand, which facilitates a comprehensive mapping of specialist distributions according to specific institutional settings.

Management of missing data

Submitted annually by all Thai hospitals using an electronic platform, the country's health workforce data, including medical specialists, are collected and maintained by the Strategy and Planning Division, Office of the Permanent Secretary, MOPH. The involved hospitals include the MOPH's district, provincial and regional hospitals; public non-MOPH hospitals (eg, those under the Ministry of Higher Education, Science, Research and Innovation, Ministry of Defence and local government); and private hospitals. This electronic platform requires hospital staff to manually enter their data, but there is no automatic validation process to prevent incorrect entries during data entry. As a result, we identified several errors, such as unrealistic figures (eg, one hospital reported that it employs 7000 doctors). These errors were eliminated

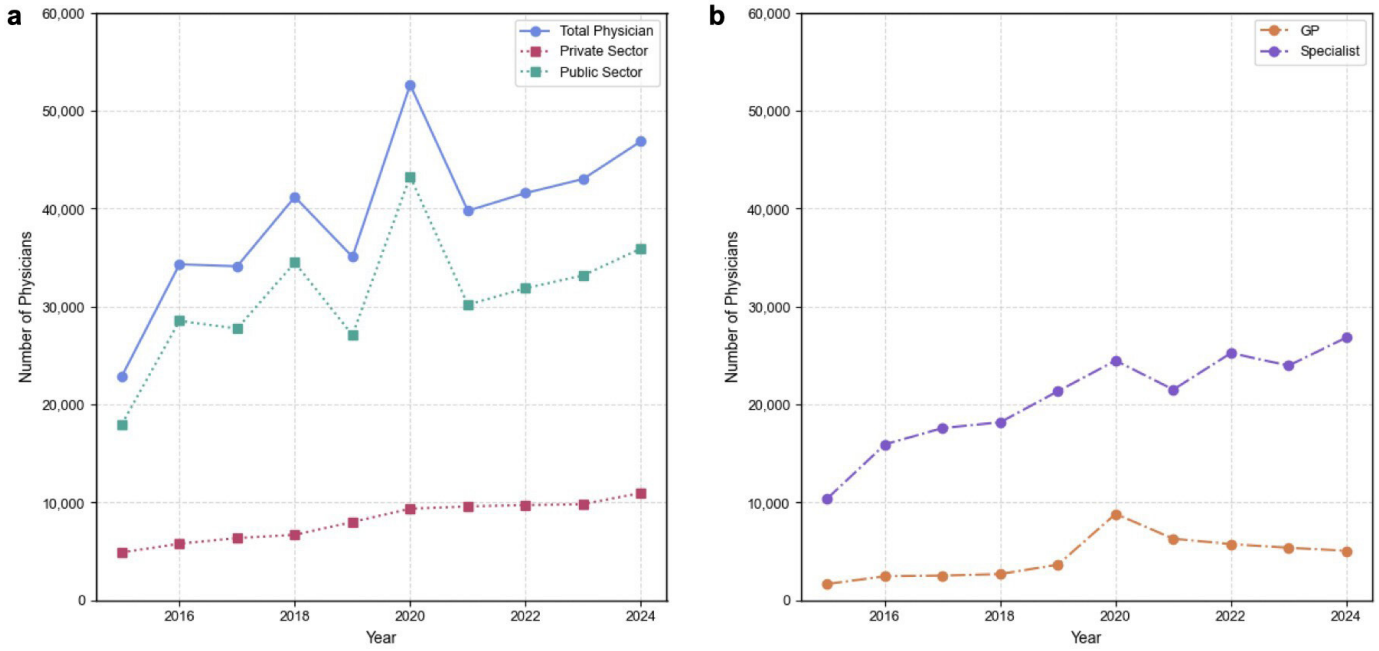

Figure 1 Availability of physicians in Thailand, 2015–2024. (a) Public and private distribution of total physicians (2015–2024). (b) Public sector specialists and GPs (2015–2024). GPs, general practitioners.

using a cross-validation method[22] to exclude extreme outliers caused by data-entry mistakes.

Of all 1560 hospitals nationwide registered in the Health Facility Registry dataset (1101 public and 459 private), 86.0% of public hospitals and 43.4% of private hospitals reported their data annually. Over the 10-year period, data were available from 1478 hospitals (1088 public and 390 private) with varying levels of completeness, as some hospitals did not submit data every year.

To address these knowledge gaps, we imputed missing data for hospitals that provided data for at least 1 year during the 10-year period. For these hospitals, their missing values for specific years were replaced using the most recently available data from previous years until they reported updated figures.

