

Analysis of Medical Specialists Graduated in Mexico from 2012 to 2018. National Study

Análisis de los médicos especialistas egresados en México durante el periodo de 2012 a 2018. Estudio Nacional

Gerhard Heinze,* Diana Guízar-Sánchez,** Napoleón Bernard-Fuentes.*

Summary

Objective: to analyze the educational quality of graduates through the following academic indicators: a. Occupational mobility, b. Number and type of scientific publications, c. Publication of chapters or medical literature, d. Postgraduate studies, and e. Certification by the corresponding specialty board.

Method: descriptive cross-sectional study. Different databases were reviewed, the following stand out: 1. List of graduates. 2. Registry of the different specialties; National Regulatory Committee of Medical Specialties Councils to know both the certification status, and in the General Management of Professions, belonging to the Ministry of Public Education, the professional certificate status. 3. Index of journal authors (PubMed, Embase, Medline), 4. Databases of medical insurance and health institutions in Mexico and 5. Databases of Postgraduate Degrees in Medicine

Results: The academic indicators of 14,770 medical specialists who graduated from the Sub-direction of Medical Specialties of the UNAM in the last six years were analyzed. The trajectory of the graduates shows a gradual increase in the percentage of board certifications, number of published articles, and post-graduate courses. Nearly 60% of the specialists work in Mexico's three largest cities. **Conclusion:** the number of graduated specialists is insufficient in quantity and distribution to cover the health needs of the country. Despite the increase in scientific production, there is still a need to increase the number of research projects, and scientific publications by graduates. It is necessary to rethink medical specialty programs in accordance with health care needs, and the international context.

Keywords: Mexico; Medical Education, Graduates, Medical Specialties, Certification

*Subdivisión de Especialidades Médicas (SEM), División de Estudios de Posgrado, Facultad de Medicina, UNAM, Ciudad de México, México.

**Laboratorio de Ciencias del Aprendizaje, Departamento de Fisiología, Facultad de Medicina, UNAM, Ciudad de México, México.

Received: 10/02/2022
Accepted: 08/08/2022

Suggestion of quotation: Heinze G, Guízar-Sánchez D, Bernard-Fuentes. Analysis of Medical Specialists Graduated in Mexico from 2012 to 2018. National Study. Aten Fam. 2023;30(1):39-46. <http://dx.doi.org/10.22201/fm.14058871p.2023.1.83859>

This is an open access article under the CC BY-NC-ND license (<http://creativecommons.org/licenses/by-nc-nd/4.0/>).

Correspondence:
Diana Guízar-Sánchez
guizar.diana@gmail.com

Resumen

Objetivo: analizar la calidad educativa de los egresados mediante los siguientes indicadores académicos: a. Movilidad ocupacional, b. Número y tipo de publicaciones científicas, c. Publicación de capítulos o literatura médica, d. Estudios de posgrado y e. Certificación por el consejo de la especialidad correspondiente. **Método:** estudio transversal descriptivo. Se revisaron diferentes bases de datos entre las que destacan: 1. Lista de egresados 2. Registro de las diversas especialidades; Comité Nacional Normativo de Consejos de Especialidades Médicas para conocer el estado de la certificación y en la Dirección General de Profesiones, perteneciente a la Secretaría de Educación Pública, para conocer el estado del certificado profesional. 3. Índice de autores de revistas (PUBMED, EMBASE, MEDLINE), 4. Bases de datos de seguros médicos e instituciones de salud de la República Mexicana y 5. Bases de datos de posgrados en medicina. **Resultados:** se analizaron los indicadores académicos de 14,770 médicos especialistas egresados de la Subdirección de Especialidades Médicas de la UNAM en los últimos seis años. La trayectoria de los egresados muestra un incremento paulatino en el porcentaje de certificaciones del consejo, número de artículos publicados y cursos de posgrado. Alrededor de 60% de todos los especialistas trabaja en las tres ciudades más grandes de México. **Conclusión:** el número de especialistas graduados es insuficiente en cantidad y distribución para cubrir las necesidades de salud del país. A pesar del aumento en la producción científica, aún persiste la necesidad de incrementar la realización de proyectos de investigación y publicación científica de los egresados. Es necesario replantear los programas

de especialidad médica de acuerdo con las necesidades de atención a la salud y al contexto internacional.

