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Simple Sampling for SARS-CoV-2 Infection in Hidalgo

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Abstract

Throughout the history of our country, different policies have left an incentive for favorable changes, however, none by itself has managed to combat the problems of chronic malnutrition, to which the current pandemic is added. The state of Hidalgo is in a nutritional transition, with persistent child undernutrition and the predominance of chronic diseases associated with malnutrition (undernutrition, overweight and obesity). Part of this research aims to contribute (in a second phase) to the adequacy of current public policy in the fight against malnutrition and, of course, to the current needs experienced by the SARS-CoV-2 infection contingency. This work develops the application of simple sampling and the stages involved in this statistical tool, whose objective is to establish which part of the reality under study should be studied in order to make inferences about a given population. From the period contemplated between April 28, 2020 and March 8, 2022, the 84 municipalities of the state of Hidalgo reported a total of 86,124 confirmed cases of SARS-CoV-2 infection, from which a sample size of 1,054 subjects has been calculated (representativeness of 91.35% of the target population). The correct application of mathematics in the context of health should allow us to enjoy good health, especially if these results are focused on the promotion and prevention of diseases and their complications; mathematics has surpassed the frontiers of knowledge in various areas and its implementation in this case with respect to public policy and nutrition.

Keywords: cases, diseases, infections, malnutrition and public policy.

1. Introduction

Health problems have a multifactorial character that allows science, society, health professionals and other areas to contribute their multidisciplinary and transdisciplinary perspectives (Salas-Perea, 2003) in the search for strategies to combat diseases, which require compliance with ethical, social, economic and scientific aspects (Cortés et al., 2020).

Malnutrition (which includes obesity, overweight and desnutrition) represents a serious health problem that not only has biological repercussions, unfortunately Mexico faces the consequences of these diseases because it is the first place in overweight and obesity in adults and children, although undernutrition has not been fought either.

As the quarantine period ascended due to SARS-CoV-2 infection, social distancing and isolation, generated negative changes in healthy eating; body weight and body mass index increased, which requires informing people about proper nutrition management and the importance of regular exercise (Ateş & Yeşilkaya, 2021).

It has been described that the high risk of severe manifestations and mortality due to SARS-Cov-2 infection is presented mainly by patients with chronic underlying diseases (although they have also been reported in any age, without previous comorbidities), such as cardiovascular disease, diabetes, chronic kidney disease, obesity (Antezana Llaveta & Arandia-Guzmán, 2020), arterial hypertension and immunosuppression (lymphomas, active tumors or under chemotherapy regimen) (Zetina-Tun & Careaga-Reyna, 2022).

In April 2022, the state of Hidalgo ranked ninth in national mortality, with a rate of 272 deaths per 100,000 inhabitants; 3 confirmed cases per 100,000 inhabitants (population size: 3,086,414) and a cumulative 93,111 confirmed cases related to SARS-CoV-2 infection (Secretaría de Salud, 2021).

Long-term complications of this infection are described, including altered insulin sensitivity, pancreatic islet damage with decreased insulin secretion, muscle weakness and atrophy with altered exercise capacity, changes in body composition with increased fat mass and elevated triglycerides and circulating fatty acids, which could ultimately lead to increased risk of future cardiovascular events (Ayres, 2020).

Various investigations in the world and national literature continue to provide valuable information on this historical pandemic event, but none specifically has characterized the population of Hidalgo in relation to malnutrition as a risk factor for this infection, so this study is considered of great impact for society and its government.

A universe or population is the set of total elements that make up the interest of an analysis and on which inferences and conclusions are made (López-Roldán & Fachelli, 2017).

In this context, the objective is to choose the size of the representative sample of the universe generated by the 84 municipalities of Hidalgo, corresponding to the subjects confirmed with SARS-CoV-2 coronavirus infection, using the simple sampling technique having as reference the state database belonging to the state of Hidalgo and considering a given period of time.

The usefulness of a representative sample allows the study subjects to have the same opportunity to be chosen and therefore, to be included in a study, achieving that the researcher extrapolates and extends his/hers results to a given population, understanding that those selected are a numerical representation of the universe from which they come (Otzen & Manterola, 2017).

The hypothesis of this exercise is that the greater the reduction of the dimension of the universe studied, the greater the understanding of the phenomenon under study.

Understanding sampling as a scientific research tool whose objective is to determine that part of the population worthy of study (Hernández & Carpio, 2019), feeds a transcendental part in the research exercise of the next phase of this publication called: evaluation of public policy in relation to malnutrition as a risk of SARS-CoV-2 in Hidalgo, describing the hypothesis that malnutrition is an element that influences the mechanics of the disease, with the vision of obtaining the necessary information to analyze, study and evaluate the current policy in the field of nutrition and food, highlighting that illness and death affect the family economy, that of health systems and that of governments.

