Original Article

Qualification of nursing potential in maternal mortality in Mexico

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A B S T R A C T

Objectives: To develop a method that measures nursing potential through the factor analysis of relevant nursing data and social context by taking maternal mortality as the study problem.

Methods: A Cross-sectional and analytical study, a multivariate analysis was performed. The Nursing Coverage Index, the Human Development Index, population density and the proportion of nurses with a bachelor’s degree or upper degree, are studied by federative entity, only data from government sources are used. The Index of Nursing Qualification in Mexico (INQM) was constructed through principal component analysis.

Results: The highest correlation was between the INQM and the Nursing Coverage Prioritization Index (NCPI), which was 0.849 (P < 0.01) and showed a strong positive linear relationship. The Population Density Prioritization Index (PDPI) shows a strong positive correlation with the INQM (0.716, P < 0.01).

Three factors were extracted by principal component analysis and the INQM was generated with the three main components in a model. There is very low correlation between INQM and maternal mortality rate (MMR) and no statistical significance was found.

Conclusions: This study shows that nursing qualification must include economic, geographic and social variables. The INQM is an indicator that summarises the potential of each federative entity. Given these results, a contribution is provided for the application of these indices, which can help determine nursing potential in a specific geographical region.

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What is known?

- It is known that maternal mortality is a major public health problem, even part of the millennium development goals, which were not met; Increased nursing coverage is one of the factors that helps to have better results in maternal mortality.

What is new?

- What has not been said is that measuring nursing coverage in isolation is not very specific, so that the construction of a qualification index that includes, own variables of the discipline, but also of economic, geographical and social character

1. Introduction

Previous studies have shown the importance of adequate levels of nursing staff for the health of populations [1,2]. However, different factors should be evaluated and correlated to identify the potential of nursing staff in different priority health problems [3]. The central idea of this work is to use an inferential method to demonstrate that the nursing coverage, the proportion of nurses with a minimum of a bachelor’s degree, the Human Development Index (HDI) of the entity and population density have an impact on maternal mortality as a serious problem of public health.
1.1. Qualifying nursing potential

Rating refers to an indicator constructed with information consisting of one or more data, such as rates, ratios, proportions or qualities, that allow the timely monitoring of a specific condition [4].

Nursing professionals in the Region of the Americas can be classified according to their academic training. Such professionals have a) a bachelor's degree in nursing or are either b) nursing technicians or c) nursing assistants. Among these professionals, 47.1% have a bachelor's or higher degree in nursing, 27% are technicians, and 25.9% are nursing assistants [5].

According to Yoshikawa, care is a phenomenon in movement, and professional nursing practice as a social construct can be impacted by knowledge [6]; thus, an academic degree is assumed to have a certain influence on professional performance. Care provided by unqualified professionals can lead to carelessness or the underutilisation of assistive technology, which in turn may cause adverse events and may endanger patients' health [7]. Thus, the proportion of nurses with bachelor's, master's or Ph.D. degrees is an important aspect to investigate.

However, nursing potential is not only determined by training. Mexico faces a relative deficit in nurses, who represent over 50% of their total health personnel. In 2013, a total of 223,284 nurses were registered to care for a population of 118,395,053 and thus the indicator of nursing coverage per 1,000 inhabitants was 1.89 for the total population [8]. The distribution of nursing personnel by federative entity and the rate of nursing service coverage per 1,000 inhabitants are shown in Table 1 [9,10].

Nursing potential is likewise related to the degree of population dispersion that requires care, which is why population density is another element that qualifies nursing performance [11].

Every act of caring is carried out within a social context. Hence, a multidimensional view of the population development level is necessary, and the HDI [12] is included in this study. The HDI focuses on three dimensions, namely, health, which is assessed by life expectancy at birth; education, which is measured by mean of years of schooling; and living dimension, which is measured by gross national income per capita.

1.2. Maternal mortality

The World Health Organization defines maternal mortality as 'the death of a woman while pregnant, at childbirth or within 42 days of termination of pregnancy irrespective of the duration and site of the pregnancy, from any cause related to or aggravated by the pregnancy or its management, but not from accidental or incidental causes' [13]. Maternal death is a public health phenomenon that is related to the social, cultural, technological and even economic development of a nation. This mortality also reflects the health status of the population and is an indicator of justice, equity and social development [14–16].

Mexico is considered as a country with medium-to-low maternal mortality. The rates reported for 2014 were approximately 38 maternal deaths per 100,000 registered live births [17]. A total of 943 maternal deaths occurred in Mexico in 2015. Evidently, challenges persist not only in the quantity but also in the quality and distribution of nursing staff [18–20].