After imputation, 53.4% of hospital–specialty–year observations were affected. At the hospital level, 77.8% of hospitals had at least 1 year with missing data requiring imputation over the study period. However, the extent of longitudinal incompleteness was generally limited: only 44.8% of hospitals were missing data for more than 1 year, and just 12.6% were missing data for more than 5 years, indicating predominantly intermittent rather than sustained gaps in annual reporting. Missing data were more common among private hospitals, where 97.7% had at least 1 year of missing data and 90.6% were missing data for more than 1 year, compared with public hospitals (70.9% and 28.7%, respectively). The prevalence of missing data also varied across health regions, with the proportion of hospitals affected by any missing year ranging from 67.1% to 88.2% and reaching 98.1% in Bangkok. Nevertheless, in most regions, only a minority of hospitals experienced missing data for more than 1 year. Accordingly, sensitivity analyses were conducted, as described in the subsequent section.

Statistical analysis

The distribution of medical specialists was assessed using two parameters. First, availability was measured by specialist density per 100 000 population in 13 health regions and 77 provinces. Second, distributional inequity was measured using the Gini coefficient (G) for specialists, which is one of the most common parameters for measuring distributional inequity.[23] The degree of inequality in the distribution of medical specialists ranges from 0 (perfect equality) to 1 (perfect inequality).[24]

$$G = 1 - \sum_{i=0}^{n-1} (F_{i+1} - F_i)\ (_{i+1} + _i) \quad (1)$$

where

$F_i = \sum_{k=1}^{i} \frac{p_k}{P}$: The cumulative proportion of the population up to the i^{th} province.

$\phi_i = \sum_{k=1}^{i} \frac{h_k}{H}$: The cumulative proportion of specialists up to the i^{th} province.

p_k: Population of the k^{th} province.

P: Total population across all provinces.

h_k: Number of specialists in the k^{th} province.

H: Total number of specialists across all provinces.

To assess the potential impact of the imputation strategy on inequality estimates, sensitivity analyses were conducted by repeating all analyses on non-imputed datasets and comparing results with those obtained from the imputed dataset. We summarised differences between approaches using the mean absolute difference (MAD) in Gini coefficients, dispersion from SD and time-series

Table 2 GPs and 16 specialist categories considering density per 100 000 population and distributional inequity in Thailand for 2015 and 2024

Specialists	Average annual change of numbers	Ratio to population (per 100 000 population)		Gini coefficient (health regions)		Gini coefficient (provinces)	
		2015	2024	2015	2024	2015	2024
GPs	+20.5%	2.5	7.7	0.17	0.14	0.42	0.22
Established specialists							
Gynaecology	+10.9%	1.4	3.2	0.24	0.26	0.41	0.34
Internal medicine	+11.5%	3.6	8.6	0.34	0.31	0.52	0.39
Orthopaedic	+11.7%	1.2	2.8	0.33	0.27	0.49	0.35
Paediatrics	+11.0%	1.7	4.0	0.29	0.32	0.47	0.40
Surgery	+11.5%	2.0	4.8	0.31	0.29	0.50	0.39
Emerging specialists							
Emergency medicine	+20.3%	0.3	1.4	0.35	0.25	0.61	0.33
Family medicine	+17.1%	0.8	3.0	0.22	0.17	0.42	0.25
Preventive medicine	+14.4%	0.3	1.0	0.28	0.20	0.56	0.32
Psychiatry	+12.8%	0.5	1.4	0.46	0.34	0.61	0.44
Scarce specialists							
Anaesthesiology	+13.9%	0.8	2.4	0.35	0.39	0.52	0.45
Neurosurgery	+10.2%	0.3	0.7	0.33	0.37	0.55	0.46
Ophthalmology	+11.3%	0.8	1.7	0.33	0.35	0.50	0.42
Otolaryngology	+11.1%	0.6	1.3	0.31	0.28	0.47	0.38
Pathology	+15.8%	0.3	1.1	0.45	0.45	0.71	0.59
Radiology	+13.4%	0.9	2.5	0.43	0.36	0.59	0.47
Rehabilitation medicine	+15.3%	0.3	0.8	0.43	0.39	0.60	0.48

*Expanded table was provided in online supplemental table 2
GPs, general practitioners.

roughness quantified by the sum of squared year-to-year changes, a commonly used smoothness/roughness measure in longitudinal smoothing frameworks.[25]

All statistical analyses were conducted using Python V.3.9.12. The analysis scripts were made publicly accessible via GitHub https://github.com/psitthirat/HRH for transparency and reproducibility.

RESULTS

Over the 10-year period from 2015 to 2024, the total number of medical doctors in Thailand doubled, with an average annual increase of approximately 2665 physicians per year (table 1). This significant increase also nearly doubled the physician-to-population ratio in the public sector over the decade. Despite this expansion, the public sector has consistently employed approximately 75% of the total number of physicians nationwide.