2. Method

Sampling makes it possible to analyze fragments of a phenomenon with the advantages of reduced costs and more accurate, faster, flexible and more supervised results. Simple sampling is a method of selecting n units in a set of N so that each of the NCn different samples has the same possibility of being elected. In practice, random sampling is performed unit by unit, that is, the units from 1 to N are listed, then a series of n random numbers between 1 and N is extracted, because through a computer program (R, Python or Julia) a table of random numbers is created, where each extraction is chosen randomly, the units that carry these n numbers constitute the sample (Cochran, 1977).

The sample size, a guide to the follow-up of a certain procedure described below (Portela & Villeta, 2007).

Stage 1. Approach to the problem (in which the phenomenon to be studied is identified, raising all the characteristics that encompass it).

Stage 2. Sample frame (a list of elements that make up the population of the phenomenon under study, known as sample units, is outlined).

Stage 3. Selection of the sampling technique (from a sample frame, the ideal technique is chosen to estimate the sample size).

Stage 4. Sample size (based on the sampling technique, the sample size and its proportional distribution for each of its elements are calculated).

Stage 5. Feasibility of the sample size (which means determining the degree of reliability of the sampling).

2.1 Sample Frame

The complexity of the universe under study, due to the large amount of data emanating from it, requires the selection of a sample, which reduces the use of resources such as financial, human, material and intangible resources such as time. By simplifying the size of the population from which we wish to analyze a series of variables, the time in which data are generated that contribute to a more accurate knowledge of a phenomenon, its behavior and prevention in terms of health, is compromising; the pandemic has given us several lessons on the right or wrong actions of governments and their effect on citizens; numbers have that power.

The size of the reported population corresponds to 86,124 subjects, confirmed with SARS-CoV-2 infection, according to the state database, collected thanks to the Epidemiology area of the State Health Secretariat (Table 1).

Table 1. Confirmed cases of SARS-CoV-2 by municipality in the state of Hidalgo

Municipalities	Registered cases
1. Acatlán	26
2. Acaxochitlán	2
3. Actopan	2,506
4. Agua Blanca de Iturbide	0
5. Ajacuba	214
6. Alfajayucan	132
7. Almoloya	96
8. Apan	1,851
9. El Arenal	24
10. Atitalaquia	231
11. Atlapexco	93
12. Atotonilco el Grande	172
13. Atotonilco de Tula	1,279
14. Calnali	156
15. Cardonal	174
16. Cuautepec de Hinojosa	495
17. Chapantongo	270
18. Chapulhuacan	48
19. Chilcuautla	117
20. Eloxochitlán	25
21. Emiliano Zapata	261
22. Epazoyucan	3
23. Francisco I. Madero	25
24. Huasca de Ocampo	57
25. Huautila	0
26. Huazalingo	75
27. Huehuetla	289
28. Huejutla de Reyes	2,275
29. Huichapan	1,602
30. Ixmiquilpan	1,831
31. Jacala de Ledezma	78
32. Jaltocán	14
33. Juárez Hidalgo	5
34. Lolotla	29
35. Metepec	367
36. San Agustín Metzquititlán	49
37. Metztitlán	208
38. Mineral del Chico	37
39. Mineral del Monte	266
40. La Misión	33
41. Mixquiahuala de Juárez	1,682
42. Molango de Escamilla	384
43. Nicolás Flores	47
44. Nopala de Villagrán	225
45. Omitlán de Juárez	80
46. San Felipe Orizatlán	1

47. Pacula	44
48. Pachuca de Soto	35,433
49. Pisaflores	41
50. Progreso de Obregón	30
51. Mineral de la Reforma	1,433
52. San Agustín Tlaxiaca	4
53. San Bartolo Tutotepec	99
54. San Salvador	52
55. Santiago de Anaya	75
56. Santiago Tulantepec de Lugo de Guererero	1,900
57. Singilucan	0
58. Tasquillo	225
59. Tecozautla	206
60. Tenango de Doria	581
61. Tepeapulco	4,153
62. Tepehuacán de Guerrero	108
63. Tepeji del Río de Ocampo	3,299
64. Tepetitlán	79
65. Tetepango	60
66. Villa de Tezontepec	64
67. Tezontepec de Aldama	151
68. Tianguistengo	43
69. Tizayuca	5,523
70. Tlahuelilpan	127
71. Tlahuiltepa	51
72. Tlanalapa	76
73. Tlanchinol	165
74. Tlaxcoapan	1,492
75. Tolcayuca	173
76. Tula de Allende	5,360
77. Tulancingo de Bravo	5,996
78. Xochiatipan	6
79. Xochicoatlán	77
80. Yahualica	0
81. Zacualtipán de Ángeles	641
82. Zapotlán de Juárez	61
83. Zempoala	72
84. Zimapán	390
Total	86,124

Note. Period contemplated from April 28, 2020 to March 8, 2022; personal elaboration.

