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Review Article

Approaches and Components of Health Workforce Planning Models: A Systematic Review

Somaieh Bosak[1], PhD candidate; Shahram Yazdani[1], MD; Mohammad Hossein Ayati[2], MD, PhD

[1]Department of Medical Education, School of Virtual Medical Education and Management, Shahid Beheshti University of Medical Sciences, Tehran, Iran; [2]Department of Traditional Medicine, School of Traditional Medicine, Tehran University of Medical Sciences, Tehran, Iran

Correspondence:
Shahram Yazdani, MD;
School of Virtual Medical Education and Management, North Vali-Asr Ave., Tehran, Iran
Tel: +98 21 26210406
Email: shahram.yazdani@yahoo.com
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Abstract

Background: To date, there is still no uniformity in forecasting models for health workforce planning (HWFP). Different countries use various HWFP models, some of which are context-specific. The objective of this systematic review is to determine approaches and components of HWFP models.

Methods: A systematic review of studies published in English and Persian between 2004 and 2021 was performed by searching PubMed Central, MEDLINE, Web of Science, Scopus, Eric, and Elmnet databases. Articles that assessed HWFP models, focused on health service delivery, used input-output models, and a clear formulation process were included. Articles that scored ≥20 points on the "strengthening the reporting of observational studies in epidemiology" checklist were considered of acceptable quality for inclusion.

Results: Twenty articles were included for qualitative synthesis based on the inclusion and exclusion criteria. Most studies used the mixed method approach "supply and demand", whereas target- and needs-based approaches were used less frequently. The number of components used to estimate supply, demand, needs, and targets were 42, 32, 11, and 6, respectively. In addition, several unique factors used in the various HWFP models were identified.

Conclusion: Different approaches are used in HWFP models, which is indicative of the lack of consensus on this topic. High diversity in the identified factors is related to the approach used and the context in which the model is applied.

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What's Known

- Different approaches are used in health workforce planning (HWFP) models, each with the country- and context-specific components.
- To the best of our knowledge, there is no systematic review study on the components of HWFP models.

What's New

- Approaches and components of HWFP models are investigated.
- Specific components related to each approach are identified.

Introduction

Workforce planning (WFP) was developed during the 1960s and early 1970s in a period of relative economic stability.[1] It remained a major performance evaluation in the human resources (HR) departments until the economic recession hit in the 1980s, when the financial crisis undermined the process and economic value of WFP. Since then, WFP has again become the top priority for many organizations.[2] The simplest and most commonly used definition of WFP is "employing the right number of people with the right qualifications, at the right job and at the right time".[2, 3] However, the most comprehensive definition that explicitly

describes its procedural perspective is "WFP is a process in which an organization tries to estimate labor demand and assess the size, nature, and sources of supply to meet that demand".[1]

According to the 2006 World Health Organization report, human health resources (also known as HR for health or health workforce), is defined as "all individuals whose job is to protect and improve the health of their communities".[4] Health professionals play a major role in providing care to a community and are among the least readily accessible workforce. Health managers, both at national and local levels, continuously struggle with the task of managing health professionals in terms of increasing their effectiveness by distributing the workload fairly and increasing their productivity.[5]

There are well-defined methods and procedures to address WFP across various professions. However, despite the development of several methodologies and approaches for health workforce planning (HWFP), there is as yet no uniformity in processes that accurately address the needs of physicians.[6, 7] However, two main forecasting approaches have been defined, namely conceptual and analytical. The conceptual approaches include various factors influencing HWFP. The main approaches include demand-based, supply-based, target-based, needs-based, and benchmarking. Each approach relies on specific factors to predict the supply and demand of the health workforce. However, these do not take into account the dynamics within the system and between variables. Simulation methods and what-if scenarios can be used when determining the impact of different policy options on forecasts.[8] The analytical approach is designed to present analytical data in a suitable format for the health system decision-makers to support their workforce plans and policies.[9, 10] Main approaches include system dynamics, trend modeling, artificial neural networks, Markov models, linear programming, nonlinear programming, simulation, and workload indicators of staffing need (WISN).[8]