Significant changes were also found in the composition of physicians, with the number of GPs who have completed their mandatory 3-year service in the public sector growing threefold, while the number of specialists increased 2.5 times. The specialist-to-GP ratio minimally changed from 6:1 to 5:1 in 10 years, which indicates that progress has been made towards balancing the composition of physicians between GPs and specialists.

Furthermore, we observed differences between specialists and GPs in the public and private sectors. The number of specialists in the private sector showed a higher growth compared with GPs, which was likely driven by the demand for specialised private-sector care in urban and affluent areas.

Despite the substantial increase in GPs over the decade, their number in the public sector began declining after 2019 (figure 1), reflecting the challenges of retaining GPs in the public healthcare system despite the overall expansion of the workforce.

Availability of GPs and specialists

Table 2 presents the number and ratio to the population for GPs and 16 medical specialties for 2015 and 2024. The comparison over this decade shows that the number of GPs in Thailand saw a remarkable threefold increase, leading to an improvement in their density from 2.5 to 7.7 per 100 000 population.

Three subgroups of specialists emerged from the analysis of their growth trends and equitable distribution

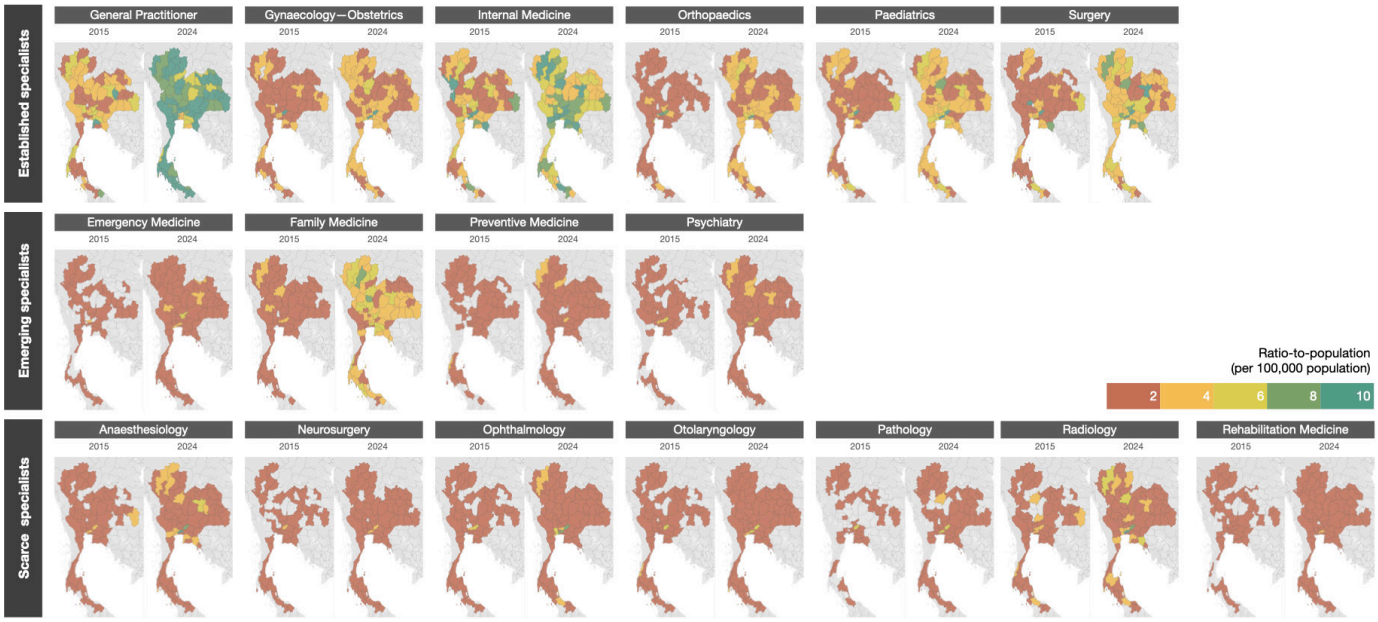

Figure 2 Group densities for GPs and 16 specialist fields per 100 000 population for 2015 and 2024. GPs, general practitioners.

between 2015 and 2024: established, emerging and scarce specialists.

- The specialists in the established group had relatively high numbers in 2015 (more than 1 per 100 000 population) and demonstrated steady growth in various fields, such as internal medicine, surgery, paediatrics and gynaecology, which reflects the population's continued demand for these specialities.
- The specialists in the emerging group initially showed low baseline numbers but experienced rapid growth, resulting in at least a twofold increase in their density and achieving better equitable distribution than the average. The growth in this group, such as in emergency and family medicine specialities, is driven by targeted policies and the growing recognition of their importance and emerging health demands in the population.
- The specialists in the scarce group exhibited low baseline numbers in 2015 and either slow growth or persistent distribution inequities during the decade, such as in neurosurgery, rehabilitation medicine and ophthalmology, and also exhibited both low baseline numbers in 2014 and slow growth during the decade. This highlights the ongoing challenges in Thailand, which were probably due to the low demand among physicians for training despite the population's demands. This group also includes specialties with significant limitations in training capacity, which results in inequitable distributions below the average equity level, such as in rehabilitation medicine and pathology.

