Scenario Modeling for Dentistry in Malaysia: Utilization, Privatization, and Specialization

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Abstract

Aim: To study to model future clinical dental workforce scenarios in Malaysia, in relation to population need–demand, to inform future change. **Materials and Methods:** A system dynamics (SD) model was developed in Vensim-software to model the need/demand and supply for dental care across public–private sectors over 3 decades (2010–2040). This model included two sub-models relating to "need/demand" and "supply," drawing on national evidence from two previous studies (student career surveys and interviews of key stakeholders nationally), together with relevant available data. This SD model provided the baseline model (S1) for Malaysia and four-distinctive-scenarios (S2–5), involving enhancing generalists–specialists across public–private sectors. An additional scenario (S6) was run to optimize workforce utilization, informed by career expectations of emerging graduates drawing on earlier scenarios (S2–5). **Results:** Modeling future five-scenarios highlighted the gap in dental workforce nationally across both sectors could range from a surplus of a total of 3739 dentists and 817 therapists in the baseline scenario to a total shortfall of 1249 dentists and surplus of 817 therapists by the year 2040, influenced by dentist working patterns, specialization, and privatization. Increasing the potential for specialist training and permitting emerging graduates' to working part-time, while optimizing public sector primary care, and responding to the career expectations of emerging graduates, has the potential to absorb potential oversupply, and, thus, utilize the entire clinician dental workforce in Malaysia in the medium term. **Conclusion:** The findings of this model demonstrate the short-term requirement to expand the Malaysian dental workforce to meet dental needs of the population, highlighting that continued production at the current rate will result in oversupply, unless action is taken to maximize primary care, enhance specialization, and embrace flexible working to meet career expectations of graduates.

Keywords: Malaysia, privatization, specialization, system dynamics, workforce modeling

INTRODUCTION

Given the uncertainty regarding the nature and profile of the future healthcare workforce,[1,2] testing and simulating different scenarios within one model to estimate possible futures is very useful in future health-related research.[3-5] Modeling the different modes of behavior is a fundamental requirement in designing future policies.[3] Sterman[6] highlights the importance of considering the philosophical and legal aspects of future care, together with the focus of healthcare services in modeling the model's behaviors.

Given the healthcare systems' increasing complexity, influenced by multiple drivers for change, including socio-demographic, economic, politics, epidemiological, and managerial factors,[2,7,8] and the need to integrate behavioral components such as workforce motivation and expectations,[9-12] particularly on specialization and privatization, there is a need to conduct a research to

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understand those influences and their impact. Thus, examining their potential implications by simulating possible influences in workforce modeling, and the model's responses, can inform practical decisions for workforce development.[13] By integrating a number of relevant influences within operational research (OR) modeling, the accuracy of workforce projections may then facilitate acceptance among policy-makers and healthcare providers.[14]

In the healthcare sector, OR is a very useful tool to inform future development as it can take account of the complexity of healthcare systems,[15,16] by testing and simulating different future scenarios within one model,[3] as a primary, distinct from other workforce modeling to represent the real systems.[15] OR has been used in many studies in medical and dental research areas; nevertheless, the system dynamics (SD) model was less utilized by modelers, particularly in dental healthcare service research until recently. However, some studies have examined the dynamicity of the dental workforce in meeting the demands of the population such as in Sri Lanka,[17] and Malaysia.[4,18] These studies which successfully used the SD model aimed to address issues pertaining to the supply–demand to dental care by simulating various scenarios to explore various practical solutions over time. However, neither of these models considered a work substitution from dental specialists and auxiliaries due to the time and logistical restrictions. Moreover, the contributions of dental specialists, the new and existing roles in dental personnel, skill mix, and the different levels of demands for services, especially complex and tertiary dental services, perhaps were ignored in these studies, despite being the main demands on the system.[17]

In light of the above, this study tested various scenarios for Malaysia as a case-study approach for the middle-income country that has responded by increasing the dental workforce, with now concerns about the long-term implication of these policies, particularly on how the expensively trained dentists will be utilized in meeting the new supply–demand of the Malaysian population.[2,19] Having explored the motivation and career expectations among emerging dental professionals[20,21] and identified major drivers for change in Malaysia with implications for specialization, privatization, and working patterns[2] and constructed a baseline model for this middle-income country,[4,22] it is appropriate to examine the implications for the dental workforce to inform workforce planning, capacity building, and utilization.

