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Inequality in the distribution of Ear Nose and Throat specialists in 15 Latin American countries

Journal:	*BMJ Open*
Manuscript ID	bmjopen-2019-030220
Article Type:	Research
Date Submitted by the Author:	05-Mar-2019
Complete List of Authors:	Bright, Tess; London School of Hygiene & Tropical Medicine, CRD Mújica, Oscar; Pan American Health Organization, PAHO/WHO, Intelligence for Action in Health Ramke, Jacqueline; LSHTM, Moreno, Claudia; Pan American Health Organization Der, Carolina ; Clínica Alemana de Santiago, Facultad de Medicina Universidad del Desarrollo Melendez, Amarilis; Hospital Santo Tomas Lara Ovares, Ericka; University of Minnesota , School of Public Health Sandoval Domingues, Edgar; Instituto de Seguridad y Servicios Sociales de los Trabajadores del Estado Santana Hernandez, Diego Jose; CBM Christoffel-Blindenmission Chadha, Shelly; The World Health Organization , WHO Programme for Prevention of Deafness and Hearing Loss Silva, Juan Carlos; Pan American Health Organization Penaranda, Augusto; Fundacion Santafe de Bogota
Keywords:	Health policy < HEALTH SERVICES ADMINISTRATION & MANAGEMENT, Organisation of health services < HEALTH SERVICES ADMINISTRATION & MANAGEMENT, OTOLARYNGOLOGY, Health equity

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Title: Inequality in the distribution of Ear Nose and Throat specialists in 15 Latin American countries

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1

1 **Abstract**

2 *Objective:* To explore socio-geographic inequalities in the availability and

3 distribution of Ear Nose and Throat specialists (ENTs) in 15 Latin American (LA)

4 countries.

5 *Design:* Ecological

6 *Setting:* Spanish and Portuguese speaking countries of Latin America

7 The number of registered ENTs in 2017 were obtained from the National ENT

8 Society in each country.

9 *Outcome measures:* The ENT rate/million population was calculated at the national

10 and sub-national (e.g. state) level. Three measures were calculated to assess sub-

11 national distributive inequality of ENTs: i) absolute and ii) relative index of

12 dissimilarity; and iii) concentration index (using the Human Development Index as

13 the equity stratifier). Finally, the ratio of ENTs/million population in the capital area

14 compared to the rest of the country was calculated.

15 *Results:* There was a more than a 30-fold difference in the number of ENTs/million

16 population across the included countries—from 61.0 in Argentina (95% Confidence

17 Interval (CI) 58.7–63.4) to 2.8 in Guatemala (95%CI 2.1–3.8). In all countries ENTs

18 were more prevalent in advantaged areas and in capital areas. To attain distributive

19 equality, Paraguay would need to redistribute the greatest proportion of its ENT

20 workforce (67.3%; 95%CI 57.8–75.6) and Brazil the least (18.5%; 95%CI 17.6–19.5).

21 *Conclusions:* There is high inequality in the number and distribution of ENTs

22 between and within the 15 studied countries in Latin America. This evidence can be

23 used to inform policies that improve access to ear and hearing services in the region,

24 such as scale-up of training of ENTs and incentives to distribute specialists equally.

25 These actions to reduce inequities, alongside addressing the social determinants of

26 ear and hearing health, are essential to realise Universal Health Coverage.

27

2

1 **Strengths and limitations of this study**

2 • This is the first regional-level analysis on the availability and distribution of ENT

3 specialists in Latin America, and includes 15 of the 19 Spanish or Portuguese-

4 speaking countries.

5 • The three inequality measures used to assess subnational inequality—the

6 relative concentration index, the absolute index of dissimilarity and the relative

7 index of dissimilarity—take into account the entire population and are population-

8 weighted, thus giving equal weight to each individual's access to ENTs.

9 • The data were obtained from national ENT societies, which may not be

10 representative of all available ENTs, as some ENTs may not be society-affiliated.

11 • Data were not available on the distribution of ENTs in private vs public health

12 services. Consequently, our results may overestimate the availability of ENTs for

13 people without the resources to access the private sector.