Distribution of GPs and specialists

Significant progress was made in the distribution of medical specialists from 2015 to 2024, as visualised by heat maps (figure 2) and the Gini coefficient (table 2). In addition, GPs demonstrated substantial improvement, with the Gini coefficient decreasing from 0.17 to 0.14 in the 13 health regions and from 0.42 to 0.22 in the provinces, reflecting increased equity and greater enabled access to primary care.

Emerging specialties, such as emergency medicine and family medicine, also showed marked improvements. The Gini coefficient for emergency medicine fell from 0.35 to 0.25 and 0.61 to 0.33 in the health regions and provinces, respectively, while the Gini coefficient for family medicine fell from 0.22 to 0.17 and 0.42 to 0.25 in the health regions and provinces, respectively. These improvements reflect the success of targeted policies to train and distribute these specialties, particularly within underserved regions and/or provinces.

Among the established specialties, internal medicine, paediatrics, gynaecology and surgery exhibited steady progress, with a minimal reduction in the Gini coefficient and heat-map shifts from low-density (red) to moderate-density or high-density (yellow and green) provinces over the decade, which indicates Thailand's consistent prioritisation of these specialties to meet its population's healthcare needs.

Conversely, progress in the scarce group demonstrated stagnation, with minimal improvement in their Gini coefficients over the decade. Despite their reduction, the Gini coefficients for these scarce specialties remained higher than those for established and emerging specialties, reflecting their inequitable distribution, which hampered the Thai population's access to these specialist care fields where adequate referrals are needed.

Interestingly, some specialties in the established and scarce groups, such as gynaecology, anaesthesiology and neurosurgery, experienced increased Gini coefficients