MATERIALS AND METHODS

Study design
This is the second of two papers involving OR modeling relating to the Malaysian dental workforce as part of a body of doctoral research.[22] As previously reported,[2] the conceptual model, in the form of a causal loop diagram (CLD), was developed by identifying model parameters, informed by the literature (research and health policy) and previous findings of the research team.[2,20,21] The conceptual model demonstrates the relationship and the complexity of two sub-models: "need/demand" and "supply." The study protocol was approved by KCL Biomedical Sciences, Dentistry, Medicine and Natural & Mathematical Sciences Research Ethics Subcommittee (Reference BDM/12/13-129). Approval was also sought and obtained within (Reference number: NMRR-14-408-20774), together with permissions from the heads of OHD and the MOH, dental deans, non-government organisations and private practitioners. This study was conducted in full accordance with guidelines of the World Medical Association Declaration of Helsinki.

Type of data needed for the stock and flow diagram
Relevant data were collected from published sources of the Ministry of Health (MOH) Malaysia, the Department of Statistics Malaysia, the Ministry of Education Malaysia, the Ministry of Finance Malaysia, Malaysian Dental Council, Malaysia Dental Association, World Data Atlas, and the International Futures at Paradee Center that provide historic data and trends. Data from students' perspectives[20,21] were used to inform the working pattern in the baseline scenario, whereas parameters of future roles, sector of practice, and working patterns were considered in framing the alternative scenarios with variation by gender. Full details of the model are available online[22] and briefly outlined below.

Need/demand sub-model
A sub-CLD was created for need and demand and integrated to produce the overall demand for clinical hours by population age-band. Need by age-group was included in the model based on the latest national surveys.[23] The level of demand for specific types of treatment was based on the national trend of dental utilization that varied by population age-band [Table 1].[24] This acted as a primary measure of clinical hours' demand, rather than normative need, which is much higher within this population than expressed need, that is, demand. Furthermore, the level of demand for dental services varied according to the preference of the sector (public or private) and workforce (generalists, specialists, and therapists). The total volume of the population requiring specific dental care was multiplied by the treatment time to convert it into clinical hours.

Supply sub-model
Workforce data in the supply model were integrated to produce clinical hours supply for the clinical dental workforce. The calculation of clinical hours' supply was initiated by the total number of generalist and specialist

Table 1: Details of the baseline scenario, the four main alternative scenarios, and recommended scenario (Scenario 6)

No.	Parameters	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5
		Definitive scenario (baseline)	Optimizing generalists in the public primary service	Enhancing generalists in the private primary service	Enhancing private specialization	Optimizing public specialization
1	Philosophy of care	Status quo	Policy on strengthening public primary service	Policy on strengthening private primary service	Policy on strengthening secondary private service	Policy on strengthening secondary public service
		Assumes that current trends continue	To provide more clinical hours supply from public generalists	To provide more clinical hours supply from private generalists	To provide more clinical hours supply from private specialists	To provide more clinical hours supply from public specialists
2	Delegation of tasks/ working patterns	Normal delegation of tasks	More provision of primary care from the public sector	More provision of primary care from the private sector	More provision of secondary care from the public sector	More provision of secondary care from the private sector
			Scenario 2 (a): S2 + 22.2% wish to work part-time at public setting			
3	Privatization rate	Privatization rate for dentists and specialists is continued as at present	Privatization rate of generalists is reduced from 5% to 4%	Privatization rate of generalists is increased from 5% to 9%	Privatization rate for generalists as at present	Privatization rate for generalists as at present
			4% is the rate for the public sector to remain dominant	9% is the rate for the private sector to become dominant	Privatization rate for specialist as at present	Privatization rate for specialist as at present
			Scenario: 64% wish to work at private and 36% at public sector (primary care) – student views			
4	Specialization rate	Training rate is continued as at present	Training rate is continued as at present	Training rate is continued as at present	Training rate for private specialists is increased by 100% from 0.5% to 1.5%	Training rate for public specialists is increased by 50%, from 85 to 128 scholars
					Scenario 4 + 5: Training rate for public and private specialists is increased to 1.5% and 128 places respectively	
					Scenario 4 (a): 59.3% of private generalists converted to specialists	Scenario 5 (a): 59.3% of public generalists converted to specialists
	Recommended scenario (Scenario 6)		Scenario 2 (a) + Scenario 4 + 5: working part-time at public sector + increasing the specialization rate			
5	Population	Birth and death rate modified intervally / Proportion across age-bands modified intervally / Constant of immigration net rate	Similar to baseline scenario	Similar to baseline scenario	Similar to the baseline scenario	Similar to the baseline scenario
z	Oral health needs	Oral health need decreased by 5% in 2030 and 2035	Similar to the baseline scenario	Similar to the baseline scenario	Similar to the baseline scenario	Similar to the baseline scenario
7	Level of demands for dental care (increase gradually over time)	Toddler (2.2%–20.2%) / Preschool (32.3%–100%) / Primary school (98%–100%) / Secondary school (80.5%–100%) / Adults (11.1%–39.1%) / Elderly (9.5%–56.6%)	Similar to the baseline scenario	Similar to the baseline scenario	Similar to the baseline scenario	Similar to the baseline scenario

dentists providing dental care (primary or secondary) serving patients across two sectors (public and private) in clinical time (hours), as was dental therapists' conversion of the total number of the dental practitioners into total clinical hours supply was undertaken by multiplying the workforce volume by total working hours per year (working time equivalent [WTE]).

