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Use of an extrapolation method to estimate the population of cats and dogs living at homes in Mexico in 2022

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Abstract

Cats and dogs have a very close relationship with humans. Currently, the overpopulation of these species in various countries worldwide has been identified as a severe public health problem. To establish effective programs for population control, it is necessary to estimate the number of cats and dogs. To our knowledge, there are no studies that assess the number of canine and feline population by state in Mexico. Therefore, this study aimed to estimate the canine and feline population living at homes using official information reported by the National Institute of Statistics, Geography and Informatics [Instituto Nacional de Estadística Geografía e Informática] through a constant-share model, a ratio extrapolation method. The estimated dog population living at homes was 42 625 010 dogs and 7 346 925 cats (at least 5.8 times less than the number of dogs). By 2022, the Mexico's estimated human:dog ratio was 2.4:1, and the human:cat ratio 17.6:1. The Estado de México had more than six million dogs and 962 177 cats. Colima had the smallest estimated dog population (245 489), and Baja California Sur the smallest estimated cat population (slightly over 30 000). Health authorities and veterinary practitioners should promote responsible ownership to increase veterinary care and control the birth of dogs and cats.

Keywords: canine/feline overpopulation; public health; human:cat/dog ratio, Mexico; constant-share model.

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Additional information and declarations can be found on page 8

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Study contribution

This study provides information on the number of dogs and cats living at homes in Mexico. The estimation reported in this paper suggests that the population of dogs in households will be at least 42 625 010 in Mexico in 2022. The cat population in households of Mexico is 5.8 times lower than the number of dogs, with a total of 7 346 925 expected by 2022. Health authorities and veterinary practitioners should promote responsible ownership to increase veterinary care and population control of dogs and cats.

Introduction

Cats and dogs have a very close relationship with humans; dogs are estimated to have lived with humans for at least 15 000 years, and cats have been domesticated more than 10 000 years ago.[1] In addition, cats and dogs satisfy essential zootechnical functions: companion animals provide their owners companionship, reducing feelings of isolation and loneliness and generally supporting people's physical and mental health. This support reduced negative health effects associated with the stress of the COVID-19 pandemic.[2] Cats and dogs depend on the human population's activities because people usually provide direct or indirect support (food, water, shelter) to survive and reproduce.[3, 4]

Although natural processes limit the excessive growth of the population of cats and dogs (i. e., only one female from the pack reproduces, the weakest specimens die, the absence of preventive and curative medicine); the overpopulation of cats and dogs occurs in various countries worldwide and is considered a severe public health problem.[5, 6] The causes that have favored the excessive growth of the number of cats and dogs are diverse; uncontrolled breeding, the abandonment of animals on public roads and the availability of their food resources, the lack of official population control programs, and the absence of domestic animal trade regulation.[7, 8] Furthermore, the scarce information and awareness of human society regarding the responsibility to maintain and care for their animals has also played an essential role in the overpopulation of these animals, in addition to the specific characteristics of dogs and cats, such as their great adaptability to complex environments.[9, 10]

Through a meta-analysis study, more than 700 million dogs were estimated worldwide in 2014.[6] In México, estimations indicate that there are 23 million dogs and cats, of which 30% live at homes, and the remaining 70% are homeless.[11] However, there are no censuses with a statistical base on existing cats and dogs' numbers to our knowledge. There are currently methods to estimate the population of dogs and cats living at homes, such as random surveys through telephone calls or home visits, statistical models to estimate animal populations based on the human population or other data.[4, 9, 12] However, to calculate the number of dogs and cats living at homes is necessary to visualize the circumstances and resources available in each area and the susceptibility of bias in the method to be chosen as under/overestimate the population size or the failure to locate or contact a household.[4,13]

In 2014, the National Institute of Statistics, Geography and Informatics [Instituto Nacional de Estadística Geografía e Informática] (INEGI) made the "Bienestar

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Subjetivo en México, Módulo BIARE Ampliado" survey, regarding the welfare of the human population of Mexico. This survey was applied during home visits of the 32 states of Mexico stratified by socioeconomic status (low, medium-low, medium-high, and high) and involving three selection stages. One of the survey questions asked if an adult per household had a pet and what kind (dog, cat, other).[14] Although this survey provided a reasonable estimate of the proportion of adults who owned a dog or a cat, it has never been used to attempt population estimates. In addition, it is essential to estimate the population of canines and felines living in Mexico to estimate the population of stray dogs and cats.[3]

Population size estimation of the cats and dogs in the states of Mexico will allow preparing a budget and a strategy to formulate and address public policies and the design of adequate control strategies population of cats and dogs. This study aims to use the official data reported by INEGI in 2014 to estimate the size of the cat and dog population living at homes in Mexico toward a constant-share model.

