COUNTRY REPORT

# Radiology in Mexico: A Country Report

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## Abstract

*Objective:* The state of radiology varies among countries. The purpose of this country report is to analyze the state of radiology in Mexico, how it has changed over the past several years, and how it compares to other countries.

*Materials and Methods:* A review was completed using the University at Buffalo (UB) catalog and database search, as well as a general Google search for articles regarding radiology in Mexico.

*Results:* While the state of radiology has improved over the past several years, the system in Mexico still lacks an adequate number of medical imaging units and an adequate number of radiologists. Both of these factors have contributed to the stagnant state of radiology in Mexico.

*Conclusion:* There are many factors contributing to the state of radiology in Mexico, including a high poverty percentage and low expenditure on healthcare. It is important to increase the number of medical imaging units throughout the country and replace the current aging scanners to help all patients.

## Introduction

Mexico is a Latin American country bordered to the north by the United States and to the south by Belize and Guatemala. It is the third largest country in Latin America and has a population of about 124 million people, the largest Spanish-speaking population worldwide. Mexico comprises 31 states and one federal district, Mexico City. Almost 80% of the population lives in urban areas. The total area of Mexico is approximately 1,960,000 km2 (760,000 square miles), which makes it the thirteenth largest country by area (1). As of 2019, the life expectancy of Mexican residents is 75 years (2), but only 7.4% of the population is aged 65 years or older. That percentage is lower than that of the other 38 member nations of the Organization for Economic Cooperation and Development (OECD), in which 17.3% of the population is aged 65 years or older (3).

Mexico gained independence from the Spanish empire in 1821. Revolutionary general Vicente Guerrero and army general Agustín de Iturbide (Augustine of Mexico) built a successful coalition that took control of the country and drafted a Mexican constitution. In 1822, Iturbide declared himself emperor, only to go into exile in Europe in May 1823. Upon his return to Mexico in 1824, he was arrested and executed. He is credited with designing the flag of Mexico. From 1823 to 1836, Antonio López de Santa Anna served as president of Mexico. He drafted a new constitution that governed a federal republic containing 19 states and four territories (4).

Mexico today has a much larger population and still many socioeconomic imbalances. Since 1994, the Zapatista Army of National Liberation, a militant group that controls a vast amount of territory in the state of Chiapas, has been in conflict with the Mexican state regarding land ownership, power distribution, and inequality. To make matters worse, drug trafficking continues to be a widespread problem in Mexico, affecting police and political corruption, inequality, and safety of the population (4).

In Mexico, there is an index categorizing socioeconomic status, referred to as "Niveles Socio Economicos" (Socioeconomic Levels Index), that places households into one of seven levels (Table 1). Factors affecting which level a household is placed in include:

1. Education level of the head of the household
2. Number of bedrooms
3. Number of bathrooms
4. Number of individuals age 14+ who are employed
5. Number of vehicles
6. Access to internet

The region with the greatest population of Level A/B citizens was Nuevo León (6).

The government powers are divided between the executive, legislative, and judicial branches. The legislative branch contains the Senate and Chamber of Deputies. Senators serve six-year terms while deputies serve three-year terms. Mexican presidents are elected to serve one, single six-year term, often referred to as 'sexenio' (1).

### Medical Environment

In 1999, the World Health Organization convened a meeting in Switzerland to address education and training for medical imaging throughout the world. One conclusion that emerged from this meeting was that the medical infrastructure in many countries in Latin America, including Mexico, is lacking because of the low level of funding for medical care. More populous areas have more advanced

**Figure 1. Map of Mexico**



equipment and technology and receive a larger portion of government funding. This is also true for medical training/education (including radiology). Well-equipped radiology departments have well-trained radiologists with more modern imaging technology. Mexico has the lowest supply of advanced technology equipment among the OECD nations (8).

### Disease burden

Ischemic heart disease remains the number one cause of death in the population. Diabetes is now the number two cause, with chronic kidney disease at number three. Over the past decade, there has been a substantial drop in the rate of neonatal disorders leading to death: between 2009 and 2019, records show a 38% drop in neonatal disorders causing death (9).

Obesity, one of the underlying causes of the high death rates due to heart disease and diabetes, remains higher in Mexico than the OECD average. In 2019, 75% of the population age 15+ in Mexico had a BMI ≥ 25. The average was 56% for other OECD nations (10).