Different HWFP models are used in various countries. Some of these models are solely designed for a given context and many organizations have adapted an existing model to fit their specific context.[11, 12] Forecasting the future health workforce depends on the selected forecasting model. Moreover, its appropriateness depends on factors such as the characteristics of the target population, prediction time period, the way each factor affects changes over time in care, the way of funding of the healthcare financial system,[13] and changes in workforce productivity.[14] Other factors, which are country-specific, include socioeconomic status,[15, 16] level of education,[17, 18] population age structure,[14] age and sex distribution, and even ethnic distribution.[19, 20]

HWFP is the main responsibility of the Ministry of Health of each country with the important task of making the best use of national resources by training the right number of qualified people to promote health in society. Divergent methods are used in different countries, each with different contexts and specific variables. In addition, methodologies, approaches, and components used in HWFP are very diverse and at times even specific to an organization. In recent years, due to the importance of HWFP, Iran has developed an HR system and established a dedicated research center at the Iranian Ministry of Health and Medical Education.[21]

Several studies have applied the above-mentioned models and approaches. However, to the best of our knowledge, none specifically investigated the various unique components of HWFP. Hence, the present study aimed to identify the approaches (dimensions) and components of HWFP models using a systematic review. Our findings will help health policymakers and experts devise an effective and evidence-based HWFP.

Materials and Methods

Search Strategy

A systematic review and meta-analysis of studies published between 2004 and 2021 were conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) checklist.[22] It is worth mentioning that despite the fact that WFP was initially developed in the 1960s and early 1970s, most of the research studies in this field have been published during the last 16 years.[23] Therefore, we limited our search to the period 2004-2021.

A comprehensive search was performed on Web of Science, Scopus, Eric, PubMed Central, MEDLINE, and Elmnet. Medical subject heading (MESH) keywords in English and equivalents in Persian were used to search the databases. Using the syntax of various databases, two researchers independently searched the following terms: ("workforce" OR "workforces" OR "human resource" OR "human resources" OR "staffing" OR "staffings" OR "manpower" OR "manpowers" OR "womanpower" OR "womanpowers" OR "labor supply" OR "labor supplies") AND (planning OR forecasting OR estimating OR estimation OR model) AND

(health). For example, the syntax for the Web of Science search strategy was: (TI=[workforce OR "Human Resources" OR "Human Resource" OR Manpower OR Womanpower OR Staffing OR "Labor Supply"] AND TI=[planning OR estimating OR estimation OR forecasting OR model] AND TI=[health)) AND LANGUAGE:(English). Indexes=SCI-EXPANDED, SSCI, A&HCI, ESCI Timespan=2004-2021

The inclusion criteria were all studies published in Persian and English on the assessment of HWFP models, with a specific focus on health services delivery using input-output models, a clear formulation process, and with acceptable quality in accordance with the strengthening the reporting of observational studies in epidemiology (STROBE) checklist. The exclusion criteria were review articles, meta-analysis, and articles of poor quality.

Data Extraction

Duplicate articles were removed using EndNote software, version 20 (Clarivate Analytics, USA). Two researchers (S.B and Sh.Y) independently reviewed the articles according to the inclusion and exclusion criteria. In the case of rejection of an article, the reason was stated by the reviewer. Any disagreements were resolved by the third researcher. The extracted data included the name of the author, year of publication, country, target group (study group), model or formula, approaches (dimensions), and components (table 1).

Quality Assessment

The 22-item STROBE checklist was used to evaluate the quality of the articles. Each item is scored based on its relevance, ranging from 15 to 33. Articles that scored ≥20 points were considered acceptable for inclusion in our review study.[24]

Results

A total of 10,646 articles were identified, of which 2,295 were removed for duplication, an additional 8,294 after eligibility assessment, and 37 for failure to meet the inclusion criteria. Eventually, 20 articles were included for qualitative synthesis (figure 1).