14

3

Introduction

In 2018 there was an estimated 466 million people with disabling hearing loss, and over 80% of these reside in low and middle income countries (LMICs).[1] The World Health Organization (WHO) has estimated that by 2050 one in ten, or 900 million people, will experience disabling hearing loss unless substantial public health measures are implemented.[1] The predicted increase in prevalence can be attributed to the expected rise in global population, and global ageing.[1]

Consequently, there is a need for ear and hearing services, including surgical (e.g. Ear Nose and Throat specialists (ENTs)) and rehabilitative services (e.g. audiologists, and speech therapists), to meet the increasing demand. Indeed, in order to achieve Universal Health Coverage (UHC) for the millions of people with hearing loss globally, equitable access to effective, high quality and affordable ear and hearing services is vital. However, access to these services is extremely low in LMICs,[2] due to a dearth of human resources.[3,4]

Latin America (LA) has a combined population of 600 million people, approximately 42 million (7%) of whom are estimated to have disabling hearing loss.[1,5] Countries within LA are highly diverse in terms of their historical, economic, political, and sociocultural contexts.[6] As an example, the GDP per capita in Chile is $15,346, more than three times as much as Guatemala ($4,470).[6,7] These vast economic differences have shaped health systems reforms in the region and efforts to achieve UHC.[6,8] As a consequence, countries in the region show variation in terms of human resource shortages for health care.[9] Previous research has found substantial shortages in the number of ENTs in 50% of LA countries.[10] Other professionals involved in ear and hearing care services, such as audiologists an speech therapists, are in even shorter supply.[11] There is also some evidence that within countries, ENTs are unequally distributed, with a higher concentration in urban compared to rural areas.[12] However, these inequities have not been examined in depth.

This study aimed to explore socio-geographic inequalities in the availability and distribution of ENTs both within and between 15 LA countries. The study hypothesised that regional variation in the availability of ENT specialists per million population exists. Within countries, ENT specialists were hypothesised to be

4

1   unequally distributed across sub-national regions, with the majority concentrated in

2   areas of higher human development.

Methods

4   This is an ecological study that assesses the distributive inequality of ENT specialists

5   in 15 countries in LA using standard measures of disproportionality across sub-

6   national social gradients (defined by Human Development Indices). Ethical approval

7   was not sought for this study, which used publicly available population data with

8   organisational practitioner data.

Data sources

Population

11 This paper focuses on the Spanish and Portuguese speaking countries of LA, of

12 which there are 17. All LA countries were invited to participate, and 15 responded.

13 The 15 included countries consist of 294 first-order sub-national units (e.g.

14 department, province, state). Population data for these units were obtained from the

15 national institutes of census and statistics of each country. The combined population

16 of the included countries represent 96.7% of people in the LA Spanish and

17 Portuguese speaking countries, and 88.2% of the total Latin America and the

18 Caribbean regional population in 2017.[13]

Personnel

20 Although ENT specialists alone do not capture the full complement of ear and

21 hearing services necessary to treat and manage hearing loss, they were chosen as a

22 key indicator to measure inequalities in access to ear and hearing services. An "ENT

23 specialist" is defined for the purposes of this paper as a medical doctor who has

24 been trained in the management of ear, nose and throat conditions, through a

25 recognised degree.[4] Hereafter we refer to ENT specialists as ENTs.

26 In each country, data on the number ENTs registered at each of the sub-national

27 units in 2017 were obtained from the National Society of ENTs. Societies were

28 contacted by the Interamerican Association of Paediatric Otorhinolaryngology-IAPO

29 or study authors, either by phone or email. Society membership requires a medical

5

degree, completion of residency at an accredited medical school, and a national practice license.

Human Development Index

The Human Development Index (HDI) was used as the equity stratifier of the sub-national units. The HDI is widely used by the United Nations Development Programme as a composite measure of achievement in three key dimensions of human development—health, education, and standard of living.[14] The HDI score is a value between zero and one which represents the geometric mean of the index of the three dimensions.[14] The most recent HDI for the sub-national units of each country were obtained from UNDP reports from each country. To create the social gradient, within each country, sub-national units were ordered from lowest HDI (most socially disadvantaged) to highest HDI (most socially advantaged).

Analysis

Availability of ENT personnel

The number of ENTs/million population was calculated for each sub-national unit of each country. The mean and 95% confidence interval (CI) of ENTs/million population at the national level were calculated.

Inequality measures

Inequality in the distribution of ENTs was assessed using three common indicators of health inequality[15,16,17]:

- Relative concentration index (RCI)

   The RCI is a relative measure of gradient inequality that indicates the extent to which a health indicator is concentrated among the disadvantaged or the advantaged.[17] In this analysis the RCI measures the extent to which the ENT distribution across sub-national units is systematically associated with the social advantage of each sub-national unit (measured by HDI). RCI takes a value between -1 and 1, with 0 indicating no inequality (i.e., equal distribution). A negative value of RCI indicates ENTs are concentrated among more disadvantaged sub-national units, and a positive value indicates ENTs are concentrated among more advantaged sub-national units.