In terms of acute illnesses, acute respiratory infections remain the most common cause of illness among the Mexican population. In 2019, almost 24 million people

**Table 1. Socioeconomic levels in Mexico.**

| Socioeconomic Levels Index | | |
|---|---|---|
| Socioeconomic Level | Description | Percent of Mexican Households at this level* |
| A-B | High Level | 6.8 |
| C+ | Medium-High Level | 10.8 |
| C | Medium Typical | 14.0 |
| C- | Middle Emerging Level | 15.4 |
| D+ | Typical Low Level | 15.2 |
| D | Extreme Low Level | 27.8 |
| E | Very Extreme Low Level | 10.0 |

*Data from 2020 (5,6).

were affected (11). While smoking rates have declined over the past decade, 8% of the population age 15+ are daily smokers (10). Intestinal illnesses were the second most common illness, contributing to 5 million cases in 2019 (11).

### Medical economy

The health care system of Mexico has three components: employment-based insurance, public assistance for uninsured citizens, and private insurance. Mexico's health spending accounted for 5.4% of the gross domestic product in 2019 and 6.2% in 2020, which is less than the 8.9% of the gross domestic product spent by other OECD countries (10). Public health care facilities account for almost 80% of all medical services across the nation; private institutions account for the remaining 20% (12).

### Workforce

The number of physicians in Mexico has risen to upwards of 300,000 as of 2019 (13). However, there is a low number of radiologists compared to the size of the overall population. There are approximately 4,000 radiologists at 7,000 medical facilities caring for the entire population. That averages to less than one radiologist per facility, which limits the imaging interpretation capacity. In the state of Chiapas, there is roughly one radiologist per 100,000 people, which is even lower than the average of three radiologists per 100,000 citizens for the country (14). There are still fewer than 200 interventional radiologists in the country (15). For this reason, teleradiology has grown substantially.

Mexico also has a low number of registered nurses, who are vital to the medical system. As of 2019, there were 2.3 nurses per 1,000 people in Mexico, whereas the average for the other OECD countries was 8.8 nurses per 1,000 people (16). Medical physicists also play a prominent role in radiology and radiation therapy. There are 133 healthcare centers in Mexico that employ medical physicists. 35 of these centers are located in densely populated regions. There are upwards of 250 medical physicists in the country (17). This is higher than all other Central American nations. For example, Costa Rica has 23 total medical physicists while Guatemala has 7 and Honduras has 3 (18). The average salary of medical physicists in Mexico is 47,597 Mexican pesos/month ($28,650/year) (19).

### Power supply

The Federal Electricity Commission of the government of Mexico controls electricity services. Most electricity is from thermal sources (75%), while renewable energy accounts for approximately 23%. Approximately 99% of the population has access to electricity, and subsidies are available to help cover the cost for residential and agricultural customers (20). Electricity costs are approximately 1.70 Pesos/kWh ($0.08/kWh) for households and 3.2 Pesos/kWh ($0.16/kWh) for businesses (21).

### Internet access

Approximately 70% of the population uses the internet. The average monthly cost of internet is approximately 300 to 800 pesos/mo ($15-$40/mo) (22). However, connection speeds are slower than the average in most other countries: the download speed is ~22 Mbps for mobile internet service and 35 Mbps for broadband connections (23).

## Radiology environment

### Equipment

According to data from the Social Security Institute of Mexico, much of the imaging technology is outdated (at least ten years old). For example, 58% of X-ray equipment, 27% of ultrasound equipment, and 59% of CT scanners have been in use for at least ten years (24). Furthermore, each unit is responsible for the care of a larger number of Mexicans relative to the number of units available for residents of other OECD nations (Table 2).

As of 2018, there were 50 total PET/CT scanners in Mexico. The World Health Organization recommends at least 2 PET/CT scanners per million inhabitants. According to the WHO's recommendation, therefore, Mexico should have at least 240 units (25). The number of imaging units per million inhabitants for several OECD members is shown in Table 3.

In the state of Chiapas, one of the poorest states in Mexico, there are four public hospitals with fully functioning X-ray units and eight with ultrasound units. There are no fully functioning CT or MRI units in these hospitals, but there are functioning CT units in three private hospitals and an MRI

**Table 2. Availability of imaging units in Mexico compared to all OECD countries.**

| No. of inhabitants per unit (average)* | | |
|---|---|---|
| Scanner type | All OECD member nations | Mexico |
| MRI scanners | 1 per 108,000 inhabitants | 1 per 714,000 inhabitants |
| CT scanners | 1 per 52,000 inhabitants | 1 per 277,000 inhabitants |

*Data from 2006 (24).