Table 1: General characteristics of the included articles for the systematic review

Author	Country	Year	STROBE score	Approaches	Components	Summary
Bazyar et al.[25]	Iran	2021	32	Supply and demand	Supply: Graduates, migration, education dropout, admission to higher education, mortality, illness, retirement, leaving job, reduction of working hours, job change Demand: Migration, population growth, workforce to population ratio	During an eight-step process using a benchmark, this study predicts the supply and demand of public health, environmental health, general practitioner, dentistry, pharmacy, nursing, and midwifery manpower in Ilam province of Iran.
Chung et al.[26]	South Korea	2010	30	Supply and demand; System dynamics	Supply: Physical time lag, workplace (urban/rural), graduates, admission to higher education Demand: Information time lag, economic conditions, growth of the health services industry, change in the size of hospitals and health organizations, decision-making factors	In a dynamic system modeling, this study predicts the supply and demand of nurses in South Korea.
Harper et al.[27]	England	2013	28	Supply and demand; Simulation	Supply: Current stock, graduates, change in policies and training programs by the government, staff recruitment costs, hours spent per person in the clinic Demand: Time spent per visit, the average number of visits per year, classification of diseases (by sex and age), service costs, age of health workers, classification of diseases	Using the scenario-based method, this study examines the supply, demand, and skill mix of the human resources of the dental team in England.

Author	Country	Year	STROBE score	Approaches	Components	Summary
Juraschek et al.[28]	United States	2011	30	Supply and demand; Linear regression	Supply: Choice of career, population growth, average of workforce to population Demand: Population changes, workforce to population ratio	Using regression, this study predicts the registered nurse shortage by examining supply and demand in the United States.
Koichubekov et al.[29]	Kazakhstan	2021	30	Supply and demand; System dynamics	Supply: Number of new hires, new graduates, current stock, emigration, immigration, an internal immigration, maternity and military leave, mortality, illness, job change Demand: Population changes, workforce to population ratio, level of service utilization, the prevalence of diseases	This research examines the supply and demand of general practitioners using dynamic system modeling in Kazakhstan.
Landry et al.[30]	United States	2016	31	Supply and demand	Supply: Graduates, people with licenses, international graduates, acceptance/rejection rate in receiving a license, attrition rate, full-time equivalent Demand: Population, demand rate, number of insured people	This research work examines the supply and demand of physiotherapists in the United States.
Leerapan et al.[31]	Thailand	2021	30	Supply and demand; System dynamics and simulation	Supply: Current stock, attrition rate, number of public and/or private employment positions, announced capacities or quotas Demand: Mortality rates, service costs, number of healthy and ill people, population, treatment duration, health literacy, quality of life, birth or mortality rate, service accessibility, demand rate, public or private employment positions, service costs, the standard number of workforce per services, staff salaries	Using system dynamics and scenario-based modeling, this study examines the supply and demand of physicians, nurses, pharmacists, medical technicians, physiotherapists, clinical psychologists, and public health practitioners in Thailand.
Oh et al.[32]	South Korea	2017	29	Supply and demand; Regression and simulation	Supply: Announced capacities or quotas, number of admissions or registrants in the field, acceptance/rejection rate in receiving the license, graduation rate, number of active and inactive people Demand: Staff salaries, age and sex of health workers, population change, level of service utilization or demand rate, change in services provided by health insurance	Using regression and mathematical formulation, and scenario-based method, the supply and demand of urologists are studied in South Korea.
Vanderby et al.[33]	Canada	2014	31	Supply and demand; System dynamics	Supply: Number or rate of registrants in the field, unemployed people, movement among age groups of health workers, study duration, student mobility during study years, number of unemployed, education dropout, job change, current stock, productivity Demand: Sex of population, number of services, per capita procedure rate by sex	Using system dynamics modeling, this research investigates the supply and demand of cardiac surgeons in Canada.