Materials and methods

Study design

The present work is a retrospective study; the calculation of the variables was made using R statistical software version 4.02.[15]

Estimation of the dog and cat population living at homes in Mexico

We used a constant-share model, a ratio extrapolation method, which can be applied in situations where the area (population) of interest is linked to the "parent" area (population) and which assumes that a smaller area's share of the larger area's population is held constant at a level observed during a base period.[12] Data from the "Bienestar Subjetivo en México, Módulo BIARE Ampliado" survey made in 2014 was used as the population in a smaller area. We obtained the number of dogs and cats indirectly by considering the number of adults who responded yes on owning a dog and/or cat to estimate the dog and cat population living at homes by state. We consider the human population reported in 2014 and the human population projection for 2022 made by the National Population Council [Consejo Nacional de Población] (CONAPO).[16]

The constant-share model is expressed as:

$$P_{it} = \frac{P_{i1}}{P_{J1}} P_{jt}$$

Where: P_{it} is the canine population projection in 2022, P_{i1} the canine population of 2014, P_{j1} the adult population of 2014, and P_{jt} is the projection of adults in 2022.

We also estimated the proportions of adults who owned a dog and adults who owned a cat, and the human:dog and human:cat ratios by dividing the estimated total adult population in Mexico in 2022 reported by CONAPO[16] into the estimated canine and feline population for 2022.

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Results and discussion

To our knowledge, there are no censuses or approximations with a solid statistical base on existing cat's and dogs' numbers. Therefore, in this paper using the official data reported from "Bienestar Subjetivo en México; Módulo BIARE Ampliado" survey made in 2014 by INEGI[14] were estimate 42 625 010 dogs and 7 346 925 cats in Mexico in 2022 through a constant-share model.[12]

According to data reported in 2014 from the "Bienestar Subjetivo en México; Módulo BIARE Ampliado" survey,[14] 39 million and 6 million out of the 80 million adults per household answered had at least one dog or cat respectively. Thus, at least 56 % of adults in Mexico had a dog or cat, 49 % had a dog, and 7.5 % of adults had a cat in 2014. This data are consistent with the reported in other countries as Guatemala, Brazil, Chile, Peru that has dog-owning households account for half or more of all the homes studied[17] in Ethiopia, 65.1 % of households owned dogs, and 39.2 % of them own cats.[18]

According to the constant-share model, the estimation of the population by state revealed that the state with the largest dog population is the Estado de México, with more than six million dogs living at homes. In contrast, the state with the smallest dog population was Colima with 245 489 (Table 1). The average number of dogs in households, considering the number of dogs in all the states of Mexico, was 1 332 032, and the sum of the number of dogs living at homes from all the states was 42 625 010.

Estimating the cats' population with the constant-share model change used in this paper suggests that the number of cats in households throughout Mexico (7 346 925) is at least 5.8 times less than that of dogs. The state that leads the list is the Estado de México, with 962 177 cats. Baja California Sur has the least number of cats with just over 30 000 (Table 1). The average number of cats living at homes in the different states of Mexico was 229 579.

The 95 % confidence interval (CI) of adults that own at least one dog/cat in 2022 are shown in Table 1. The ownership of dogs per adult in Mexico varies between 30 and 60 %. According to the results obtained, in Guanajuato, 58 % of adults own a dog. The state where the adults have fewer dogs is Ciudad de México, with 31 %. The average number of adult dog owners in Mexico is 49.71 %. The number of adult owners of cats varies between 5 and 14 %. Michoacán was the state in which more adults owned cats are reported (13.73 %). In contrast, Chiapas and Ciudad de México have fewer adults who own a cat (lower than 5 %). The average of adults who own cats in Mexico is 8.8 % (Table 1).

Considering the total population, Mexico's human:dog ratio was 2.4:1, and the human:cat ratio was 17.6:1. The highest human:dog ratio of the 32 states corresponded to Ciudad de México with 4.2:1, while Estado de México, Guanajuato, and Yucatán have the lowest human:dog ratio (2.6:1). The highest human:cat ratio was estimated for Chihuahua, with 31.4:1, while that of Michoacán and Yucatán was the lowest (11:1) (Table 1).

The human to dog/cat ratio is often used as an indicator of canine or feline over-population.[18] In this study, the estimate for the year 2022 of the relation human: dog and human: cat was established for each Mexican state; other studies that have shown a similar assessment of human:dog living at homes; in Puebla, Mexico was 3.4:1,[19] in Mexicali, Baja California was 4.3:1.[20] In the current study, the estimate was 2.8:1 for Puebla and 3.0:1 for Baja California. In other countries

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Table 1. Estimated proportions of adults that owned at least one dog/cat and the human:dog; human:cat relationship in each state of Mexico for 2022