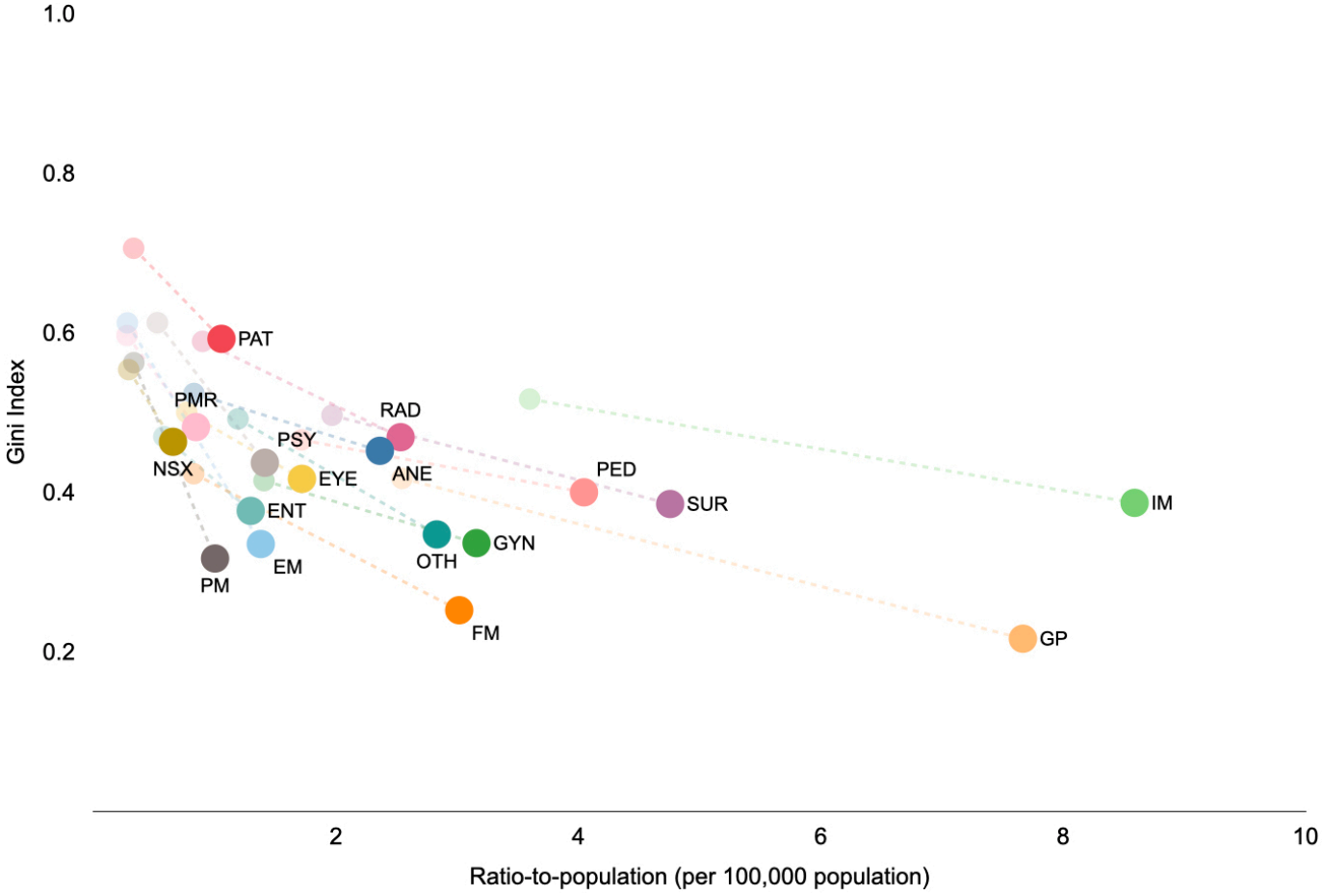

Figure 3 Availability and distribution of GPs and 16 medical specialist categories in Thailand comparing the changes between 2015 (lighter colour) and 2024 (full colour). ANE, anaesthesiology; EM, emergency medicine; ENT, otolaryngology; EYE, ophthalmology; FM, family medicine; GPs, general practitioners; GYN, gynaecology; IM, internal medicine; NSX, neurosurgery; OTH, orthopaedic; PAT, pathology; PED, paediatrics; PM, preventive medicine; PMR, rehabilitation medicine; PSY, psychiatry; RAD, radiology; SUR, surgery.

at the regional level despite provincial-level improvements. This reflects the growing interregional disparities, as shown in the heat maps, with specialists clustering in provinces in the central region and around Bangkok. These trends underscore the need for policies to address systemic imbalances and promote the equitable distribution of specialists across regions.

Temporal changes between availability and distribution of GPs and specialists

The scatter plot in figure 3 offers a temporal view of the availability of specialists as measured per 100 000 population (x-axis) and their distribution as measured by the Gini coefficient (y-axis), comparing the changes between 2015 (lighter colour) and 2024 (full colour) among the GPs and 16 specialist groups. This visualisation highlights the trends over the decade, with most specialties showing progress in both dimensions.

The 10-year trend shows increased availability (ie, higher specialist-to-population density) and improved equity (ie, lower Gini coefficient), with notable progress among GPs and specialists in family and emergency medicine. GPs achieved a threefold increase in numbers, which was accompanied by a substantial reduction in inequity, while emergency and family medicine physicians, respectively, demonstrated significant downward and rightward shifts on the scatter plot, reflecting the impact of targeted policies and expanded training programmes. Established specialties, such as internal medicine, paediatrics and surgery, showed steady improvements, meeting population demands. In contrast, specialties such as rehabilitation medicine, pathology and ophthalmology made modest gains, remaining in the left upper quadrant, highlighting their persistent challenges in availability and equity that require further attention.

Sensitivity analyses

Sensitivity analyses were conducted at both the provincial and health region levels to assess the robustness of inequality estimates to the imputation strategy. Comparisons of Gini coefficients derived from imputed and non-imputed datasets demonstrated a high degree of consistency across specialties and over time at both geographical scales. At the provincial level, absolute differences between imputed and complete-case estimates were generally modest (MAD: 0.069±0.057). Similarly,

health regional level analyses showed stable inequality patterns with small differences between estimates (MAD: 0.057±0.054).

In addition, imputed estimates exhibited reduced temporal variability compared with non-imputed estimates. At the provincial level, the imputed series showed lower year-to-year variability, with reduced overall dispersion and substantially lower time-series roughness relative to the non-imputed series; similar patterns were observed at the health region level. These findings indicate that imputation attenuated short-term fluctuations associated with intermittent missing data while preserving overall trends and relative patterns of inequality. Comparative longitudinal trends are presented in online supplemental figure 2.

DISCUSSION

This study explored Thailand's progress in workforce production and distribution over the past decade, highlighting significant improvements in GPs and some specialities, although persistent inequities continue in certain specialities, which offers effective policy interventions towards addressing lacking and maldistributed specialities.

Availability and distribution of GPs in Thailand

Our findings showed that Thailand has achieved significant improvement in GP availability and equitable distribution. These improvements can be attributed to targeted policies in medical education and deployment. Unlike many other LMICs, Thailand has assigned the newly graduated medical students to work as GPs in nationwide public hospitals since 1968 and continues to date.[13] These new GPs must spend their first year in provincial hospitals and their 2nd and 3rd years in district hospitals before pursuing specialty training or continuing to provide GP services in a public health career (online supplemental figure 2).