Palabras clave: México, educación médica, egresados, especialidades médicas, certificación

Introduction

Human resources are one of the essential pillars of the health care system. The responsiveness, performance, and benefits this system can offer depend, to a large extent, on the knowledge, skills, and motivation of the people responsible for providing health services; such is the case of general practitioners and, of course, of specialist physicians.¹ The quality of training programs for physicians in general, and specialists in particular, has been a growing concern in recent years in various countries, including Mexico.^{2,3}

Nowadays, the training of good medical specialists is more complex, not only because of the enormous advances in knowledge related to medicine and health, the large amount of scientific information published daily, and the number of technologies available to prevent, diagnose, and repair damage to health, but also because of the way in which all these factors have changed and continue to change societies in which medical specialists will provide their services.⁴⁻⁶ In this context, in which globalization and the valid demand of society to receive quality services in the attention to their health problems stand out, the School of Medicine of the National Autonomous University of Mexico (UNAM) faces new challenges in the fulfillment of its educational mission and assumes the responsibility to ensure that its plans and programs of postgradu-

ate medical studies are kept up to date to meet the purpose of responding to the new and foreseeable educational demands.^{5,6}

The UNAM's Graduate Studies Division (DEP) offers the largest number of specialization programs in Mexico (78 out of 81 specialty programs), and has the largest number of students enrolled (11,366 out of 26,789 specialty students).⁵⁻⁷ Medical specialties are governed under the Single Plan of Medical Specialties (PUEM). This curricular plan, organized in a functional conceptual construction, is intended to lead medical educational actions, socially and culturally considered as valuable and professionally efficient; its design has been the result of discernment actions that establish various commitments agreed upon by the School of Medicine, health institutions, and Mexican specialists councils, it implies a free exercise to clearly define the purposes to which academic action should be oriented, and to specify the best resources and strategies to achieve them.^{5,6}

Society demands that human resource training institutions guarantee the quality of their graduates. For this purpose, mechanisms have been established for the accreditation and evaluation of medical schools or faculties, and the certification of general practitioners and specialists.⁷⁻⁹ It is known that in addition to the accreditation, evaluation and certification processes, an indispensable factor for improving the quality of graduates are the studies of their careers and their follow-up; these studies provide an objective view of the training of physicians achievements and failures, and are basic tools for feedback and redesign of medical curricula and academic programs.

At present, the performance of three substantive professional functions can be distinguished in a high-quality medical practice: the provision of quality medical care, the development of research, and the educational activities.⁵ These three functions, around which the PUEM is organized, guided the present study.

In Mexico, during the period in which this research was conducted, there was a lack of follow-up studies of graduates of medical specialties, so the present work aims to analyze the educational quality of physicians graduated in medical specialization from the Faculty of Medicine of the UNAM, in Mexico, from 2012 to 2018, by measuring indicators such as: a. Validity of certification by the corresponding specialty board, b. Number of scientific publications in indexed journals, c. Publication of chapters or medical literature, d. Postgraduate studies completed (master's, doctorate or postgraduate high specialty in medicine - PAEM) and e. Geographical location where they practice their professional activity.

Methods

Descriptive cross-sectional study. Through a review of the databases of various organizations, among which the following stand out:

1. List of graduates from 2007 to 2017.
2. Registration of the various specialties in the National Regulatory Committee of Medical Specialty Councils (CONACEM), to know the certification status, and in the General Management of Professions belonging to the Ministry of Public Education (SEP) to know the professional license status.
3. Index of journal authors (PUBMED, EMBASE, MEDLINE) and list of authors of the virtual medical library of the UNAM.

4. Databases of postgraduate (master's and doctoral) degrees in medicine.

This research was approved by the Research and Ethics Committee of the UNAM.