Possible working patterns (full- and part-time) of dental professionals, by gender, informed by current policy and students' perspectives[20,21] were used to calculate the potential future supply of clinical hours. Historical trend data, namely, employment rate, attrition, migration, and study leave, were extrapolated to the future. Given that the modeling was initiated from 2010 onward, comparison with current workforce data[25] was undertaken as part of the model validation and calibration.

Conversion of Malaysians' working days to clinical hours' supply

The number of working days for each type of workforce personnel per year was calculated, based on the difference between the total number of working days and the number of annual leaves taken per year. Clinical hours supplied were based on an 8-h day. The total supply of, and demand for, clinical hours from these two main models was then compared to calculate the level of clinical hours being used, or not, and the volume needed for the respective workforce category.

The difference in clinical hours between the supply and need/demand sides determined the gap in clinical hours, such that the level of "used" or "non-used" clinical hours, thus, suggests whether there is potential of under or oversupply of clinical hours. The gap in clinical hours between the two sub-models was divided by the total clinical hour supply per individual workforce member annually (WTE) in order to indicate the workforce volume needed.

Scenario testing outputs

Following the outputs of the baseline model which indicated the possibility of dentist surplus by 2040 or earlier, four scenarios were run to examine the implications of specialization and privatization within the workforce to inform policymakers on how to best utilize the workforce to meet population need and demand as outlined below:

S1 : Baseline.
S2 : Enhancing generalists in the public sector informed by/responding to the privatization rate.
S3 : Enhancing generalists in the private sector informed by/responding to the privatization rate.
S4 : Enhancing private specialization informed by/responding to the privatization rate.
S5 : Enhancing public specialization informed by/responding to the privatization rate.

Essentially, different levels of "privatization" and "specialization" were tested, along with parameters relating to their future role, sector of practice, and working pattern (full- or part-time) of dentists, which varied by gender. The dental therapist workforce remained stable throughout, in line with stakeholder views.[2] Table 1 summarizes the four scenarios against the baseline model, outlining their philosophy, delegation, privatization, and specialization. All other parameters in the baseline scenario remained constant.

One additional optimal scenario (S6) was run to combine the effects of the above with alternative workforce utilization by permitting part-time working, in line with graduate career expectations and reported in Table 1:

S6 : Optimizing the workforce and embracing part-time working in the public sector with increasing specialization in the public sector and private sector.

RESULTS

Scenario 1: Definitive baseline (S1)

The basis of the model assumptions for this scenario baseline is listed in Table 1. The baseline scenario suggests the possibility of dental workforce (therapists and dentists) by 2035 (*n* = 817), increasing further by 2040 (*n* = 3739). The model also suggests that there will be surplus of generalists in 2035, with a potential shortage of specialists across sectors.

Scenario comparison output

Comparison of the total workforce volume outputs across Scenarios 2–5 in Figure 1 reveals a possible surplus of dentists by 2040, like the baseline scenario (S1) [Figure 1]. As expected, the number of therapists required remained constant across the scenarios given that the flow of therapists was not linked with the dentists as presented in the conceptual model (CLD). However, the volume of generalists and specialists required across sectors varied, based on the different specialization and privatization rates being stimulated. Table 2 provides an overview and comparison of the workforce required by type across the four alternative scenarios and with the baseline scenario.

Scenario 2: Optimizing generalists in the public sector primary care service (S2)

Simulation with an adjusted level of public sector generalists increased the potential for a surplus in the total number of dentists by 2040 due to recruiting, retaining, and increasing volumes of the public generalists. The primary intervention of this scenario was to strengthen the workforce (generalists) in the public sector to meet the high demand of population in the public service, informed by the local policy. The implementation of this policy will increase the oversupply of public generalists

by 1.4 times into a total of **5556** dentists by 2040. Conversely, the potential surplus of generalists in the private sector reduces by 1.5 times, albeit an oversupply of **1365** dentists still exists. Notably, the volume of public specialists and therapists remains constant, with only a slight improvement with the volume needed for private specialists.

Scenario 3: Enhancing the generalist workforce in the private sector primary care service (S3)

Under this scenario, empowering more generalists in the private sector by increasing their flow from the public sector at the adjusted privatization rate of 0.9 to ensure the private sector is dominant will increase the oversupply of the private generalists two-fold. Notably, the potential for an oversupply of total dentists by the year 2040 still exists, although the volume is less under this policy. This scenario suggests that oversupply of generalists in the public sector will reduce. Similar to Scenario 2, the numbers of public specialists and therapists also remain constant, with only a slight improvement in the volume needed for private specialists throughout the simulation period.