2.2 Selection of the Sampling Technique

Assuming that the target population is finite (since the total number of observation units that compose it is known), we have that (Aguilar-Barojas, 2005):

$$n = \frac{N * Z_{\alpha}^{2} PQ}{E^{2}(N-1) + Z_{\alpha}^{2} PQ} \quad (1)$$

Where:

- n = Sample size.
- N = Total population size.
- $Z\alpha$ = Confidence level at 0.95 and with a significance level at 0.05. Below the curve of the normal distribution is 1.96.
- P = Probability of success.
- Q = (1 – P) = Probability of failure.
- E = Error admitted in the sample.

It is important to clarify that *N* is the 86,124 subjects and *n*, the revealing sample size calculation; *P*, explains the possibility of being selected as part of the sample and that *Q* is the probability of not being selected (or known as failure), so it assigns 50% versus 50% (0.5+0.5=1); that is, both P and Q have the same probability of being selected.

Its main estimators are the following (Pérez, 2005):

- Sample size by item:

$$n_i = \left(\frac{N_i}{N}\right) * n\ ;\quad i = 1,2,3,\ldots,k \tag{2}$$

Where:

- N_i = Any of the states, i.e., the size of the population of each municipality.
- N = Total population size.
- n = Sample size.
- k =1,2,3,4...k As the total number of municipalities.
- Estimator of the total of the sample:

$$Y = n\bar{Y} \tag{3}$$

Where:

$\bar{Y}$ = Population size of each municipality.

Sample meaner:

$$\bar{Y} = \sum_{i=1}^{K} \frac{Y_i}{n} \tag{4}$$

Σ^k = The average number of objects within each sample, starting from municipality 1 to minucipality 84.

Y_i = Sample size in any municipality.

- Confidence intervals:

$$\bar{Y} - (Z_\alpha)\left(\sqrt{\mathrm{Var}(\bar{Y})}\right) < \bar{Y} < \bar{Y} + (Z_\alpha)\left(\sqrt{\mathrm{Var}(\bar{Y})}\ \right) \tag{5}$$

- Expansion factor (Ackoff & Sasieni, 1977):

$$Fx = \frac{N}{n} \tag{6}$$

- Variance of the sample:

$$S^2 = \frac{\sum_{i=1}^{K}(Y_i - \bar{Y})^2}{n-1} \tag{7}$$

- Variance of the average:

$$\mathrm{Var}(\bar{Y}) = \frac{S^2}{n}\left(\frac{N-n}{N}\right) \tag{8}$$

- Absolute error:

$$Ea(\bar{Y}) = \left(\frac{\sqrt{\mathrm{Var}(\bar{Y})}}{\bar{Y}}\right) * 100 \tag{9}$$

- Degree of adjustment:

$$Gr = 100 - Ea(\overline{Y}) \quad (10)$$

For the calculation of the sample and its estimators, we start from a confidence level of 0.95 and a significance level of 0.05, with an error of 0.03.

2.3 Sample Size

Based on the algebraic expression (3) and based on the following data:

- N = 86124
- $Z\alpha$= 1.96
- P = 0.50
- Q = 0.50
- E = 0.03

Substituting in the algebraic expression (1):

$$n = \frac{N*Z_{\alpha}^{2}PQ}{E^{2}(N-1)+Z_{\alpha}^{2}PQ} = \frac{86{,}124+(1.96)^{2}(0.50)(0.50)}{(0.03)^{2}(86{,}124-1)+(1.96)^{2}(0.50)(0.50)} \quad (11)$$

Therefore, the sample size is:

$$n = \frac{82{,}713.4896}{78.4711} = 1054.1 \sim 1054 \quad (12)$$

Based on the sample size and applying the algebraic expression (6), the results are shown in Table 2 below.

Table 2. Sample size of confirmed SARS-CoV-2 cases in each municipality of the state of Hidalgo.