Beyond mandatory service, multiple rural retention policies such as CPRID and ODOD have significantly boosted the pool and distribution of GPs. In these programmes, students were trained in faculties of medicine together with national entrance examination tracks during their first 3 years of medical education (for basic sciences and preclinical courses), then they would be trained by qualified educators in 19 MOPH-affiliated medical education centres hosted by regional hospitals in the last 3 clinical years. In 2023, there were 1059 annual graduates from the CPIRD and ODOD programmes, compared with 2163 annual graduates from the national entrance examination track. Our findings align with earlier studies examining the impact of such programmes on workforce equitable distribution.[17 26 27] This progress supports quality services at primary care as a foundation for achieving UHC.

However, the long-term sustainability of these programmes becomes a main challenge in Thailand. Our findings revealed the downward trend in GPs' availability after 2020, raising concerns about the open-ended stock of GPs as the side effects of mentioned policies. Data from the Thailand Medical Council reported that out of approximately 3000 annual medical graduates who must serve as GPs in their mandatory programme, 90% transition to residency training programmes each year, leaving a relatively small proportion to continue providing public services[28]. Furthermore, the resignations of GPs with incomplete 3-year programmes might increase in the future due to changing economic conditions and competing career opportunities.[29 30] That means the mandatory programmes currently act as the refilling mechanism to a leaking stock. To strengthen the GPs' retention in district or provincial hospitals, interventions should be considered, including financial incentives, such as hardship allowances, and non-financial incentives such as career promotion, social recognition through annual best rural doctor award by various agencies.[13 31]

Availability and distribution of specialists in Thailand

Our findings captured the various changing patterns in 16 specialist groups in terms of availability and distribution. We observed the emerging specialist groups which referred to the groups with rapid expansion and well-distribution across the country. During the 2010s, several targeted policies focusing on specific specialties were implemented and might have been associated with the observed improvements. For example, the Emergency Medical Act BE 2551 (AD 2008)[18] prioritised emergency medicine in the national health agenda, leading to increased training quotas and targeted deployments.[32] Similarly, the Primary Health Systems Act BE 2562 (AD 2019)[19] set specific targets for family medicine physicians to support the function of primary healthcare. This Act aims to achieve one primary care team (consisting of one family medicine specialist, a team of nurses and public health officers from subdistrict healthcare centres and village health volunteers) per 10 000 population. Within the legislative framework, workforce production and distribution strategies have been shaped. As a result, the observed patterns in specialist availability and distribution may be partly explained by these policy contexts. However, the impact of such policies on workforce equity must be interpreted cautiously, as establishing causation requires consideration of broader contextual and system-level factors, which need to be further investigated (key policy implementations are summarised in online supplemental table 1).

For some scarce specialists, task shifting might influence the workforce production as the competing mechanism. In fields like rehabilitation medicine, non-physician providers, such as physical therapists, play a critical role in rural service delivery, shifting the specialists to rather work in urban centres.[33] Similarly, the longstanding use of nurse anaesthetists in perioperative care has alleviated the shortages of anaesthesiologists in rural hospitals.[34] While effective in addressing immediate gaps, task shifting may

inadvertently result in specialists becoming concentrated in urban areas, thereby reducing rural populations' access to these medical specialists. To ensure equitable distribution, future strategies must carefully delineate which services require specialist expertise or can be managed by trained non-physician healthcare professionals.[35]

The classification of medical specialists into 'established', 'emerging' and 'scarce' categories in this study represents an author-derived analytical framework developed to capture longitudinal dynamics in both workforce supply and equitable distribution. Previous literature in LMICs has mostly relied on aggregate physician density, rural–urban ratios or cadre-level shortages.[36 37] However, our approach adopts a two-dimensional perspective, considering growth trajectories and distributional inequity. Some existing studies have described similar patterns, in which certain specialties have been recognised at the policy level, while newer specialties—particularly family medicine—expand rapidly following legislative or training reforms, which align with our 'established' and 'emerging' classes.[38]

Moreover, some specialties in our 'scarce' class align with previous systematic reviews on specialty workforce stocks, such as anaesthesiology.[39] We therefore position this typology not as a universal classification, but as a tool that helps illuminate how different specialties respond to social movements and policy interventions within specific institutional contexts. This typology may help policymakers construct targeted workforce policies, as discussed later.