State	Adults : dogs proportion (CI)[1]	Adults : cats proportion (CI)	Estimated dogs	Estimated cats	Human : dog ratio	Human : cat ratio
Aguascalientes	0.4570 (0.4559 - 0.4581)	0.0605 (0.0601 - 0.0611)	435 786	57 732	3.3 : 1	25.2 : 1
Baja California	0.4789 (0.4783 - 0.4795)	0.0551 (0.0548 - 0.0554)	1 208 477	139 122	3.0 : 1	26.4 : 1
Baja California Sur	0.4771 (0.4758 - 0.4785)	0.0541 (0.0535 - 0.0547)	266 954	30 282	3.0 : 1	26.8 : 1
Campeche	0.5192 (0.518 - 0.5205)	0.0894 (0.0887 - 0.0901)	352 591	60 702	2.8 : 1	16.4 : 1
Ciudad de México	0.3094 (0.3091 - 0.3098)	0.0494 (0.0492 - 0.0495)	2 104 749	335 871	4.2 : 1	26.5 : 1
Chiapas	0.5024 (0.5018 - 0.503)	0.0473 (0.047 - 0.0476)	1 747 581	164 582	3.5 : 1	20.7 : 1
Chihuahua	0.4687 (0.4682 - 0.4693)	0.0785 (0.0782 - 0.0788)	1 201 936	201 321	3.0 : 1	31.4 : 1
Coahuila	0.5573 (0.5566 - 0.558)	0.0569 (0.0566 - 0.0573)	1 194 600	122 033	2.7 : 1	26.4 : 1
Colima	0.4551 (0.4537 - 0.4565)	0.0952 (0.0944 - 0.0961)	245 489	51 372	3.2 : 1	15.2 : 1
Durango	0.4921 (0.4912 - 0.4931)	0.0830 (0.0824 - 0.0835)	600 109	101 149	3.1 : 1	18.3 : 1
Estado de México	0.5555 (0.5552 - 0.5558)	0.0797 (0.0795 - 0.0799)	6 706 251	962 177	2.6 : 1	18.2 : 1
Guerrero	0.5061 (0.5054 - 0.5067)	0.1076 (0.1072 - 0.108)	1 164 644	247 540	3.1 : 1	14.5 : 1
Guanajuato	0.5830 (0.5825 - 0.5835)	0.0737 (0.0735 - 0.074)	2 379 129	300 919	2.6 : 1	20.5 : 1
Hidalgo	0.5525 (0.5518 - 0.5532)	0.1122 (0.1118 - 0.1126)	1 142 493	232 006	2.7 : 1	13.2 : 1
Jalisco	0.4642 (0.4638 - 0.4646)	0.0884 (0.0881 - 0.0886)	2 622 731	499 363	3.2 : 1	16.7 : 1
Michoacán	0.5063 (0.5057 - 0.5069)	0.1373 (0.1369 - 0.1377)	1 576 997	427 638	3.0 : 1	11.0 : 1
Morelos	0.5113 (0.5105 - 0.5122)	0.1141 (0.1136 - 0.1147)	719 841	160 645	2.8 : 1	12.6 : 1
Nayarit	0.4908 (0.4897 - 0.4918)	0.1268 (0.1261 - 0.1276)	419 641	108 445	3.0 : 1	11.8 : 1
Nuevo León	0.4514 (0.4509 - 0.452)	0.0606 (0.0604 - 0.0609)	1 763 372	236 780	3.2 : 1	23.7 : 1
Oaxaca	0.5188 (0.5182 - 0.5194)	0.1138 (0.1134 - 0.1142)	1 394 967	306 079	2.9 : 1	13.3 : 1
Puebla	0.5505 (0.5501 - 0.551)	0.1153 (0.115 - 0.1156)	2 377 201	497 873	2.8 : 1	13.2 : 1
Querétaro	0.5350 (0.5342 - 0.5359)	0.0934 (0.0929 - 0.0939)	834 436	145 659	2.8 : 1	15.8 : 1
Quintana Roo	0.4571 (0.4561 - 0.4581)	0.0819 (0.0814 - 0.0825)	545 434	97 777	3.2 : 1	17.9 : 1
Sinaloa	0.4466 (0.446 - 0.4473)	0.1001 (0.0997 - 0.1005)	962 155	215 712	3.3 : 1	14.6 : 1
San Luis Potosí	0.5270 (0.5263 - 0.5277)	0.0920 (0.0916 - 0.0925)	1 003 550	175 254	2.8 : 1	16.3 : 1
Sonora	0.5111 (0.5104 - 0.5118)	0.0886 (0.0882 - 0.089)	1 077 319	186 668	2.9 : 1	16.6 : 1
Tabasco	0.4170 (0.4162 - 0.4178)	0.0532 (0.0528 - 0.0535)	713 210	90 945	3.6 : 1	28.0 : 1
Tamaulipas	0.4886 (0.488 - 0.4892)	0.0663 (0.066 - 0.0667)	1 203 024	163 357	3.0 : 1	22.0 : 1
Tlaxcala	0.5587 (0.5576 - 0.5597)	0.1054 (0.1047 - 0.1061)	515 056	97 177	2.7 : 1	14.2 : 1
Veracruz	0.4700 (0.4695 - 0.4704)	0.1074 (0.1071 - 0.1076)	2 723 861	622 382	3.1 : 1	13.5 : 1
Yucatán	0.5620 (0.5611 - 0.5628)	0.1309 (0.1303 - 0.1314)	886 808	206 525	2.6 : 1	11.0 : 1
Zacatecas	0.4991 (0.4981 - 0.5001)	0.0951 (0.0945 - 0.0956)	534 619	101 840	3.0 : 1	16.0 : 1