Municipalities	Sampling
1. Acatlán	0
2. Acaxochitlán	0
3. Actopan	31
4. Agua Blanca de Iturbide	0
5. Ajacuba	3
6. Alfajayucan	2
7. Almoloya	1
8. Apan	23
9. El Arenal	0
10. Atitalaquia	3
11. Atlapexco	1
12. Atotonilco el Grande	2
13. Atotonilco de Tula	16
14. Calnali	2
15. Cardonal	2
16. Cuautepec de Hinojosa	6
17. Chapantongo	3
18. Chapulhuacan	1
19. Chilcuautla	1
20. Eloxochitlán	0
21. Emiliano Zapata	3
22. Epazoyucan	0
23. Francisco I. Madero	0
24. Huasca de Ocampo	1
25. Huautila	0

26.	Huazalingo	1
27.	Huehuetla	4
28.	Huejutla de Reyes	28
29.	Huichapan	20
30.	Ixmiquilpan	22
31.	Jacala de Ledezma	1
32.	Jaltocán	0
33.	Juárez Hidalgo	0
34.	Lolotla	0
35.	Metepec	4
36.	San Agustín Metzquititlán	1
37.	Metztitlán	3
38.	Mineral del Chico	0
39.	Mineral del Monte	3
40.	La Misión	0
41.	Mixquiahuala de Juárez	21
42.	Molango de Escamilla	5
43.	Nicolás Flores	1
44.	Nopala de Villagrán	3
45.	Omitlán de Juárez	1
46.	San Felipe Orizatlán	0
47.	Pacula	1
48.	Pachuca de Soto	434
49.	Pisaflores	1
50.	Progreso de Obregón	0
51.	Mineral de la Reforma	18
52.	San Agustín Tlaxiaca	0
53.	San Bartolo Tutotepec	1
54.	San Salvador	1
55.	Santiago de Anaya	1
56.	Santiago Tulantepec de Lugo de Guererero	23
57.	Singilucan	0
58.	Tasquillo	3
59.	Tecozautla	3
60.	Tenango de Doria	7
61.	Tepeapulco	51
62.	Tepehuacán de Guerrero	1
63.	Tepeji del Río de Ocampo	40
64.	Tepetitlán	1
65.	Tetepango	1
66.	Villa de Tezontepec	1
67.	Tezontepec de Aldama	2
68.	Tianguistengo	1
69.	Tizayuca	68
70.	Tlahuelilpan	2
71.	Tlahuiltepa	1
72.	Tlanalapa	1
73.	Tlanchinol	2

74. Tlaxcoapan	18
75. Tolcayuca	2
76. Tula de Allende	66
77. Tulancingo de Bravo	73
78. Xochiatipan	0
79. Xochicoatlán	1
80. Yahualica	0
81. Zacualtipán de Ángeles	8
82. Zapotlán de Juárez	1
83. Zempoala	1
84. Zimapán	5
Total	1,054

Note. Random selection, personal elaboration.

Calculating the variance of the sample:

$$S^2 = \frac{\sum_{i=1}^{K}(Y_i - \overline{Y})^2}{n-1} = 89.256 \qquad (13)$$

Based on the above, the variance of the sample mean:

$$Var(\overline{Y}) = \frac{S^2}{n}\left(\frac{N-n}{N}\right) = \frac{188.71}{1054}\left(\frac{86{,}124 - 1054}{86{,}124}\right) \qquad (14)$$

$$Var(\overline{Y}) = \frac{(188.71)(0.9878)}{1{,}054} = 1.1768 \qquad (15)$$

By Calculating your confidence interval, you have to:

- S2 = 188.71.
- $Z\alpha$ = 1.96.
- $\overline{Y}$ = 12.55.
- $\sqrt{Var(\overline{Y})} =$ 1.085.

Replacing:

$$12.55 - (1.96)(1.085) < \overline{Y} < \overline{Y} + 12.55 + (1.96)(1.085) \qquad (16)$$

Such that:

$$875 < \overline{Y} < 1232 \qquad (17)$$

With a confidence level of 0.95 and a significance level of 0.05, the sample size will range between 875 and 1232.

Feasibility of sample size

Based on the size of the population and the sample, the expansion factor of the selected units is 82, that is:

$$\frac{N}{n} = \frac{86{,}124}{1{,}054} = 81.71(18)$$

Each individual who is randomly selected has the ability to answer 82 individuals in the population.

Calculating the relative error from the algebraic expression (9):

$$Ea(\overline{Y}) = \left(\frac{1.085}{12.55}\right) * 100 = 8.65\% \qquad (19)$$

Obtained the degree of adjustment:

$$Gr = 100- Ea(\bar{Y})=100 - 8.65 = 91.35 \% \quad (20)$$

3. Results

The universe constituted by the 84 municipalities of the state of Hidalgo, corresponds to the subjects confirmed with SARS-CoV-2 coronavirus infection, in a period contemplated between April 28, 2020 and March 8, 2022, according to the database of the Epidemiology area of the State Health Secretariat.