In this context, the aim of this work is to develop a method that measures nursing potential in Mexico through the factor analysis of relevant nursing data and social context by taking maternal mortality as the study problem.

| Federative Entity | Nursing coverage per 1,000 inhabitants | Proportion of nurses with a bachelor’s or upper degree (%) | Human Development Index | Population density by km² |
|-------------------|--------------------------------------|--------------------------------------------------------|-------------------------|---------------------------|
| Aguascalientes    | 1.93                                 | 37.7                                                   | 0.76                    | 234                       |
| Baja California   | 2.49                                 | 30.3                                                   | 0.77                    | 10                        |
| Sur               | 1.81                                 | 18.6                                                   | 0.75                    | 46                        |
| Campeche          | 2.85                                 | 50.5                                                   | 0.67                    | 71                        |
| Chiapas           | 1.53                                 | 31.4                                                   | 0.69                    | 26                        |
| Chihuahua         | 1.60                                 | 17.6                                                   | 0.73                    | 14                        |
| Ciudad de México  | 3.97                                 | 31.4                                                   | 0.83                    | 5967                      |
| Coahuila          | 2.08                                 | 26.1                                                   | 0.77                    | 20                        |
| Colima            | 2.26                                 | 46.6                                                   | 0.76                    | 126                       |
| Durango           | 1.95                                 | 35.4                                                   | 0.73                    | 14                        |
| Estado de México  | 1.24                                 | 28.3                                                   | 0.74                    | 724                       |
| Guanajuato        | 1.74                                 | 36.0                                                   | 0.72                    | 191                       |
| Guerrero          | 1.86                                 | 36.2                                                   | 0.68                    | 56                        |
| Hidalgo           | 1.83                                 | 32.3                                                   | 0.72                    | 137                       |
| Jalisco           | 1.50                                 | 27.4                                                   | 0.75                    | 100                       |
| Michoacán         | 1.41                                 | 39.2                                                   | 0.70                    | 78                        |
| Morelos           | 1.61                                 | 39.4                                                   | 0.75                    | 390                       |
| Nayarit           | 2.06                                 | 52.2                                                   | 0.73                    | 42                        |
| Nuevo León        | 2.18                                 | 32.2                                                   | 0.79                    | 80                        |
| Oaxaca            | 1.83                                 | 45.4                                                   | 0.69                    | 42                        |
| Puebla            | 1.41                                 | 36.2                                                   | 0.72                    | 180                       |
| Querétaro         | 1.34                                 | 36.0                                                   | 0.76                    | 174                       |
| Quintana Roo      | 2.17                                 | 23.2                                                   | 0.75                    | 34                        |
| San Luis Potosí   | 1.76                                 | 34.6                                                   | 0.72                    | 45                        |
| Sinaloa           | 2.04                                 | 30.9                                                   | 0.76                    | 52                        |
| Sonora            | 1.80                                 | 25.6                                                   | 0.73                    | 16                        |
| Tabasco           | 2.26                                 | 50.5                                                   | 0.74                    | 97                        |
| Tamaulipas        | 2.24                                 | 59.6                                                   | 0.76                    | 43                        |
| Tlaxcala          | 1.97                                 | 49.2                                                   | 0.73                    | 318                       |
| Veracruz          | 1.50                                 | 46.2                                                   | 0.71                    | 113                       |
| Yucatán           | 2.88                                 | 34.0                                                   | 0.74                    | 53                        |
| Zacatecas         | 1.68                                 | 60.7                                                   | 0.72                    | 21                        |
2. Material and methods

This study was carried out in four steps: (1) variables that determined the performance of nursing personnel were selected from official data, (2) a nursing qualification index was constructed through the use of a prioritization method, (3) maternal mortality, as an important public health problem, was added to the results of prioritization to observe the impact of nursing qualification on a specific health problem and (4) finally, factor analysis was carried out to verify the correlation and significance of all the variables.

2.1. Data description

Data on total population and nursing human resources were derived from Mexican government sources such as the Ministry of Health for the latter two variables. Information on the HDI was obtained from the United Nations Development Programme, whilst population density was obtained from the 2015 Intercensal Survey of the National Institute of Statistics and Geography (Instituto Nacional de Estadística y Geografía).

2.2. Study design

A cross-sectional and analytical study, a multivariate analysis was performed. The following variables were studied by federative entity: the Nursing Coverage Index, the Human Development Index, population density and the proportion of nurses with bachelor’s, master’s and Ph.D. degrees.