Moreover, specialists also faced the leaking stock phenomenon as leaving the public sector to private sector, which mostly concentrated in affluent provinces, cities and the Bangkok metropolitan area. This poses a significant challenge to the equitable distribution of specialists. Our findings revealed the relatively stable proportion between public and private physicians that suggests systemic issues. For example, the larger income and lighter workload among private sector specialists, as well as policies allowing private hospitals to register in the stock market, all synergistically contribute to the specialist 'brain drain' from the public sector to the private sector[40]. Multisectoral strategies, including strengthened retention incentives and regulatory mechanisms, are necessary to counterbalance this dynamic and ensure equitable access across health regions or provinces. Furthermore, current public sector regulations do not allow specialists in the public sector to work part-time in the private sector and vice versa for specialists in the private sector. However, public specialists can legally practise privately during off hours.

Equity at different geographical scales: health regions versus provinces

The divergent equity patterns observed at the provincial and health region levels likely reflect differences in policy instruments and health system organisation across geographical scales. At the provincial level, workforce distribution represents a sufficiently granular unit for targeted policy interventions. Provinces with limited specialist availability can be directly prioritised through deployment policies, mandatory service requirements or targeted recruitment strategies, facilitating gradual convergence in specialist presence across provinces.

In contrast, at the health region level, inequality dynamics are shaped by structural heterogeneity within and between regions. First, university-based hospitals which serve as major training, referral and specialist concentration hubs are unevenly distributed across health regions. Regions hosting more medical schools or academic hospitals tend to attract and retain higher numbers of specialists, particularly in established and scarce fields, contributing to persistent inter-regional concentration.[13] Second, the ongoing development of general hospitals has progressed unevenly across health regions, with some regions hosting more than ten general hospitals, while others have fewer than five.[41] Differences in investment priorities, service expansion strategies and referral roles among regions may lead to variable specialist absorption capacity, reinforcing regional disparities even as provincial-level distribution improves.

Together, these factors help explain why inequality may decline at the provincial level while stagnating or worsening at the health region level for certain specialties. These findings underscore the importance of assessing workforce equity at multiple geographical scales and aligning national and regional planning mechanisms with the structural realities of health system development.

Aligning the workforce with the population's health needs and continuous monitoring

Our analysis demonstrated progress in specialist distribution using population size as the primary denominator; however, such distributional equity may not fully align with population health needs across regions or across specialties. In some contexts, particularly in primary care, population-based distribution may reasonably reflect demographic demand. In contrast, for specialties closely linked to disease burden, population size alone may be insufficient.

For example, in Thailand, certain cancers such as cholangiocarcinoma have a disproportionately high prevalence in the north-eastern region,[42] creating greater demand for surgical specialists in these areas. When assessed using crude population-based denominators, Gini coefficients may therefore underestimate inequities relevant to such region-specific disease burdens. A needs-based equity approach, which incorporates disease burden, demographic structure and epidemiological risk profiles into the denominator, may provide a more appropriate framework for aligning workforce supply with population health needs. These two concepts represent distinct approaches to equity assessment and pose different challenges to workforce policy design and evaluation.

Thailand's system for specialist training is governed by different Royal Colleges under the Medical Council. These Royal Colleges regulate training capacity and training programme accreditation.[43] While these bodies aim to align the supply of specialists with local demands, variations in competitiveness across specialties, demands from the private sector, the attractiveness of different specialties and disparities in workforce deployment and incentives persist.[44] Enhanced collaboration between training institutions and health policymakers could optimise workforce planning.

A few actions are needed to inform health workforce policies, such as continuous monitoring of the progress in specialist density and equitable distribution across regions and provinces. Predictive modelling to forecast the population demand for different specialities should consider regional variations in the burden of diseases, healthcare infrastructure, the dynamic between the public and private sectors, retirement and professional attrition[45].

Policy implication to global health

Given lesson learns from Thailand, mandatory service programme and rural recruitment programmes have successfully expanded GP availability and distribution in underserved areas, but their sustainability requires integration with reforms in medical education curriculum. In Thailand, the 6-year medical curriculum includes workplace-based training for final-year students in provincial hospitals. Additionally, competency-based evaluation at the end of the first mandatory service year ensures quality assurance before GPs can enter residency training. Policymakers should consider aligning service requirements with competency frameworks to maintain training quality while addressing workforce shortages.