6

1   The RCI was calculated for each country using non-linear optimization to fit a

2   Lorenz concentration curve and calculating the area under the curve.[18] The

3   curve equation fit the observed cumulative proportion of the population (as

4   ranked by the HDI of each sub-national unit) against the cumulative proportion of

5   ENTs.

6   • <u>Absolute index of dissimilarity (aID)</u>

7   The aID quantifies the number of ENTs within a given country who would need to

8   be redistributed for the national rate of ENTs/million population to be achieved in

9   each sub-national unit i.e. equitable distribution. The aID is half the sum of the

10   absolute value of the differences between the national average ENTs and the

11   number of ENTs observed in each unit.

12   • <u>Relative index of dissimilarity (rID)</u>

13   The rID is the relative equivalent of the aID, representing the percentage of ENTs

14   who would have to be redistributed to achieve equitable sub-national distribution.

15   The rID is computed by dividing the aID by the total number of ENTs

16   available.[15,18] The closer rID is to 100%, the greater the inequality.

17

18   *Regional benchmarking*

19   WHO recommends benchmarking within regions to understand one country's level of

20   inequality in relation to others.[17] To benchmark ENT distribution in LA we calculated

21   the regional weighted mean of ENTs/million population and the regional distributional

22   inequality (measured by the RCI). We used these regional averages to construct a

23   framework[19] with four quadrants and mapped each country based on whether its

24   ENT rate and RCI were higher or lower than the regional average. The HDI level of

25   each country[20] was also indicated.

26   *Urban concentration*

27   To assess the extent of urban concentration of ENTs, the ENTs/million population in

28   the capital area for each country (i.e. the sub-national unit that contains the

29   constitutional capital or the seat of government city), as compared to the rate in the

30   rest of the country combined (i.e. all sub-national units apart from the capital area).

31   The ratio of ENTs/million population in the capital compared to the rest of the country

32   was calculated.

7

All statistical analyses were performed in MS Excel Solver and ToolPak add-ins (Microsoft Corp., Redmond, Washington, USA), using a semiautomated analytical template tool developed by the Pan American Health Organization (PAHO) for exploratory data analysis of social inequalities in health. Uncertainty was ascertained by computing 95% CIs for all summary measures of health inequality as well as the mean number of ENTs/million population.

Results

Between country inequality

In these 15 LA countries, there was large variation in the size of the ENT profession, the rate of ENTs/million population and the distributive inequality (Table 1). For example, Brazil had 6,159 registered ENTs while Nicaragua had only 38. When the population size was taken into account, there was a more than a 30-fold difference in the number of ENTs/million population—from 61.0 in Argentina (95%CI 58.7–63.4) to 2.8 in Guatemala (95%CI 2.1–3.8) (Table 1). There was also large variation in distributive inequality. In all countries ENTs were more prevalent in advantaged areas but the extent of this inequality varied greatly—inequality was lowest in Brazil (RCI 0.249; 95%CI 0.133–0.365) and highest in Paraguay (RCI 0.819; 95%CI 0.769–0.870) (supplementary figure 1).

Regional benchmarking

The regional variation in the ENT rate and distributive inequality is depicted in Figure 1. The high ENT rate in Argentina—more than twice as high as the rate in the next highest country—inflated the regional weighted mean of 24.5/million (95%CI 23.3–25.7) (Figure 1). Brazil and Chile were the only other countries to have an ENT rate higher than the regional average. These three countries also had lower distributive inequality than the regional average (RCI 0.344; 95%CI 0.227–0.460), placing them in the best performing, top left quadrant of Figure 1. In contrast, the countries in the bottom right quadrant had a lower ENT rate and higher inequality compared to the regional average, with Guatemala arguably furthest behind other countries in the region.

8

1 The ENT rate tended to reflect the national HDI level. Countries with very high HDI

2 had the highest ENT rate, followed by countries with high HDI, and then countries

3 with medium HDI tending to have the lowest ENT rate. Distributive inequality was

4 similar with two exceptions—Paraguay and Panama are high HDI countries but had

5 distributive inequality more equivalent to countries of medium HDI (Figure 1).

6 *Within country inequality*

7 The redistributive potential to achieve equality mirrored the RCI results, with Brazil

8 needing to redistribute the lowest proportion of their ENTs to achieve distributive

9 equality (rID 18.5%; 95%CI 17.6–19.5) and Paraguay the highest (rID 67.3%; 95%CI

10 57.8–75.6) (Table 1). Due to the size of the respective workforce, this equates to

11 redistributing 1,142 ENTs in Brazil and 70 in Paraguay (aID; Table 1).