Scenario 4: Enhancing private specialization (S4)

The potential for an oversupply of the total dentists under this policy will slightly improve on the baseline scenario by the year 2040. This scenario increases the specialization rate, reducing the oversupply of private generalists by 1.3 times. The adjusted rate of 1.5% is the minimum to convert all of the undersupply of private specialists presented in the baseline scenario. Consequently, this scenario leads to an oversupply of private specialists by **181** specialists in the year 2040. The volume of public generalists and specialists remains constant, similar to the baseline scenario, if there is no change to privatization rate between sectors.

Scenario 5: Optimizing public specialization (S5)

Conversion of public generalists into specialists at the adjusted rate of a 50% of increase from the baseline model, considering the restriction of funding and places for postgraduate training will reduce the oversupply of the workforce by only 15.5%. This will also increase the volume of public specialists by 2.4 times. In this scenario, the volume of private generalists and specialists and therapists remains constant, if there is no change to privatization rate between sectors. Moreover, the proportion of specialists under the optimized scenario in both sectors also shows some reduction from 25% in 2010%–20% in 2040, albeit lower than the career expectations of the emerging workforce.

Scenario 6: Optimizing workforce utilization overall

Following analysis of the initial scenarios, a further scenario (S6) was examined to utilize emerging graduates'

perspectives on undertaking part-time working in the public care setting; (22.2% of public sector generalists could work part-time), and thus absorb the potential of oversupply of the generalists.

Table 3 demonstrates the integration of additional policy in S6 (adapted from S2), when compared with the baseline (S1); the model suggests that the dentists may be absorbed until 2040 under this approach. The output also indicates a potential reduction in the oversupply of public sector generalists by **4.8** times in 2040, albeit that they may still face oversupply starting from 2035. Indeed, this sub-scenario has no impact on specialists in both sectors.

Given the various scenarios tested, modification of other/scenarios was considered appropriate to address the concern about how the future Malaysian dental workforce will be best utilized while meeting both population and profession expectations. First, fulfilling the expectation of emerging workforce to practice part-time, while strengthening the public primary care services (S2); second, a combination of specialization in public and private sectors (S 4 + 5). Following simulation under this scenario, the model suggests that there will be a reduction in the oversupply of total dentists by the year 2040, combined with the baseline. The output also indicates a possible slight undersupply of public generalists and private specialists in the same year [Table 4]. This combination scenario provided the optimal output in providing the balance of workforce supply in meeting population need/demand across sectors and harnessing workforce career expectations.

DISCUSSION

The imperative for conducting scenario testing in this study was to provide different pictures of the healthcare services and the dental workforce in a reliable way.[26] It aimed to assist future workforce planning on the optimal utilization for potential oversupply of clinical hours in meeting current and future population demand. Modeling multiple scenarios, informed by student and stakeholder views, demonstrates the uncertainty of privatization and specialization to best utilize the dental workforce of the future. Supply outputs highlight the potential mismatch of career expectations in relation to population need/demand, which may have implications for the future. The findings provide deeper insights suggesting that if the level of specialization relates to population need and the emerging dentist workforce is permitted to fulfill their career expectations in working part-time, while optimizing the public care primary service to meet basic needs, this combined approach has the potential to absorb the potential oversupply and best utilize the entire clinician dental workforce across sectors in Malaysia, recognizing oral health trends, changing population demography, and increasing demands for care.
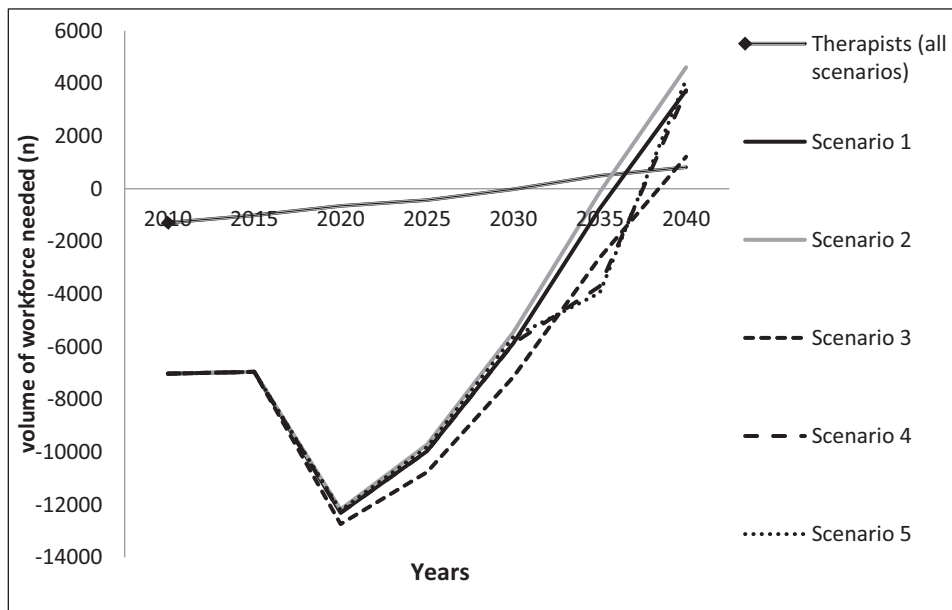
Figure 1: Modeling the workforce volume needed for the total dentists and therapists across scenarios, 2010–2040. Based on used/non-used clinical hours **divided by** %WTE of workforce type in a year. Oversupply of the workforce is indicated when the line is above the level of 0