Results

The academic indicators of 14,770 medical specialists graduated from the Sub-direction of Medical Specialties of the UNAM in the last six years were analyzed.

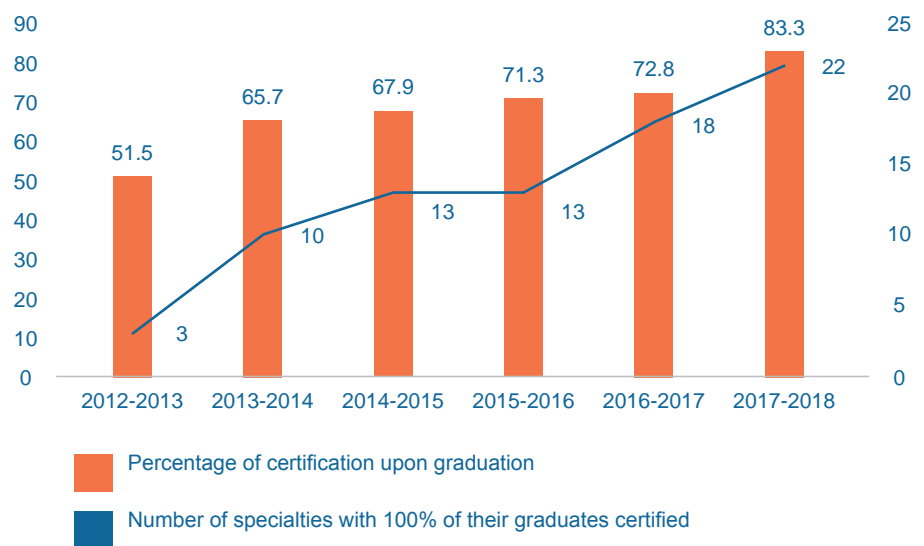
A. Certification of the graduates of the UNAM Subdivision of Medical Specialties by the corresponding specialty board.

In Mexico, CONACEM is the auxiliary organization of the Federal Public Administration in charge of supervising the knowledge, abilities, skills, aptitudes and qualification of expertise required for certification in the different medical specialties. It is composed of the National

Academy of Medicine of Mexico, the Mexican Academy of Surgery, and 47 medical specialty councils (with 118 chapters).¹⁰ Figure 1 shows the percentage of certification at graduation by the corresponding specialty council, as well as the number of medical specialties with 100% of their certified graduates. Figure 1 shows a 31.8% increase of graduates with current certification upon graduation from the Division of Postgraduate Studies of the UNAM School of Medicine between 2012 to 2018. At the same time, the number of medical specialties with 100% of their graduates certified upon completion of the specialty has increased more than seven times.

It is important to highlight that, from the 2012 generation to the one graduated in 2018, the specialties of Audiology, Otoneurology, and Phoniatics 100% of their graduates are currently certified.

Figure 1. Certification of Graduates of the Subdivision of Medical Specialties of the UNAM by the Corresponding Specialty Board



B. Scientific Articles in Indexed Journals and Chapters in Medical Books Published by Graduates of the Subdivision of Medical Specialties of the UNAM.

Scientific publications, for graduate medical specialists, are a source of knowledge that allows improving treatments, making evidence-based medicine and the disseminating clinical and technological advances. In Mexico, the main organization in charge of regularizing scientific publications is the National Council of Science and Technology (Conacyt); up to 2013, it is reported that our country publishes 17,662 scientific articles per year, being the second place in Latin America after Brazil and 28 worldwide. The world literature records that only twenty countries, with 10,051 publications in five years, are competing for high impact journals, the United States is in the first place.^{11,12}

The decision to continue with medical education through a medical specialization shows interest in acquiring more knowledge and skills; as an institution of higher education, it is interesting to see if part of this acquired knowledge is reflected, in addition to the specialization of knowledge, in critical thinking based on evidence that translates into scientific publications in indexed journals. Figure 2A shows the number of indexed publications at the year of graduation from the medical specialty, as well as the number of publications up to 2019 for the generations from 2012 to 2018. Figure 2B shows the number of medical book chapters published at the year of graduation from the medical specialty, as well as the number of medical book chapters published up to 2019 by the generations from 2012 to 2018. Period shows a 20% increase in the number of chapters at the year of graduation from