[1]CI: 95% onfidence interval, calculated using the constant-share model with information based on official census data.[14]

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as Ethiopia, the human to dog ratio was 6:1, and the human to cat ratio was 10:1,[18] whereas 5:1–6:1 was reported from urban places of Chile,[21] 3.8:1 for Philippines.[22] The variation in the dog and cat population in the different reports could be related to the countries' socioeconomic status and cultural differences.

The present study is based on official data reported by INEGI, where the sample size was designed to guarantee the national and federal representativeness of the responses of the adult population.[14] INEGI carried out around 44 500 random surveys in Mexico, a figure that is higher than 38 405 surveys, which is the amount of the sample size required to have a 95% of confidence level and a margin of error of 0.05 with a population of 131 701 579 Mexicans 2022, according to the Survey System Software (https://www.surveysystem.com/sample-size-formula.htm).

This study shows the proportion of adults who own dogs and cats, including the total of adults surveyed with a CI of 95%, indicating that the real value within the given range is 95% certainty. Furthermore, reports suggest that the household selection method must guarantee a random and representative sample of the region.[3] Therefore, it is fair to say that the sample they used to carry out the survey is representative and extrapolated.

In the present work, a growth of the population of dogs in households is 26.15% and cats of 6.8% in 8 years is estimated. In Mexico, although the parameters used are unknown, a population growth rate of stray dogs of 20% in 10 years has been estimated.[23] It is known that the growth of the canine and the feline population is not linear, especially in animals that are not under the direct care of humans.[24] So, it is necessary to perform further studies to validate the population growth rate in Mexico since estimations indicate that 30% of animals are living at homes, and the remaining 70% are homeless.[11]

The canine and feline overpopulation represent a serious problem.[25] The most common strategies for population control are humanitarian euthanasia and surgical spaying and neutering.[26, 27] However, Diase et al.[28] reported that they do not have a significant impact on the decrease in the animal population since it has even been estimated that with neutering 100% of the animals annually, it would not be possible to obtain proportions higher than 86% and 88% of the dogs and cats neutered respectively after 20 years due to the high introduction of new intact animals, and would only obtain a reduction of 12-14% of the dog population.[28]

So, the population control of dogs and cats should be taking on count not only spaying and neutering campaigns but also the improvement of responsible ownership the abandonment, and by reducing the carrying capacity of the environment as availability of water and food, shelter, the mindset and behavior of human beings, and the fact that dogs and cats are very prolific species.[8, 28] Female dogs present one to three estrous cycles each year and can have more than ten puppies in each litter; the cats have cycles continuously every 4 to 30 days if exposed to 14 light hours per day and can have 1 to 5 kittens per litter.[29, 30] According to the World Organization for Animal Health, encouraging responsible dog ownership can significantly reduce the number of dogs and cats and the incidence of zoonotic diseases; since feline and canine ecology is linked to human activities, thus, the effective control of the dog and cat population must be accompanied by changes in human behavior.[8, 31]

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A significant limitation in this study is the limited information available and therefore is difficult to estimate the number of cats and dogs with a robust statistical model. Despite the limited data availability, we used the constant-share model to estimate the cat and dog population. This method requires historical data from only one point and assumes that all the smaller areas will grow simultaneously as the parent area.[12] Furthermore, we assumed that the proportion of people who owned dogs and cats in 2014 is the same as those who owned a canine or feline in 2022. In the BIARE survey, one adult per house was asked if they had at least an animal or pet for company.

A positive answer corresponds only to a dog or cat; therefore, the estimation reported in this paper could represent an overestimate population size bias because it is probably that in a house, there is more than one dog. Thus, national censuses for the pet population are necessary to use more robust statistic methods that considered load capacity, cat and dog birth, and the female: male ratio to obtain exact data of feline and canine population in Mexico.

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Data availability

All relevant data are within the manuscript. The datasets used and analyzed here are available from the corresponding author on reasonable request.

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Conflicts of interest

None of the authors has a personal or financial relationship with other organizations or people that could influence or bias the content of the paper.

Author contributions

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