Author	Country	Year	STROBE score	Approaches	Components	Summary
Lodi et al.[34]	Italy	2016	30	Supply and demand; System dynamics	Supply: Number of admissions in the field, job change, age and sex of health workers, current stock, mortality, migration, number of graduates, students, movement between public and private sectors Demand: Age and sex of health workers, age and sex of population, population change, workforce to population ratio, level of service utilization, the standard number of workforce per services	Using the system dynamics method, this research probes the supply and demand of medical specialties in Italy.
Nooney et al.[35]	United States	2007	28	Supply and demand	Supply: Age and sex of health workers, movement among age groups of health workers, new graduates, immigration, emigration, internal migration, mortality, retirement, disability, admission to higher education Demand: People's income level, staff salaries, age of the population, population change, level of service utilization, full-time equivalent, race, economic condition, insured people	This research investigates the supply and demand of registered nurses, licensed practical nurses, and nursing assistants in the United States.
Fakhri et al.[36]	Iran	2014	29	Need-, demand-, and target-based; Combined formula	Demand, need, target: Need coefficient, service coverage, number of services and workload, activity standard, available working time per year	This study presents a combined formula for calculating family health staff based on the need-, demand-, and target-based approaches in Iran.
Gailey et al.[37]	Saudi Arabia		32	Need	Need: Prevalence of diseases, population, service coverage, cost-effective interventions	Using a need-based model, this study predicts the needs of the population, cost-effective services, delivery models, and the productivity of the nursing workforce in Saudi Arabia.
Tomblin Murphy et al.[38]	Canada	2012	31	Supply and need; Regression and Scenario-based	Supply: Rate of admissions in the field, job change, age and sex of health workers, current stock, new graduates, study duration, retirement, mortality, job change, rate of active persons, activity rate, participation rate, attrition rate, productivity, registration rate in the field, salary level, creation of collaborative networks, dialogue between employees and staffs, absence from work Need: Age and sex of health workers and patient population, prevalence or incidence of disease, service delivery level, income, health status	Using regression and scenario-based methods, this study examines the supply and needs of registered nurses in Canada.

Author	Country	Year	STROBE score	Approaches	Components	Summary
Ghosh et al.[39]	England	2006	29	Demand; Artificial neural network	Demand: Number of the workforce and working hours per day, number of services and workload, standard activity, available working time per year, number of beds, bed occupancy rate, number of workforce per bed, time spent by the workforce per patient or time spent per visit, allowance factor	Using computer-assisted methods, this research predicts the demand for physicians in the UK.
Hooker et al.[40]	United States	2014	30	Supply	Supply: Employment rate, number of educational programs, number of graduates, not renewing the license, mortality, retirement, inactive persons, emigration	This research examines the supply of physician assistant labor using the stock-flow method in the United States.
Tjoa et al.[41]	Zambia	2010	31	Supply; Simulation	Supply: Employment rate, number of new hires, number of admissions in the field, graduation rate, students	This study investigates the supply of doctors, nurses, midwives, and clinical officers in Zambia in a scenario-based method.
Seo et al[42]	United States	2015	29	Demand; Regression	Demand: Staff salaries, number of illness days, labor market characteristics, time lag	Using logarithm and regression, this research assesses the demand for temporary agency nurses in the United States.
Azimi Naibi et al.[43]	Iran	2018	31	Demand; Workload indicator of staffing need	Demand: Workload, activity standard, available working time per year, category/ individual allowance factor, time spent by workforce per activity	Using the Workload indicators of staffing need method, the study examines the demand for emergency department nurses in Iran.
Sanaeifar et al.[44]	Iran	2021	30	Demand; Workload indicator of staffing need	Demand: Workload, activity standard, available working time per year, category/ individual allowance factor, time spent by workforce per activity	Using the workload indicators of the staffing need method, the study examines the demand for radiotherapist staff in Iran.