Optimizing generalists in the public sector primary care service

The outputs from Scenario 2 indicate a potential oversupply of total number of dentists by 2040, or earlier. As the flow of dentists into the private sector is restricted in this scenario, there is the potential for undersupply in the private sector. The primary modification of this policy involved continued dental compulsory service in the public sector through recruitment and a greater emphasis on retention in the public sector.

This scenario, strengthening primary care in the public sector, is of primary importance in contemporary healthcare.[27] This was evident from reported issues related to the accessibility of dental care physically or financially[28] and highlighted by the local stakeholders.[2] The public sector is assumed to increase its overall share of provision, and this can be done through retaining more dentists in the public sector. Primary care that utilizes generalists is strongly required, especially in meeting the dental needs of adults and elderly people.[23] An increase in supply, along with potential health promotion and education activities, may be required, however, to encourage the uptake of dental care options among these groups. Therefore, the oral health status of the population, specifically for these two age-bands may improve, particularly if a preventive approach is embraced.[29]

Optimization of the public sector may increase the potential oversupply of overall dentists. An additional policy that integrates the students' perspective (22.2%) of working part-time (80% which is maximum part-time) in the public setting explored in S6 could improve the situation. The potential oversupply is absorbed, and

the aspirations of the emerging workforce, particularly of female dentists to work in a flexible environment and at reduced capacity, are fulfilled.[21] Consequently, a motivated and highly skilled workforce is retained. Also, under "compulsory service" in the public sector, new graduates will be assimilated into a competent and quality dental workforce.[30]

Realistically, the limited dental facilities in the public sector may restrict the number of new graduates required to be absorbed. The only constraint toward this policy is the low level of allocated healthcare expenditure.[31] However, taking a public health approach, the rate of specialization should be based on the level of need, and this might cause further conflict with the workforce retention, which will require ingenious consideration. Nevertheless, their future role could be altered, for example, in training dentists with extended skills who remain generalists in primary care settings, while developing some more specialized expertise.[32]

Enhancing generalists in the private primary service

Scenario 2 output indicates a potential surplus of total number of dentists by 2040, but at a much lower volume than S1. This policy reduced the oversupply of generalists in the public sector and increased the oversupply of generalists in the private sector, given the public reluctance currently to utilize private services. There was no effect on the oversupply of dental specialists and therapists. This policy simulated different values of model parameters for the privatization rate of generalists. Application at rates of 0.9%, and above, results in the dominance of private practitioners within the simulation period. The primary intervention of this policy was to allow movement of

Table 2: Linear outputs for volume needed for all clinician dental workforce across baseline and alternative scenarios