Regarding the calculation of the sample and its estimators, a confidence level of 0.95 and a significance level of 0.05 were used, with an error of 0.03, which, after calculation, yields a sample size of 1,054 subjects.

By applying the simple random sampling technique, the individuals in the study population will all have the same probability of being selected.

Regarding the expansion factor, this describes that each randomly selected subject has the power to respond to 82 individuals in the population, therefore, "it does not matter which subject is chosen", as long as it meets the selection criteria of the population to be sampled, i.e., belonging to the state records referred to above and also includes those subjects for whom there is a total number of responses for each of the variables of interest for the study.

The relative error of 8.65% describes that this percentage of the selected sample would not provide the relevant information for the study. Finally, the sample size can range between 875 and 1232 subjects, having a representativeness of 91.35% of the target population.

For the purposes of this research, it has been decided to obtain the greatest possible representativeness of the sample, so the upper limit range of subjects under study will be taken, that is, 1232, in addition to not excluding any municipality in the same, adjusting the sampling revealed here (except those municipalities that report with 0 registered cases).

The realization of this sampling implies the construction of two other models where the first one focuses on the reduction of the dimension of the variables and the second one in reference to the estimation of the evolution of the health status of the subjects.

4. Discussion

Simple sampling is a vital tool for the research proposed here; it is necessary to evaluate public policies focused on malnutrition in Mexico and the state of Hidalgo, in order to obtain the necessary information to optimize, propose and act on real proposals, generated precisely in the heart of this population.

In Mexico, a double burden of disease effect has been described, where poor diet quality is responsible for both obesity and malnutrition (Barquera et al., 2001).

Throughout the history of our country, different policies and proposals have left an incentive for favorable changes, however, none alone has managed to combat the problems of malnutrition that to date have worsened and moved to a state of chronicity, which imposes the current challenges to which are added adversities such as the current pandemic.

Nutritional status and diet are determinants of health and, in the case of SARS-CoV-2, could play a transcendental role in the prevention and development of complications, since, in recent decades, there have been multiple changes in the dietary patterns of Mexican families. Together with sociocultural transformations, product of a globalized economic model, occupations and physical activity habits have been modified, people have become more sedentary and devote much of their time to television and device screens (Castro et al., 2020).

Despite the fact that 1 in 5 people who contract SARS-CoV-2 ends up presenting a severe picture and experiencing respiratory difficulties, it is known that in our country a large part of the population is within the risk group not necessarily because they are older people, but because of the presentation of previous medical conditions such as arterial hypertension, cardiac or pulmonary problems, diabetes or cancer (Rivas et al., 2020).

Poor metabolic control, together with an elevated body mass index or excess adipose tissue, appear to be risk factors for SARS-CoV-2 complications. Prevention is mainly based on the promotion of healthy habits and the effective and persistent control of these behaviors. In this population, inadequate or insufficient nutrition may result in increased susceptibility to infection (Vecilla et al., 2020).

Our country is facing a pandemic that puts at risk the advances in social development and with it the health of the population, which are affecting various sectors of the population to a greater or lesser degree, some due to economic deprivation, others due to their health status, loss of employment, food insecurity, educational deficiencies, inequity and lack of equality, in addition to a long list of social afflictions. The question is, How long will it take for the country to recover, or even to think about whether or not it will be able to overcome the situation it is going through?; isolated solutions are unthinkable, coordination between sectors is needed.

5. Conclusion

The proper application of mathematics in the context of health should allow us to enjoy good health and therefore a positive economic impact (Serrano et al., 2020), especially if these results were focused on the promotion and prevention of diseases and their complications. The research and execution of medicine in conjunction with mathematics has contributed to the knowledge of risk factors and the way in which various pathologies behave (Olmedo & Ariza, 2012), including the chronic conditions highlighted here. For example, the use of mathematical models makes it possible to pose and test hypotheses about the use of certain treatments or to personalize therapies, run simulations and predict the behavior of human biology (Pérez-García et al., 2016).

The initial objective of choosing a representative sample size has been achieved; mathematics has surpassed the frontiers of knowledge in different areas and its application in this case to public policy, medicine and nutrition; the mathematical models of the second phase will be a fundamental part in the continuity of this research that in the near future will characterize the population of Hidalgo in terms of malnutrition and SARS-CoV-2 infection, factor analysis and multidisciplinary scaling are made visible.

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