As presented in table 1, different HWFP approaches and methodologies have been used in different countries. The most commonly used in these studies were the mixed supply- and demand-based approaches (n=11, 55%),[25-35] and the least frequently used were the needs-based (n=3, 15%),[36-38] and target-based (n=1, 5%) approaches.[36] Only one study used the skill mix of HR for assessment.[27] One study used the artificial neural network WFP,[39] and another study explicitly stated the use of a benchmark to estimate demand.[25] In terms of analytical approaches, the most used approach was the system dynamics (n=5, 25%),[29, 31, 33, 34, 39] and the least frequently used the artificial neural network (n=1, 5%).[39] The main target populations in the included studies were nurses (n=9, 45%) and general practitioners (n=5, 25%).

Supply-Based Approach

Of the included studies, supply was assessed in 14 studies,[25-35, 38, 40, 41] from which 42 components used for modeling, forecasting, and estimation were extracted. The components were current stock, number of students, employment issues, choice of career, training capacity; study duration, student mobility during study years, new graduates and graduation rates, immigration, internal migration (e.g. transfer from one city to another or from one medical center to another); transfer from public to private sector, change of policies and training programs by the government, staff recruitment costs, hours spent per person in the clinic, number of inactive people; number and rate of active people, issues related to license (board), population growth, reduction of working hours,