Scenarios	Year	Public generalists (PuG) (*n*)	Private generalists (PrG) (*n*)	Public specialists (PuS) (*n*)	Private specialists (PrS) (*n*)	Total dentists (*n*)	Therapists (*n*)
Scenario 1: Definitive baseline	2010	− 3739	− 322	− 2414	− 552	− 7027	− 1290
	2015	− 3702	− 450	− 2258	− 546	− 6956	− 1011
	2020	− 6703	− 1435	− 3348	− 824	− 12,310	− 654
	2025	− 4885	− 1121	− 3179	− 787	− 9972	− 432
	2030	− 2097	− 382	− 2731	− 660	− 5870	− 19
	2035	**+ 1080**	**+ 768**	− 2128	− 477	− 757	**+ 492**
	2040	**+ 3948**	**+ 2065**	− 1928	− 346	**+ 3739**	**+ 817**
Scenario 2: Optimizing generalists in the public primary service	2010	− 3739	− 322	− 2414	− 552	− 7027	− 1290
	2015	− 3702	− 450	− 2258	− 546	− 6956	− 1011
	2020	− 6480	− 1530	− 3348	− 825	− 12,183	654
	2025	− 4446	− 1309	− 3179	− 791	− 9725	− 432
	2030	− 1354	− 701	− 2731	− 670	− 5456	− 19
	2035	**+ 2214**	**+ 277**	− 2128	− 496	− 133	**+ 492**
	2040	**+ 5556**	**+ 1365**	− 1928	− 380	**+ 4613**	**+ 817**
Scenario 3: Enhancing generalists in the private primary service	2010	− 3739	− 322	− 2414	− 552	− 7027	− 1290
	2015	− 3702	− 450	− 2258	− 546	− 6956	− 1011
	2020	− 7464	− 1111	− 3348	− 817	− 12,740	− 654
	2025	− 6307	− 512	− 3179	− 770	− 10,768	− 432
	2030	− 4405	**+ 613**	− 2731	− 625	− 7148	− 19
	2035	− 2318	**+ 2242**	− 2128	− 413	− 2617	**+ 492**
	2040	− 714	**+ 4100**	− 1928	− 243	**+ 1215**	**+ 817**
Scenario 4: Enhancing private specialization	2010	− 3739	− 322	− 2414	− 552	− 7027	− 1290
	2015	− 3702	− 450	− 2258	− 546	− 6956	− 1011
	2020	− 6703	− 1515	− 3348	− 745	− 12,311	− 654
	2025	− 4885	− 1264	− 3179	− 650	− 9978	− 432
	2030	− 2097	− 614	− 2731	− 436	− 5878	− 19
	2035	**+ 1080**	− 65	− 2128	− 174	− 1287	**+ 492**
	2040	**+ 3948**	**+ 1511**	− 1928	**+ 181**	**+ 3712**	**+ 817**
Scenario 5: Optimizing public specialization	2010	− 3739	− 322	− 2414	− 552	− 7027	− 1290
	2015	− 3702	− 450	− 2258	− 546	− 6956	− 1011
	2020	− 7036	− 1469	− 2937	− 781	− 12,223	− 654
	2025	− 5321	− 1194	− 2577	− 723	− 9815	− 432
	2030	− 2610	− 501	− 1948	− 574	− 5633	− 19
	2035	− 2425	− 46	− 1112	− 373	− 3956	**+ 492**
	2040	**+ 3337**	**+ 1836**	− 809	− 218	**+ 4146**	**+ 817**

Based on used/non-used clinical hours **divided by** %WTE of workforce type in a year.

Oversupply is indicated by volumes in **bold** with a positive (+) sign.

Scenario 2: Privatization rate is reduced from 5% to 4% per year.

Scenario 3: Privatization rate is increased from 5% to 9% per year.

Scenario 4: Postgraduate training rate (private) is increased from 0.5% to 1.5% per year.

Scenario 5: Postgraduate training rate (public) is increased by 50% from 85 to 128 scholarships per year.

The volume of therapists remains constant across scenarios because they are not influenced by the policy testing

dentists into the private sector and rectify the primary issue related to the constraints on dental facilities in the public sector based on stakeholder views.[21]

This policy also presents the opportunity for the young workforce to value the importance of gaining clinical skills in the public sector as limited clinical experience is available after a certain period of time. The way dentists practice may also change as the private market is flooded with a large number of dentists. Group practices may be

formed to keep the workforce competitive and allow them to survive in the new environment trade liberalization in dentistry.[33] The alternative policy was also tested by incorporating the students' aspiration (64%) to work in the private sector. The output indicated an increased oversupply in the volume of workforce needed.

The cost of dental treatment is relatively high. Hence, the lack of health insurance options in the country reduces the affordability and accessibility to private services.[34]

Table 3: Linear outputs for volume needed for all clinician dental workforce if public generalists are allowed to work part-time at public sector

Scenarios	Year	Public generalists (PuG)	Private generalists (PrG)	Public specialists (PuS)	Private specialists (PrS)	Total Dentists (n)	Therapists
Scenario 1: Final baseline	2010	− 3739	− 322	− 2414	− 552	− 7027	− 1290
	2015	− 3702	− 450	− 2258	− 546	− 6956	− 1011
	2020	− 6703	− 1435	− 3348	− 824	− 12,310	− 654
	2025	− 4885	− 1121	− 3179	− 787	− 9972	− 432
	2030	− 2097	− 382	− 2731	− 660	− 5870	− 19
	2035	**+ 1080**	**+ 768**	− 2128	− 477	− 757	**+ 492**
	2040	**+ 3948**	**+ 2065**	− 1928	− 346	**+ 3739**	**+ 817**
Scenario 2(a): S2 (0.5 of privatization rate) + 22.2% of PuG wishing to work part-time	2010	− 3739	− 322	− 2414	− 552	− 7027	− 1290
	2015	− 3702	− 450	− 2258	− 546	− 6956	− 1011
	2020	− 7567	− 1530	− 3348	− 825	− 13,270	− 654
	2025	− 5834	− 1309	− 3179	− 792	− 11,114	− 432
	2030	− 3105	− 701	− 2731	− 670	− 7207	− 19
	2035	**+ 56**	**+ 277**	− 2128	− 469	− 2264	**+ 492**
	2040	**+ 817**	**+ 1365**	− 1928	− 380	− 126	**+ 817**

Oversupply is indicated by volumes in **bold** with a positive (+) sign.