2.3. Data analysis

The Index of Nursing Qualification in Mexico (INQM) was constructed with the raw data of nursing coverage, the proportion of university graduate nurses, the Human Development Index and population density by federative entity.

Once obtained, the INQM was correlated with the maternal mortality rate (MMR) per 100,000 registered live births. All the statistical tests were performed via SPSS v.21.0 (IBM Corp., Armonk, NY, USA).

The INQM is a summary indicator proposed by the authors of this article as a construct based on four components, namely, (1) nursing coverage per 1,000 inhabitants (NC); (2) the proportion of nurses (PUN) with bachelor’s, master’s or Ph.D. degrees; (3) the Human Development Index (HDI), which is an indicator that allows for a multidimensional view of a population’s development level [21]; and (4) population density (PD), which indicates population dispersion and thus the availability of access to health services.

The INQM was calculated by principal component analysis [22]. The INQM varies between 0 and 100. Its value expresses the magnitude of the qualification, and its mathematical formulation is

\[
\text{INQM} = 1/4 (NC + PUN + HDI + PD)
\]

where INQM represents the Index of Nursing Qualification in Mexico, 1/4 represents the proportional fraction of the hundredth, NC is nursing coverage, PUN refers to the proportion of nurses with a bachelor’s degree, HDI represents the Human Development Index and PD is population density.

The following formula was used for the construction of each of the four components.

\[
\text{NCPI} = \frac{MI - M_{\text{min}}}{M_{\text{max}} - M_{\text{min}}} \times 100
\]

where NCPI is the Nursing Coverage Prioritization Index, \( M_{\text{max}} \) represents the value to be prioritised, \( M_{\text{max}} \) represents the maximum value of the population to be compared and \( M_{\text{min}} \) represents the minimum value of the population to be compared [23].

The maximum value in the prioritization of NC was 3.97 in Mexico City, and the minimum was in Estado de Mexico, with 1.24 nurses per thousand inhabitants. The prioritization results were as follows: PUN showed that the maximum value was in Zacatecas, with 60.7, and the minimum value was in Chihuahua, with 17.6; HDI obtained the maximum value in Mexico City, with 0.83, and the minimum value in Chiapas, with 0.667; and finally, PD had the maximum value in Mexico City, with 5.967, and the minimum value in Baja California Sur, with 10 (Table 1).

The INQM was nationally constructed by federative entity on the basis of the MMR as a priority health problem [24].

3. Results

Data obtained through the Prioritization Indices are shown in Table 2. All the variables were considered independent in the factor analysis. A correlation matrix was constructed on such a principle (Table 3). The matrix is a double entry table in which the list of variables was presented horizontally and vertically, thereby showing the correlation coefficient at the corresponding intersection for each of the variables. In this analysis, the model measured and showed the interdependence in the relationships between each pair and all of the variables simultaneously. In conclusion, the correlation coefficient analysis showed the validity of the INQM.

The highest correlation was between the INQM and the Nursing Coverage Prioritization Index (NCPI), which was 0.849 (\( P < 0.01 \)) and showed a strong positive linear relationship.

The Proportion of University Nurses Prioritization Index (PUNPI) showed a low positive correlation with the INQM (0.374, \( P < 0.05 \)). The INQM had a medium positive correlation with the Human Development Prioritization Index (HDPI) (0.597, \( P < 0.01 \)), which in turn had a low negative average correlation with the MMR (\( -0.403, P < 0.01 \)). The Population Density Prioritization Index (PDPI) shows a strong positive correlation with the INQM (0.716, \( P < 0.01 \)).

Finally, the results in Table 3 show a simple correlation coefficient for INQM and MMR of (\( -0.082, P = 0.05 \)) so there is very low correlation and no statistical significance was found.

In the matrix of components, the first factor was constituted by the NCPI and the PDPI (these two variables were saturated in a single factor, that is, factor 1), the INQM and the HDPI were also included in this first factor. The second factor included the PUNPI, the HDPI and the INQM. Finally, the third factor was formed by the MMR and the HDPI. Only two cases had variables with values lower than 0.4.

The data confirmed that the first component had a considerable explanation with the INQM (0.927), NCPI (0.919), PDPI (0.847) and HDPI (0.682) variables. The second component was explained by the PUNPI (0.994), the HDPI (\( -0.368 \)) and the INQM (0.344). The MMR (0.975) and the HDPI (\( -0.522 \)) explained the third component.