Figure 2A. Publications in indexed scientific journals by graduates of the UNAM Medical Specializations Branch

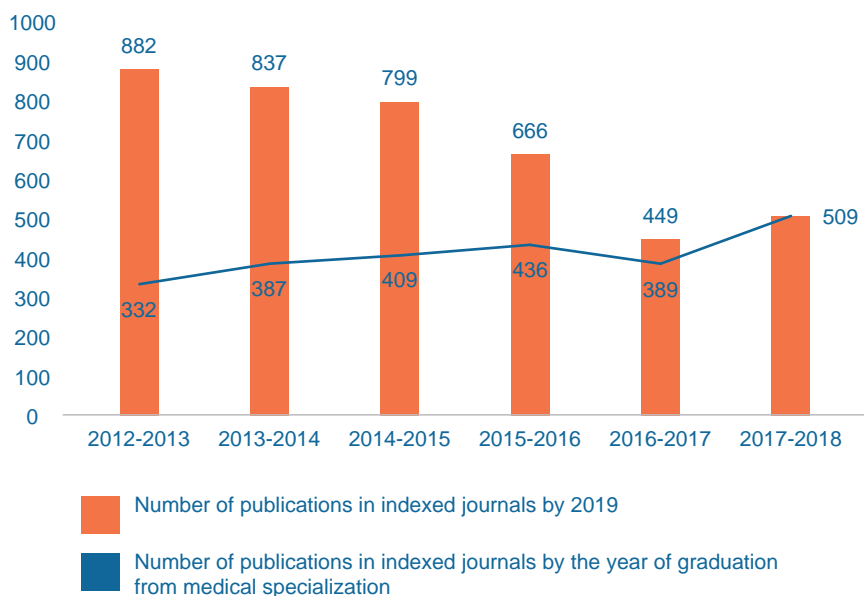
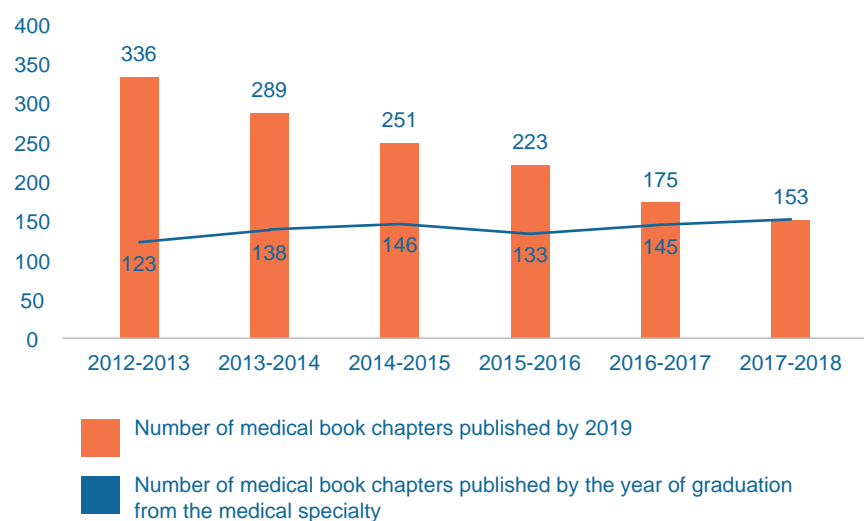


Figure 2B. Chapters of medical books published by graduates of the UNAM Medical Specializations Branch



the medical specialty, while documenting the continuity in the production of scientific articles and medical literature by graduates of other generations.

Table 1 illustrates the medical specialties and hospitals with the highest number of book chapters and articles published in indexed scientific journals. It is noted that Critical Medicine and Neurosurgery have significantly increased their production of scientific articles, while Psychiatry and Urology have increased their production of medical literature chapters in the last three years.