Part-time: 4 days in a week

Table 4: Linear outputs for volume needed for all clinician dental workforce if public generalists are allowed to work part-time in the public sector under the policy of strengthening public primary services and optimum specialization in both sectors

Scenarios	Year	Public generalists (PuG)	Private generalists (PrG)	Public specialists (PuS)	Private specialists (PrS)	Total dentists (n)	Therapists (T)
Scenario 1: Definitive baseline	2010	− 3739	− 322	− 2414	− 552	− 7027	− 1290
	2015	− 3702	− 450	− 2258	− 546	− 6956	− 1011
	2020	− 6703	− 1435	− 3348	− 824	− 12,310	− 654
	2025	− 4885	− 1121	− 3179	− 787	− 9972	− 432
	2030	− 2097	− 382	− 2731	− 660	− 5870	− 19
	2035	**+ 1080**	**+ 768**	− 2128	− 477	− 757	**+ 492**
	2040	**+ 3948**	**+ 2065**	− 1928	− 346	**+ 3739**	**+ 817**
Scenario 6: Optimizing workforce utilization	2010	− 3739	− 322	− 2414	− 552	− 7027	− 1290
	2015	− 3702	− 450	− 2258	− 546	− 6956	− 1011
	2020	− 8534	− 1677	− 2937	− 7010	− 20,158	− 654
	2025	− 7405	− 1616	− 2577	− 608	− 12,206	− 432
	2030	− 5324	− 1241	− 1948	− 404	− 8917	− 19
	2035	− 508	− 187	− 1172	− 86	− 1953	**+ 492**
	2040	**+ 93**	− 659	− 809	**+ 126**	− 1249	**+ 817**

Oversupply is indicated by volumes in **bold** with a positive (+) sign.

Scenario 6: Scenario 2a + 4/5 (a): working part-time in the public sector + increasing the specialization rate

Privatization of the future health system is indeed at stake following conflicts between politicians, professional expectations, and healthcare policies. The suggested change from the subsidized healthcare model to the health social insurance model may steer the local dental market toward privatization. Overall, there is limited potential for the private sector. As dental benefits are not yet introduced in the country, this is partially responsible for the slow movement of the dental workforce and patients toward the private sector.

Enhancing private specialization

Under Scenario 3, the model suggests that the oversupply of total dentists is slightly improved and is similar to the baseline scenario. Private generalists are absorbed and utilized as specialists. Conversion of private dentists into specialists reduces the oversupply of private sector generalists and the undersupply of private sector specialists. Nonetheless, the scenario resulted in the oversupply of private specialists in 2040, which in public health terms is not in the best interests of the population.

The primary intervention of this policy is to increase the rate of specialization within private practitioners in Malaysia given that secondary care in this sector, particularly for orthodontic and periodontal care, has increased in demand. Secondary dental care is recognized

as an important agenda in healthcare service planning generally at the national level.

Research among dental students suggested that the future Malaysian dental profession might also be expected to be ambitious for continuous learning including specialization,[21] and for a better work–life balance, although it could be argued that there is no statistical correlation between them for several reasons such as altered expectations following a period of work experience or looking at other career opportunities. The aspirations of the new emerging dental workforce should alert the current dental profession that future preference for provision of care is merely pro-specialist, suggesting there is potential oversupply of dental specialists if they pursue specialist training at their anticipated level of 64%. Our modeling, however, did not go into which type of specialist, which requires further consideration in relation to need, and this is an area for future research.

Simulation was performed on different values of model parameters for the specialization training rate. An increase of 1% from the baseline scenario was applied, considering that the places and funding to support postgraduate training are very limited. At 1%, the output illustrated potential oversupply of private specialists by the year 2040; this situation was not anticipated in the baseline scenario.