Targeted policies, such as those implemented for family medicine and emergency medicine in Thailand, have effectively increased workforce supply in priority fields. However, comprehensive workforce demand analysis is still necessary. For example, to ensure that primary care teams function as integrated units, family physicians should not be considered as standalone providers; instead, primary care nurses, pharmacists and community healthcare workers should be equally integrated into workforce planning.[46]

Similar dynamics have been observed in Brazil, where large-scale workforce expansion under the Unified Health System (SUS) has increased the overall number of physicians without fully resolving regional and specialty-specific maldistribution. Recent evidence shows that, despite sustained public investment and targeted programmes such as Mais Médicos, physician growth has remained disproportionately concentrated in wealthier regions, with private medical education playing an increasingly dominant role in workforce expansion. This expansion has not consistently translated into improved equity in specialist distribution, highlighting the limitations of supply-side growth when not explicitly aligned with population health needs and service demand. The Brazilian experience thus reinforces the importance of coupling targeted training and deployment policies with needs-based workforce planning and retention strategies to achieve equitable distribution under UHC systems.[47]

In terms of retention strategies, a recent framework as the Root Stem Model addresses interventions across the career development continuum, particularly by promoting job training, enhancing the working environment and advocating for appropriate remuneration and incentives.[48] These elements are particularly relevant for emerging and scarce specialties, where competitive labour markets and limited career support can accelerate attrition. Therefore, targeted policies and retention-based policies should be implemented in parallel to ensure the long-term sustainability of workforce planning.

Workforce planning should be driven by real-time, high-quality data to allow for adaptive policymaking. A well-designed national workforce data architecture should be prioritised to track workforce trends, anticipate shortages and inform policy adjustments dynamically. Policymakers should invest in digital health workforce management systems to ensure timely and evidence-based workforce interventions.

Limitations

This study relied on secondary data, which may introduce limitations, such as potential inaccuracies in hospital-reported figures. For example, the reported absence of GPs in certain provinces, such as Uttaradit Province in 2015, likely reflects data inconsistencies rather than actual shortages. Reliance on self-reported data also limits real-time assessments and regional variations in workforce deployment. The MOPH is committed to establishing a NHWA in Thailand.[5] Future studies may include the application of primary data collection and more granular demographic analyses to address these gaps, analyse the datasets collected by all relevant Royal Colleges and produce demographic profiles for all specialists' genders and ages, in addition to the hospitals they served in.

There is a discrepancy in the figures between this study and other sources. For example, the physician-to-population ratio was 0.5 in 2024 in this study, which is lower than that of the Global Health Observatory, reporting 0.9 in 2022[49] and World Development Indicators, reporting 0.9 in 2020.[50] Therefore, careful interpretation of the data is required.

The observed improvements in specialist distribution likely result from synergistic policy influences, including national initiatives, Royal College interventions and service planning by the MOPH, making it challenging to attribute changes to specific policies. Additionally, other factors, such as physician preferences, choices of specialty, private practice opportunities and sociocultural influences, may play a critical role in shortages within certain specialties and vice versa in other specialities. These dimensions were not examined in this study but warrant further investigation to complement quantitative

findings and inform more effective policies. While this study assessed availability and equity quantitatively, it did not link these changes to health outcomes or service quality. Future research should explore the impact of workforce distribution on outcomes such as population health, mortality reduction and system efficiency. Mixed-methods approaches, such as stakeholder interviews and policy-specific evaluations, could also help disentangle the effects of overlapping policies and provide a more comprehensive understanding of policy effectiveness.

For the methodology domain, the imputation strategy in our study may influence density estimates and inequality measures in two opposing ways. First, in administrative workforce reporting, non-response for specific specialties may sometimes reflect a true absence of personnel rather than missing information. In such cases, imputing missing values could overestimate workforce availability, potentially resulting in density estimates and Gini coefficients that appear more equitable than the underlying reality.

However, our imputation procedure was designed to mitigate this risk by first distinguishing between structurally zero observations and likely reporting omissions and then evaluated using an outlier-based longitudinal consistency approach. This approach aimed to restore longitudinal plausibility rather than inflate workforce counts. The resulting imputed series exhibited reduced temporal roughness compared with the non-imputed data, suggesting attenuation of artificial volatility arising from intermittent reporting.

Finally, while the Gini coefficient is widely used to summarise inequality in various aspects, it has several important limitations. First, the Gini coefficient captures inequality between aggregated geographical units and therefore cannot detect intraprovincial or intraurban disparities, such as clustering of specialists within metropolitan areas or differential access within cities. Second, it does not account for patient mobility across administrative boundaries. Third, the Gini coefficient is insensitive to whether observed inequality reflects inappropriate maldistribution or legitimate concentration driven by service complexity, referral roles or economies of scale. Thus, Gini-based measures should be interpreted as indicators of distributional equity rather than direct measures of access or need-based equity which need further investigations.

CONCLUSION

Thailand's progress in improving the availability and equitable distribution of medical specialists over the past decade represents a significant step towards achieving universal access to specialist care. The positive trends observed among GPs and key specialties reflect the efficiency of workforce policies. However, the persistence of disparities highlights the need for continuous monitoring and policy adaptations. Other LMICs seeking to optimise their medical workforce can apply Thailand's experience as a model for balancing workforce production, retention and distribution equity.

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