C. Postgraduate Studies Completed (Master's, Doctorate or Postgraduate Studies of High Specialty in Medicine - PAEM) By Graduates of the Subdivision of Medical Specialties of the UNAM.

Figure 3 shows the number of medical specialists with another postgraduate course at the end of their training, as well as the total number of graduates with other postgraduate studies completed up to 2019, for the generations from 2012 to 2018. It is important to note that around 80% of the postgraduate degrees belong to PAEM, followed by master's and doctoral degrees in Medical, Dental, and Health Sciences.

D. Geographical Location where Graduates of the Subdivision of Medical Specialties of the UNAM Practice their Professional Activity.

On table 2, 54.3% of the graduated medical specialists practice their professional activity in four states: Mexico City, Jalisco, State of Mexico and Nuevo Leon. In contrast, nine states have less than 1% of graduates: Aguascalientes, Baja California Sur, Campeche, Colima, Guerrero, Nayarit, Tlaxcala, Quintana Roo, and Zacatecas.

Table 1. Specialties and clinical sites with the highest number of book chapters and articles published in indexed scientific journals

Specialties with the highest number of articles published in indexed journals*	Anesthesiology, Cardiology, General Surgery, Plastic and Reconstructive Surgery, Dermatology, Gynecology and Obstetrics, Internal Medicine, Ophthalmology, Medical Oncology and Pediatrics
Hospitals with the highest number of publications*	Dermatological Center "Dr. Ladislao Pascua", ABC Medical Center, National Medical Center "Siglo XXI", Médica Sur Clinic Foundation, General Hospital "Dr. Eduardo Liceaga", Federico Gómez Children's Hospital of Mexico, National Institute of Cardiology "Dr. Ignacio Chávez", National Institute of Medical Sciences and Nutrition "Dr. Salvador Zubirán", National Institute of Neurology, Neurosurgery "Manuel Velasco Suárez", National Institute of Pediatrics, and the Conde de Valenciana Ophthalmology Institute Foundation.
Specialties with the highest number of publications*.	Cardiology, General Surgery, Critical Medicine, Internal Medicine, Neurosurgery, Pediatric Neurology, Ophthalmology and Medical Oncology.
Hospitals with the highest number of published book chapters*.	ABC Medical Center, National Medical Center "Siglo XXI", National Medical Center "20 de Noviembre", General Hospital "Dr. Manuel Gea González", General Hospital "Dr. Eduardo Liceaga", Federico Gómez Children's Hospital of Mexico, National Institute of Cardiology "Dr. Ignacio Chávez", National Institute of Medical Sciences and Nutrition "Dr. Salvador Zubirán", National Institute of Neurology, Neurosurgery "Manuel Velasco Suárez", and the National Institute of Pediatrics.

*Alphabetical order

Figure 3. Postgraduate studies completed (master's, doctorate or postgraduate degree in medicine - PAEM)

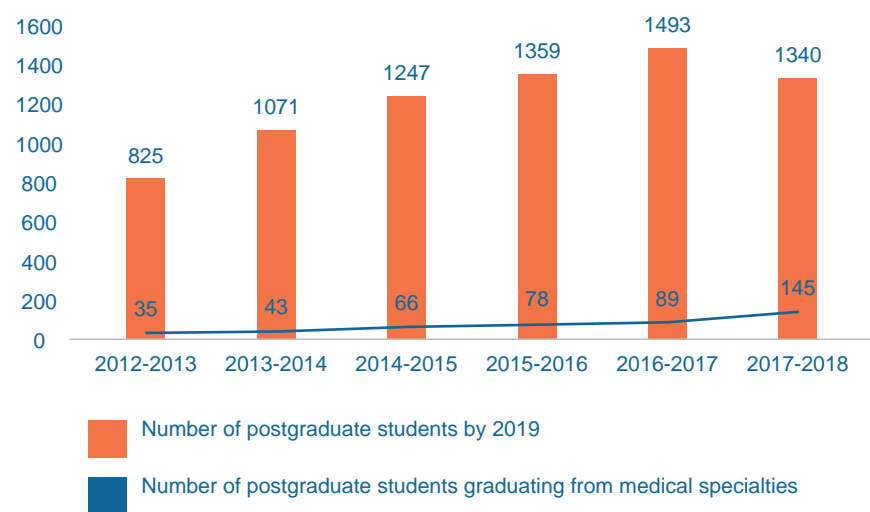


Table 2. Geographical location where graduates of the UNAM's Medical Specialties Sub-Directorate practice their medical specialties