The eigenvalues of the extracted factors in this study were 2.956, 1.420 and 1.032. The three extracted factors above explained the total variance of 90.12%. Extraction was performed by principal component analysis. Thus, the INQM was generated with the three main components by means of the expression:

\[
\text{INQM} = [(\text{FAC1}_2 \times 2.956) + (\text{FAC2}_2 \times 1.420) + (\text{FAC3}_2 \times 1.032)]
\]

where FAC is the factor value extracted per analysis unit.
4. Discussion

On the literature review no articles were found that included economic, geographic and social variables to qualify the potential for nursing in the face of a serious public health problem. In some entities with apparently lower MMR, underreporting of health information is frequent. Special mention should be made of Mexico City, which is where the highest health infrastructure is located, patients with very serious health problems from all federal entities attend, and on many occasions the outcome is fatal, so the death record is increased for this city. Being so, this city has the highest qualification index but does not report low MMR.

5. Conclusions

The INQM is an indicator that summarises the potential of each federative entity depending on its level of nursing coverage, the proportion of university nurses, the HDI and the population density per square kilometre.

As a data reduction technique, factor analysis is a highly useful tool to approach nursing qualifications as well as an indicator that converges the number of nurses, their level of education, the geographical distribution of the staff and the prevailing level of human development.

The validity of this model, which is obtained through confirmatory factor analysis, presents satisfactory and statistically significant results. Therefore, the structure of the generated classification and grouping allows for the adjustment of the INQM on the basis of three indicators, namely, the nursing coverage for every 1,000 inhabitants, the proportion of nurses with a bachelor’s or higher degree and the HDI. However, even no statistical significance was found between INQM and MMR moving forward with new research and studies is necessary. Given these results, a contribution is provided for the application of these indices, which can help determine nursing potential in a specific geographical region.

Table 2

| Federative Entity | Nursing Coverage Prioritization Index | Proportion of University Nurses Prioritization Index | Human Development Prioritization Index | Population Density Prioritization Index | Index of Nursing Qualification in Mexico | Maternal Mortality Rate (%) |
|-------------------|--------------------------------------|----------------------------------------------------|--------------------------------------|----------------------------------------|--------------------------------------|-----------------------------|
| Aguascalientes    | 25.27                                | 46.64                                              | 57.06                                | 3.76                                   | 33.18                                | 25.7                        |
| Baja California Sur | 45.79                              | 29.47                                              | 68.87                                | 0.00                                   | 35.53                                | 32.1                        |
| Baja California    | 22.34                                | 2.32                                               | 57.06                                | 0.60                                   | 20.58                                | 42.3                        |
| Campeche           | 58.97                                | 76.33                                              | 50.31                                | 0.10                                   | 46.43                                | 65.4                        |
| Chiapas            | 10.62                                | 32.02                                              | 0.00                                 | 1.02                                   | 10.92                                | 54.8                        |
| Chihuahua          | 13.19                                | 0.00                                               | 41.10                                | 0.07                                   | 13.59                                | 59.8                        |
| Ciudad de México   | 100.00                               | 32.02                                              | 100.00                               | 100.00                                 | 83.00                                | 41.9                        |
| Coahuila           | 30.77                                | 19.72                                              | 61.96                                | 0.17                                   | 28.16                                | 27.0                        |
| Colima             | 37.36                                | 67.29                                              | 58.90                                | 1.95                                   | 43.37                                | 22.5                        |
| Durango            | 26.01                                | 41.30                                              | 39.26                                | 0.07                                   | 26.66                                | 41.2                        |
| Estado de México   | 0.00                                 | 24.83                                              | 47.85                                | 11.99                                  | 21.17                                | 36.1                        |
| Guanajuato         | 18.32                                | 42.69                                              | 32.52                                | 3.04                                   | 24.14                                | 34.9                        |
| Guerrero           | 22.71                                | 89.56                                              | 7.36                                 | 0.77                                   | 30.10                                | 59.4                        |
| Hidalgo            | 21.61                                | 34.11                                              | 34.36                                | 2.13                                   | 23.05                                | 37.5                        |
| Jalisco            | 9.52                                 | 22.74                                              | 51.53                                | 1.51                                   | 21.33                                | 22.4                        |
| Michoacán          | 6.23                                 | 50.12                                              | 20.25                                | 1.14                                   | 19.43                                | 36.7                        |
| Morelos            | 13.55                                | 50.38                                              | 50.31                                | 6.38                                   | 30.20                                | 44.5                        |
| Nayarit            | 30.04                                | 80.28                                              | 40.49                                | 0.54                                   | 37.04                                | 36.2                        |
| Nuevo León         | 34.43                                | 33.87                                              | 75.46                                | 1.18                                   | 36.24                                | 14.8                        |
| Oaxaca             | 21.61                                | 64.50                                              | 8.59                                 | 0.54                                   | 23.81                                | 50.4                        |
| Puebla             | 6.23                                 | 43.16                                              | 30.67                                | 2.85                                   | 20.73                                | 31.8                        |
| Querétaro          | 3.66                                 | 42.69                                              | 57.06                                | 2.75                                   | 26.54                                | 35.0                        |
| Quintana Roo       | 34.07                                | 12.99                                              | 53.37                                | 0.40                                   | 25.21                                | 46.2                        |
| San Luis Potosí    | 19.05                                | 85.85                                              | 36.20                                | 0.59                                   | 35.42                                | 31.8                        |
| Sinaloa            | 29.30                                | 30.86                                              | 55.21                                | 0.71                                   | 29.02                                | 26.7                        |
| Sonora             | 20.51                                | 18.56                                              | 68.71                                | 0.10                                   | 26.97                                | 40.2                        |
| Tabasco            | 37.36                                | 76.33                                              | 46.01                                | 1.46                                   | 40.29                                | 27.4                        |
| Tamaulipas         | 36.63                                | 97.45                                              | 55.83                                | 0.55                                   | 47.62                                | 41.7                        |
| Tlaxcala           | 26.74                                | 73.32                                              | 36.81                                | 5.17                                   | 35.51                                | 23.2                        |
| Veracruz           | 13.19                                | 66.36                                              | 28.22                                | 1.73                                   | 27.37                                | 46.4                        |
| Yucatán            | 60.07                                | 38.05                                              | 44.17                                | 0.72                                   | 35.75                                | 50.8                        |
| Zacatecas          | 16.12                                | 100.00                                             | 32.52                                | 0.18                                   | 37.20                                | 44.2                        |