**Table 3. Imaging unit for OECD countries per million population.**

| Country | No. of units per 1,000,000 inhabitants | |
|---|---|---|
| | MRI | CT |
| Mexico | 3 | 6 |
| Costa Rica | 1 | 3 |
| Chile | 12 | 24 |
| United States | 40 | 44 |
| OECD average | 17 | 27 |

*Data from 2021 (26).

machine in one private hospital. In the state of Chiapas, there are approximately 1.1 radiologists per 100,000 citizens (14). In the second poorest state in the country, Guerrero, which has a poverty rate of almost 70%, most citizens lack health coverage and there is limited medical equipment available in hospitals. There is only one X-ray unit per 40,000 citizens (24). There are approximately three radiologists per 100,000 citizens (14).

The Security and Social Services for State Workers, which provides health care for millions of government workers in Mexico and their families, has worked to improve workflow in the radiology realm. In 2019, they implemented a picture archiving and communication system (PACS), a clinical information system, and a radiology information system at 40 public hospitals. This change also helped transition the existing imaging systems into a digital format (27).

### Radiology training

Radiology residency programs last four years in Mexico, and research is required for residency graduation. Certification is granted by the Mexican Council of Radiology and Imaging, formed in 1972; recertification is required every five years. There are many subspeciality training opportunities available in Mexico, including neuroradiology, interventional radiology, abdominal imaging, and breast imaging, which are not available in Guatemala or Honduras. Because of the availability of subspecialty training, less than half of radiologists travel abroad for specialization. This is unlike the situation in the Dominican Republic, for example, which lacks subspecialty training. Many of their physicians travel abroad for specialization training in radiology. There are between 51-100 radiology residency programs in Mexico, among the highest in Latin America (28).

Certifying exams are both oral and written. Medical physics plays an important role in the radiology curriculum and is taught by a medical physicist. In contrast, medical physics is taught by a radiologist in countries such as Guatemala and Honduras (28).

One of the most prestigious radiology residency programs in Latin America is the Monterrey Institute of Technology and Higher Education that is based in Monterrey, Mexico, and was founded in 1976. The program consists of eight semesters of training completed over four years. In addition to physics, there is an emphasis on ethics and quality healthcare which are all courses that begin in the first semester. Because research is mandatory during residency, the program offers a research course aimed at beginning the thesis project in the third semester and a final oral presentation of the thesis given during the eighth semester. Elective opportunities are offered in the seventh and eighth semester (29).

The Autonomous University of Nuevo León, located in the state of Nuevo León, also has a prestigious radiology residency program. The program requires a thesis course taken each of the four years. There is also the opportunity to conduct a rotation outside of the program during the final year. Physics instruction begins in the first year. The breast

imaging rotation begins in the first year with a consecutive course in breast imaging taken in the fourth year. In contrast, the chest radiology rotation is taken in the first and second year (30).

### Radiology market and employment

Mexico is the second largest market in Latin America for radiology services behind Brazil (31). This need is expected to grow as the population ages and the need for imaging to assess chronic conditions increases. The average salary of a radiologist is 1,484,272 Mexican pesos per month ($73,000/year) (32). The national unemployment rate in Mexico is approximately 3.5%, which is lower than the average for all OECD members (5.3%) (33).

## Visiting Mexico

### Spoken languages and education

Spanish is the main language in Mexico, spoken by ~90% of citizens. There are several indigenous languages that are still spoken by a minority of citizens. The Mexican government recognizes 68 national languages (34). The literacy rate in Mexico as of 2020 is approximately 95% (35).

### Local safety

Violent crime such as homicide and kidnapping are widespread and common in Mexico. For this reason, the US Department of State lists "do not travel" warnings for five states: Colima, Guerrero, Michoacán, Sinaloa, and Tamaulipas. US citizens traveling to the states of Campeche and Yucatán are advised to exercise "normal precautions." It is recommended that visitors avoid traveling at night, stay in tourist areas, and be cautious on highways. At the time of writing this article, the US State Department has a level 2 travel advisory in place for US citizens traveling to Mexico because of its moderate rates of COVID-19 (36).

### Health advisories

It is recommended to be up to date on all routine vaccinations, including those for varicella, diphtheria/tetanus/pertussis, influenza, measles/mumps/rubella, and poliovirus as well as for hepatitis A and B. Because rabid dogs are prevalent in various parts of Mexico, visitors should also consider vaccination against the rabies virus before travel if they will be around wildlife. The US Centers for Disease Control also recommends prescription medicine for malaria for travelers to certain areas (37).

## Conclusion

Mexico is the second largest market in Latin America for radiology services with tremendous room for growth. While the state of radiology and medical imaging has improved over the past several years, the number of medical imaging units is not yet sufficient to address the needs of the Mexican population. By upgrading existing equipment while also

increasing the workforce in the radiology realm, the growth of radiology in Mexico can further prosper while helping the population at large.

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## Conflicts of interest

The authors report no conflicts of interest.

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