Under this approach, the oversupply of total number of dentists is reduced at a high rate. Different inputs for specialization were utilized by integrating the students' perspective to specialize and own a private clinic in the long term. Nevertheless, it will cause potential heavy surplus of private sector specialists as the demand for specialist care in that sector is low. Thus, this policy utilizing students' input should be avoided. This has raised concerns about how the policy-makers can balance the aspirations of this new emerging workforce with needs of population. Their failure may result in loss of expertise should the dental workforce migrate to other countries which offer greater potential.[35]

Optimizing public specialization

Under Scenario 4, the model illustrated that the oversupply of the total number of dentists was slightly increased compared with the baseline scenario. The volume of public sector generalists needed was increased as they were utilized as specialists after training. Conversion of public dentists into specialists reduces the oversupply of both public and private sector generalists and increases the number of public sector specialists. As more public generalists become specialists, the migration of generalists across sectors is reduced. Thus, the volume of generalists needed in the private sector is also reduced.

Apart from the above issues, nearly 28% of specialist posts in the MOH were unoccupied in the year 2012.[36] Malaysia seemingly needs more specialists to strengthen the standards of secondary and tertiary dental care services within this short duration of time. Considering the high need for specialist care in the country, the primary intervention of this policy is to escalate the rate of specialization within public sector practitioners.

This policy was simulated with different values of model parameters for the specialization rate using a quota number. The fund allocation is restricted and divided across ministries.[37] In addition, there is little public sector funding available to support postgraduate training. This increment caused a slight increase in the potential oversupply of the total dentists compared to the baseline but with potential for undersupply of specialists and oversupply of generalists respectively across the sector.

On the other hand, for fulfilling the expectations of the young workforce that have high expectations to pursue specialization, extreme values from the students' input were utilized. Integration of the students' perspective to be specialists at the premium rate also produced extreme output with overall turnaround compared to the baseline scenario for the workforce type, except for the therapists. It is expected to lead to high oversupply of total dentists, including specialists in the public sector and the private sector. If the system fulfills the students' expectations, severe undersupply of public dentists ensues.

The stakeholders interviewed suggested that they only need 30% of the total dentists to be specialists.[22] This may result in conflict of retention and stability of the workforce. The current baseline reveals that approximately 25% of the total dentists are specialists in the country.[38] This volume is expected to reduce to 12% by the year 2040 as the graduate output rate of dentists is much higher than the opportunities for specialist training. Considering all these approaches, there is growing recognition for the new concept of developing dentists with enhanced skills (special interest) as a way to upgrade the level of care provision among dentists by allowing them to treat cases of intermediate complexity[12] as already discussed.

Strengths and limitations

This study has a number of strengths, which include its national approach, taking a needs-led approach based on normative and expressed need, and utilizing the best available data on supply. Furthermore, it has been informed by student views and stakeholder opinion.[2,20,21] The research team with its combined expertise has involved a diverse range of experts, and the OR modeling approach has facilitated a sophisticated but transparent approach, the details of which are available.[22,24]

Some limitations of this study need to be acknowledged. First, the parameters used in the model have a certain level

of uncertainty, which may influence the accuracy of the modeling outcome. Second, this research was conducted before the COVID era, and it will take some time for the impact of the global pandemic to be realized for dentistry; however, it is anticipated that the findings of this research will be helpful in planning for the future. Moreover, we further consider the generalist/specialist mix of workforce within the country, as explored in the African context.[39]

This model could also be developed further to examine a range of issues including urban/rural supply; working patterns of males and females; individual dental specialties; treatment times for children, adults and elderly; and even costs.

Conclusion

To conclude, the model short-term requirements to expand the Malaysian dentist workforce to meet population dental needs, highlighting that continued production at the current rate will result in oversupply unless action is taken to maximization primary care, enhance specialization and embrace flexible working to meet graduates career expectations. The various scenarios inform debate on how the health providers could balance those expectations with the level of need by the population for secondary care and the country's healthcare policy.

Clinical relevance

Scientific rationale for study: Understanding Malaysia's dental care needs in both public and private sectors for dental therapists and dentists is crucial for workforce planning and retention.

Principal findings:

The research identified a requirement to increase the workforce to match the increasing demand for dentists and therapists due to population growth. It emphasizes that maintaining the current production rate will lead to an oversupply unless steps are taken to optimize primary care, improve specialization, and adopt flexible work arrangements to align with graduates' career aspirations.

Practical implications:

The findings, influenced by input from students and stakeholders, provide valuable perspectives on the potential scenarios and varying aspects of health-care services and the dental workforce. This includes navigating uncertainties surrounding privatization and specialization to effectively harness the future dental workforce in Malaysia.

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Conflicts of interest

There are no conflicts of interest.

Authors contributions

EG, EB and MFCM conceived and designed the study. MFCM conducted the fieldwork, analysed the data and drafted the first version of the manuscript. All authors, including JM and PH contributed to and approved the final version of the manuscript.

Ethical policy and Institutional Review Board statement

BDM/12/13-129 and NMRR-14-408-20774.

Data availability statement

Upon request, data will be made available from the corresponding author.

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