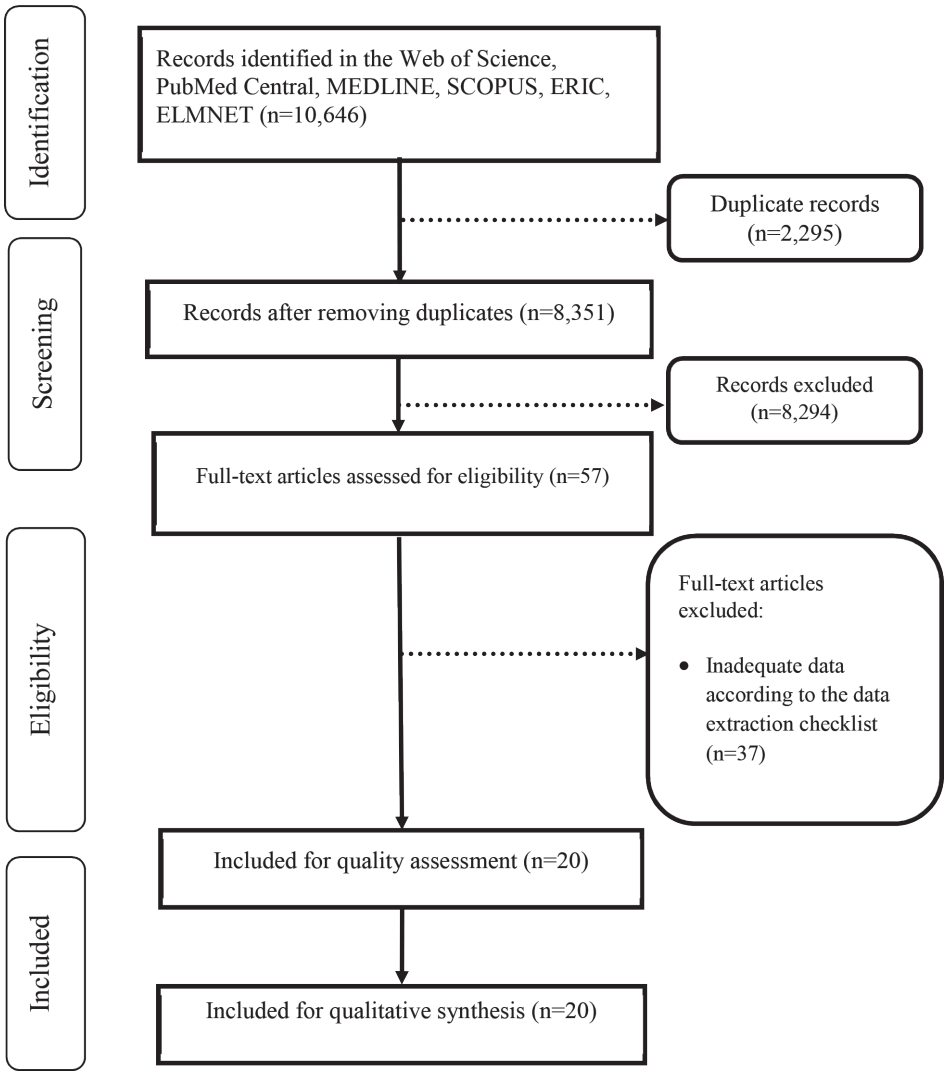

Figure 1: The flow diagram depicts the selection process of studies in accordance with the PRISMA guidelines.

education dropout; job change, admission to higher education, mortality, illness, disability, retirement; emigration, average workforce to patient, workforce per service ratio, maternity leave, military service; attrition rate, full-time equivalent, target number of employees, average working hours per workforce (activity rate), average level of services provided per hour of work (participation rate); salary level, creation of collaborative networks, dialogue between employees and staffs, absence from work, productivity, physical time lag, and workplace (urban/rural).

Employment issues include employment rate,[40, 41] number of new hires,[29, 32] and number of public and/or private employment positions.[31] Training capacity includes the announced capacities or quotas,[31, 32] number or rate of admissions or registrants in the field,[32-34, 38, 41] and number of educational programs.[40] Internal migration includes people who are native to a country, but study at universities abroad and return to their home country after graduation and foreigners who enter the country and occupy a job position (non-native). Inactive in the specialized field includes unemployed people,[31] job change,[25, 34, 38] and people who have not been employed in their field of study for any reason.[27, 35] Moreover, issues related to licensing that affected the supply include not renewing the license,[40] and the acceptance/rejection rate in receiving the license.[32]

In several studies, the age and sex of health workers,[34, 35, 38] population,[38] and movements among age groups of health workers[33, 35] were considered. Of these, the most frequent components in supply-based modeling included graduates, current stock, emigration, training capacity, mortality, and retirement.

Demand-Based Approach

Of the included studies, demand was

assessed in 16 studies,[25-36, 39, 42-44] from which 32 components used for modeling, forecasting, and estimation were extracted. The components were population changes, a workforce to population ratio, the number of insured people, the standard number of workforce per service, information time lag; economic issues, growth of the health service industry, change in the size of hospitals and health organizations, decision-making factors, need coefficient; the number of services and workload, activity standard, available working time per year, number of the workforce working hours per day, service coverage; the number of beds, bed occupancy rate, number of workforce per bed, time spent by the workforce per patient or time spent per visit or activity; the average number of visits per year, allowance factor, level of service utilization or demand rate, the prevalence of diseases, change in services provided by health insurance, number of healthy and ill people; treatment duration or sickness absence in days, health literacy, quality of life, service accessibility, per capita procedure rate by sex, labor market characteristics, and race.

The population changes include birth and mortality rates,[31] economic issues including economic conditions,[26, 35] people's income level,[35] service costs,[31] and staff salaries.[31, 32, 35] Workload refers to the number of activities that each workforce can perform per unit of time, and activity standard refers to the time required to perform a standard activity by a fully trained person in the workplace. Moreover, available working time per year is equal to the number of days a person works per week multiplied by the number of weeks in a year, minus the number of days of voluntary and compulsory absences from work.

There are two types of allowance factors, namely the category of allowance factor (CAF) and individual allowance factor (IAF). CAF is a coefficient used to calculate the number of health workers required for health care services and support activities. IAF is the number of personnel required to perform additional activities.[45] Other factors used in some other studies to estimate demand were the classification of diseases and treatments,[27] classifications of age,[27, 32, 34] and sex[32, 34] of health workers, and the age[34, 35] and sex of the population.[33, 34] Among these, the most frequently used components were population changes, level of service utilization or demand rate, and the number of services or workload of activities.