Table 3

| Indicator | INQM | NCPI | PUNPI | HDPI | PDPI | INQM |
|-----------|------|------|-------|------|------|------|
| MMR       | 0.092| 0.071| 0.403 | 0.022| -0.082|      |
| P<0.05    | 0.374| 0.597| 0.716 |      |      |      |

Note: **P < 0.01; *P < 0.05; NCPI--Nursing Coverage Prioritization Index; PUNPI--Proportion of University Nurses Prioritization Index; HDPI--Human Development Prioritization Index; PDPI--Population Density Prioritization Index; INQM--Index of Nursing Qualification in Mexico; MMR – Maternal Mortality Rate.

4. Discussion

On the literature review no articles were found that included economic, geographic and social variables to qualify the potential for nursing in the face of a serious public health problem. In some entities with apparently lower MMR, underreporting of health information is frequent. Special mention should be made of Mexico City, which is where the highest health infrastructure is located, patients with very serious health problems from all federal entities attend, and on many occasions the outcome is fatal, so the death record is increased for this city. Being so, this city has the highest qualification index but does not report low MMR.

5. Conclusions

The INQM is an indicator that summarises the potential of each federative entity depending on its level of nursing coverage, the proportion of university nurses, the HDI and the population density per square kilometre.

As a data reduction technique, factor analysis is a highly useful tool to find homogeneous groups from a large set of variables. Thus, factor analysis is a highly useful tool to approach nursing qualifications as well as an indicator that converges the number of nurses, their level of education, the geographical distribution of the staff and the prevailing level of human development.

The validity of this model, which is obtained through confirmatory factor analysis, presents satisfactory and statistically significant results. Therefore, the structure of the generated classification and grouping allows for the adjustment of the INQM on the basis of three indicators, namely, the nursing coverage for every 1,000 inhabitants, the proportion of nurses with a bachelor’s or higher degree and the HDI. However, even no statistical significance was found between INQM and MMR moving forward with new research and studies is necessary. Given these results, a contribution is provided for the application of these indices, which can help determine nursing potential in a specific geographical region.

Declaration of competing interest

The authors declare that there is no conflict of interest.

CRediT authorship contribution statement

Reny Arturo Salcedo-Alvarez: Conceptualization, Methodology, Validation. Blanca Consuelo González-Caamaño: Writing - original draft, Writing - review & editing, Supervision. Sara Huerta-González: Software. Andrea Del Prado-Vázquez: Data curation, Investigation.
Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jnss.2020.05.004.

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