State	Number of Specialists	%
Mexico City	4452	30.1
Jalisco	1390	9.4
State of Mexico	1197	8.1
Nuevo Leon	989	6.7
Puebla	543	3.7
Veracruz	525	3.6
Guanajuato	494	3.3
Baja California	362	2.5
Michoacan	329	2.2
Chihuahua	328	2.2
Tamaulipas	323	2.2
San Luis Potosi	311	2.1
Yucatan	294	2
Coahuila	284	1.9
Sonora	282	1.9
Sinaloa	282	1.9
Oaxaca	262	1.8
Queretaro	249	1.7
Hidalgo	218	1.5
Chiapas	194	1.3
Tabasco	191	1.3
Morelos	185	1.3
Durango	178	1.2
Aguascalientes	144	1
Guerrero	144	1
Quintana Roo	124	0.8
Nayarit	112	0.8
Zacatecas	91	0.6
Campeche	84	0.6
Baja California Sur	76	0.5
Tlaxcala	69	0.5
Colima	64	0.4
Total	14770	100

Discussion

Postgraduate courses offer the possibility of perfecting the skills developed during training in a higher education institution, promoting research activities, updating the theoretical contents acquired in the undergraduate program, and specialization of knowledge.

In the current national health system, postgraduate medical specialization courses arise from the need and interest of a general practitioner to broaden his or her professional development with theoretical, technical, and methodological knowledge, as well as skills and values, on a specific area of medicine.¹³

According to the OECD (Organization for Economic Cooperation and Development), in the United States, up to 88% of general practitioners will study a medical specialty, this percentage decreases to 35% in Mexico. For this reason, it must be guaranteed that higher education institutions graduate the personnel that both the population, and health services require; therefore, it is essential to determine the academic quality of the people to be trained and the orientation that such training should have to adjust to institutional requirements, and population changes.

The Division of Graduate Studies at the UNAM, an area of medical specialist training, is the largest in the country and probably one of the largest in the world. In 2018 alone, 11,366 residents were enrolled in this program at one of the 151 sites in the metropolitan area, and in the different states of Mexico. One third of the incoming students come from the UNAM, while more than two thirds come from other medical schools and faculties, both in the country and abroad. It is a national postgraduate program because students from all Mexico are enrolled,⁴ so

it is of great interest to know the trajectory of its graduates. Among the teaching purposes of the specialties included in the PUEM are:

1. To train the student in the mastery knowledge, methods, and preventive, diagnostic, therapeutic, and rehabilitation techniques in the health case-problem, in their area of study. An indirect external evaluator of the previous point corresponds to the CONACEM and the different councils of each specialty, who, as in the United States, and Canada perform once or twice a year, depending on the Council, the certification of the different specialties; which is understood as the accreditation performed by specialists of similar training to that of the evaluated of recognized academic, clinical, and research prestige at the national level; it is used as a measure of the professional competencies of the subject in the practice of the specialty, regardless of the training institution or their job location.¹⁴ From 2012 to 2018, there has been an increase of 31.8% in the number of graduates of the Subdivision of Medical Specialties with current certification immediately after graduation (51.5% to 83.3%). At the same time, the number of medical specialties with 100% of their graduates certified upon completion of the specialty has increased more than seven times (from three to 22 specialties). Eight years after certification became mandatory, not all physicians who graduate from residency training are certified.