Needs-Based Approach

Three studies examined needs assessment models,[36-38] from which 11 components used for modeling, forecasting, and estimation were extracted. The components were need coefficient, population, number of services, activity standard, available working time per year, service coverage, prevalence or incidence of disease, cost-effective interventions, income, service delivery level, and health status. Among these, the most common were population, number of services, and prevalence of diseases. In the models developed by Tomblin Murphy and colleagues, an assessment of needs was made based on the age group and sex of the health workers, as well as the patient population.[38]

Target-Based Approach

One study used the target-based approach,[36] extracting six components that were used for modeling, forecasting, and estimation. The components were the needs coefficient, size of the target population, number of services to be provided annually to each person, activity standard, available working time per year, and service coverage.

Discussion

In a systematic review, 20 studies published in English and Persian between 2004 and 2021 were reviewed. Components and approaches of WHFP models were identified. The forecasting approaches used in these models were conceptual with four components (supply, needs, demand, and target), and analytical with five components (system dynamics, simulation, regression, WISN, and artificial neural network). In one study, a benchmark was explicitly used to estimate demand.[25]

The results showed that HWFP models contain many unique components. The diversity of these components depends on the approach and context modeling used. The variety of components in the models confirms the fact that each country faces its own issues and conditions for HWFP. Each of these models is designed in a specific time and place, and thus may not apply to other communities with different conditions. Predicting the future workforce in the health sector depends on the choice of a forecasting method. The appropriateness of the prediction approach depends on the variables such as the characteristics of the target population, time period, factors affecting change in care over time, funding of the health financial system, and changes in workforce productivity.[14] Other variables include socioeconomic status,[15, 16] level of education,[17, 18] age and sex distribution, ethnicity distribution,[19, 20] population age structure, and type of health care and treatment.[13]

The education system, health policies, health literacy, and many other factors that are country- and context-specific must be taken into account. Therefore, the available models are not fully applicable in the context of every country, including Iran.

The diversity in the available models is indicative of the lack of a comprehensive and universally accepted approach. Most models tend to use common approaches to supply and simply replace the factor "people" with the "subject of interest". Furthermore, it is clear that most forecasting models tend to predict the demand for services based on population growth rather than needs. Our results showed that only three studies used the needs-based approach, and those conducted in Iran did not use this approach at all. Tomblin Murphy and colleagues stated that the word "needs" is often used interchangeably with other words such as "demand" and even "use",[46] and it is, therefore, difficult to compare unique forecasting models developed with different default values and methods.[47] The needs-based approach to HWFP, especially if evidence-based, is an area of innovation.[48]

Most of the forecasting models do not include the dynamic relationship between components,[49, 50] for which the use of system dynamics modeling is most appropriate.[51] On the other hand, the impact of different decisions and policies on HWFP can be predicted using simulation.[39] Therefore, a combination of system dynamics modeling and simulation systems can provide the best results. Regression, one of the components of the analytical forecasting approach, allows the estimation of the effect of different parameters and their impact on the supply, demand, and needs of health care professionals.[6] However, regression methods do not manage sensitivity analysis.[52]

The main limitation of this study was the exclusion of articles in other languages than Persian and English. Therefore, their data and findings are not included in our systematic review.

Conclusion

Different approaches are used in health workforce planning models, each with specific strengths and weaknesses. Depending on the context, the use of the most appropriate model or a combination of models is recommended. Given that each model contains context-specific components, the inclusion or exclusion of a component has a significant impact on the forecasting accuracy and power of the HWFP model used. On the other hand, HWFP should be based on context and evidence. It is strongly recommended to include the specific conditions and context of a country when using a HWFP model. In the case of Iran, inclusion of socioeconomic status, epidemiological situation, goals of the health system, and the actual needs of health services is recommended.

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Authors' Contribution

All authors were fully or partially involved in the study concept, design, data acquisition/interpretation/analysis, and draft version/critical review of the manuscript. The authors have read and approved the final manuscript and agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

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