2. To provide the student with the institutional conditions that allow him/her to enter into the rigorous process of medical research in his/her specialization. Research is an important component during the training of the medical specialist. Its practice allows the

development of critical appraisal skills for scientific articles, the promotion of critical thinking and continuous learning, and greater satisfaction with their academic training.¹⁵⁻¹⁸ The percentage of residents who have published an article varies according to the country, and the studied residency site, with differences as wide as 5% to 21% between North American residents who have not and have done a research rotation, respectively, to proportions such as 59.2% in the same country.^{18,19} In the Subdivision of Medical Specialties and in different clinical sites, strategies have been designed to promote research during residency, some of which have had results in terms of:

A. Scientific production. From 2012 to 2018, the 34.7% increase of publications in indexed journals, in the year of graduation from the medical specialty, (from 332 to 509) stands out.

B. Prestige of the academic programs where residencies have been carried out. The SEP, in coordination with the Conacyt, based on institutional and program quality, has implemented the National Quality Graduate Program (PNPC), one of the policies of the graduate program is to increase the largest number of Educational Institutions to participate in the program, and to promote good practices in training at this educational level, according to international trends and policies. Currently, the Subdivision has 81 courses enrolled in the Program.

However, the world literature reports 0.8 publications per month and Mexico does not appear in this heading;¹² in the specific case of our graduates, a minimal part has a scientific publication upon graduation. In this regard, among the factors studied: having completed the higher years of residency, and having

done an external rotation outside the country are variables associated with having published a scientific article, so it is necessary to implement strategies to improve and increase publications.

3. Encourage the generation and analysis of medical literature pertaining to their specialized field. In the same period of time, there was a 20% increase in the number of book chapters published in the year of graduation from the medical specialty (123 to 153), while the continuity in the production of medical literature by graduates of other generations is documented. However, as with scientific publications, an analysis of the factors involved in the low production of medical literature among graduates is required in the search for areas of opportunity in the implementation of improvement strategies.

4. Continuous updating of medical graduates. To this end, master's and doctoral programs offered by PAEM provide higher education in, either, a discipline or interdisciplinary area, deepening training in theoretical, technological and professional development for research, study, and specialized training. More than 80% of graduates of a medical specialty took another postgraduate course within one year of graduation.

Similarly, a review of the geographic distribution of graduate medical specialists reveals significant inequality and inequity among the country's states; this is consistent with what has been reported in other parts of the world,²⁰ where a greater concentration of specialists is reported in a few large cities, in contrast with cities with hundreds of thousands of inhabitants and entire states with no or very poor coverage. The 2018 school workforce was mostly

concentrated in Mexico City (10,051 out of 11,366). Therefore, an adequate planning of medical residency positions is required, which does not necessarily imply increasing positions in the existing sites but opening new specialty sites in the different states of the country, in support of a more efficient and equitable allocation of work positions.

We could say that the limitations of this study lie in the availability of data. Only the graduate medical specialists for whom information was available in one of the many databases could be counted and located.

The present study allows us for the first time to have an overview of: a) occupational mobility, b) number and type of scientific publications, c) publication of chapters or medical literature, d) post-graduate studies in progress (master's, doctorate, or high specialty course in medicine) and e) validity of the certification by the corresponding specialty board, of the graduates of the largest medical specialist training program in the country.

Conclusion

Productivity in the research area is one of the elements of a multifactorial process that programs take into account when evaluating graduates. To our knowledge, there has been no analysis of raw data related to academic indicators at the time of graduation of medical specialists in Mexico; we consider that this study allows the identification of significant variables related to better performance at the end of training in a medical specialty. Based on the obtained information, the development and implementation of educational policies that improve the quality of medical training in our country can be encouraged.

Authors' contributions

D G-S, GH: conceptualization, development and writing; D G-S, N B-F: data analysis; D G-S, GH, N B-F conceptualization, analysis and discussion of results, and writing. All authors approve the publication of this paper.

Funding

This research did not receive external funding.

Conflicts of Interest

The authors declare not having conflicts of interest.

References

1. World Health Organization: World Health Report. Health Systems: Improving Performance [Internet]. [cited 2019 Jun 18]. Available from: <http://www.who.int.proxy.lib.uwo.ca:2048/whr/2000/en/whr00ch4en.pdf>
2. Cedillo-Pozos A, Mendoza-Aguilar AN, Roldan-Valadez E. Comparison between Mexican and International Medical Graduates' scores obtained in the ENARM competing for surgical specialties in Mexico during 2012-2019: data visualization, trend and forecasting analyses. *Cir Cir*. 2021;89(1):22-32.
3. Organización Panamericana de la Salud, Organización Mundial de la Salud. 2015. Situación de Salud en las Américas, Indicadores Básicos. Washington: Pan American Health Organization.
4. Heinze-Martin G, Olmedo-Canchola VH, Bazán-Miranda G, Bernard-Fuentes NA, Guízar-Sánchez DP. Los médicos especialistas en México. *Gac Med Mex*. 2018;154(3):342-351.
5. Fajardo DG, Santacruz VJ, Lavalle MC. La formación de médicos especialistas en México. Documento de postura. México: Academia Nacional de Medicina; 2015.
6. Sistema Integral de la División de Estudios de Posgrado de la Facultad de Medicina [Internet]. [cited 2021 Jun 18]. Available from: <http://www.sidep.fmposgrado.unam.mx:8080/SIDEP/#no-back-button>
7. Comisión Interinstitucional para la formación de Recursos Humanos para la Salud [Internet]. [cited 2019 Jun 18]. Available from: http://www.cifrh.s.gob.mx/site1/enarm/reportes_00.html
8. Consejo Mexicano para la Acreditación de la Educación Médica, A. C. [Internet]. [cited 2019 Jun 18]. Available from: <http://www.comaem.org.mx/acreditación.html>
9. ANUIES. Anuarios estadísticos 2004-2007 [Internet]. [cited 2019 Jun 18]. Available from: http://www.anuies.mx/servicios/e_educacion/index2.php

10. Comité Normativo Nacional de Consejos de Especialidades Médicas CONACEM [Internet]. [cited 2019 May 8]. Available from: <https://conacem.org.mx/>
11. Consejo Nacional de Ciencia y Tecnología (CONACYT) [Internet]. [cited 2019 May 8]. Available from: Disponible en: <http://www.conacyt.gob.mx/index.php/el-conacyt>
12. Van Noorden, R. Open access: The true cost of science publishing. *Nature*. 2013;495:426-429.
13. Rodríguez WFL, Ramírez AJL. ¿Tenemos claro lo que es la residencia médica? *Acta Med*. 2016;14(3):183-184.
14. Fernández-Ortega MÁ, Cuevas M, Aldrete-Velasco JA, Barrell AE. Convergencia de procesos de certificación y recertificación de especialistas en Estados Unidos y México. *Med Int Mex*. 2016;32(3):263-269.
15. Valencia SJ, Vázquez PM, Leyva GF, Gómez CFJ, Gómez AGM. Análisis de los Cursos de Posgrado de Alta Especialidad en Medicina en México, respecto al contexto internacional. *Inv Ed Med*. 2019;8(32):112-120.
16. Valle R, Perales A. Nueva normativa de titulación en el residentado médico en el Perú: problemas y perspectivas. *Rev Perú Med Exp Salud Publica*. 2016;33(2):357-361.
17. Seaburg, LA, Wang AT, West CP, Reed DA, Halvorsen AJ, Engstler G, et al. Associations between resident physicians' publications and clinical performance during residency training. *BMC Med Educ*. 2016;16:22.
18. Edalatpour A, Nkana ZH, Bentz ML, Afifi AM. Academic Productivity in Plastic Surgery: A Comparison of US and International Medical Graduates. *J Craniofac Surg*. 2020;31(8):2136-2138.
19. Siegel N, Lopez J, Cho A, Lifchez SD. A Bibliometric Analysis of Research Productivity During Residency for 125 Hand Surgery Fellows. *J Surg Educ*. 2020;77(3):710-716.
20. Machado SR, Jayawardana S, Mossialos E, Vaduganathan M. Physician Density by Specialty Type in Urban and Rural Counties in the US, 2010 to 2017. *JAMA Netw Open*. 2021;4(1):e2033994.