12 <u>Urban concentration</u>

13 In all countries, even when the population size was taken into account, ENTs were more

14 concentrated in capital areas (Table 2). Argentina fared best, but the ENT rate in the

15 capital area remained over twice as high as the rest of the country (C:R ratio 2.3; 95%

16 CI 2.1–2.5).

17 The largest inequality between capital and other areas was seen in Paraguay (C:R ratio

18 36.7; 95%CI 23.6–57.2), Venezuela (C:R ratio 15.2; 95%CI 12.9–17.9) and Panama

19 (C:R ratio 15.1; 95%CI 4.7–48.5). The high C:R inequality observed in Paraguay and

20 Venezuela was driven by high ENT rates in the capital. In turn, these rates were driven

21 by the low proportion of the national population residing in the capital area (7.6% and

22 6.6% respectively), combined with the majority of ENTs being located there (75.0% and

23 51.9% respectively). In contrast, the high C:R inequality in Panama was driven by the

24 very low ENT rates in the rest of the country, with only three of the country's 53 ENTs

25 (5.7%) stationed outside the capital (Table 2).

26

9

1 **Table 1:** Distributive inequality of ENTs per million population in 15 Latin American countries, 2017

Country	Population[a]	Number of ENTs[b]	Number of sub-national units (e.g. states)[a]	ENTs per million population Mean	95%CI	Concentration index Mean	95%CI		Absolute index of dissimilarity Mean	95%CI	Relative index of dissimilarity Mean (%)	95%CI
Argentina	44,044,811	2,688	23	61.0	58.7-63.4	0.259	0.128-0.391	†	575	534-618	21.4	19.9-23.0
Bolivia	11,145,770	130	9	11.7	9.7-13.8	0.686	0.507-0.864	†	75	64-86	57.7	49.1-65.8
Brazil	207,660,929	6,159	27	29.7	28.9-30.4	0.249	0.133-0.365	†	1,142	1,083-1,203	18.5	17.6-19.5
Chile	17,598,287	461	13	26.2	23.9-28.7	0.287	0.058-0.517	†	115	98-134	24.9	21.2-29.1
Colombia	49,291,609	584	33	11.8	10.9-12.8	0.349	0.262-0.437	†	155	135-177	26.5	23.1-30.3
Costa Rica	4,947,481	103	7	20.8	17.0-25.2	0.334	-0.065-0.732	†	35	26-45	34.0	25.6-43.6
El Salvador	6,581,940	59	14	9.0	6.8-11.6	0.670	0.546-0.794	†	34	27-41	57.6	44.9-69.4
Guatemala	16,924,191	48	22	2.8	2.1-3.8	0.782	0.749-0.816	†	32	25-38	66.7	52.5-78.3
Honduras	8,866,351	71	18	8.0	6.3-10.1	0.570	0.441-0.699	†	36	28-44	50.7	39.3-62.0
Mexico	124,041,731	2,207	32	17.8	17.1-18.6	0.336	0.238-0.433	†	631	590-673	28.6	26.7-30.5
Nicaragua	6,262,703	38	17	6.1	4.3-8.3	0.442	0.291-0.593	†	16	11-22	42.1	27.9-57.8
Panama	4,098,135	53	12	12.9	9.7-16.9	0.651	0.564-0.738	†	22	16-29	41.5	29.3-54.9
Paraguay	6,941,905	104	18	15.0	12.2-18.2	0.819	0.769-0.870	†	70	60-79	67.3	57.8-75.6
Peru	29,381,884	646	25	22.0	20.3-23.7	0.385	0.276-0.494	†	213	190-237	33.0	29.5-36.7
Venezuela	31,428,916	580	24	18.5	17.0-20.0	0.446	0.307-0.586	†	275	252-299	47.4	43.4-51.5
All countries	569,216,643	13,931	294	24.5	23.3-25.7	0.344	0.227-0.460	†	3,426	3,139-3,725	28.5	25.5-31.5

2 *ENT: Ear nose and throat specialist*

3 *a Source: National Institute of Statistics   b Source: National Society of ENTs*

10

1 **Table 2:** Number of ENTs per million population in the capital area compared to the rest of the country in 15 Latin American countries, 2017

Country	ENTs per million population				Ratio of ENT rate Capital: Rest-of-country (C:R ratio)			Proportion of population in Capital area (%)[a]	Proportion of ENTs in Capital area (%)[b]	Capital area description
	Capital area		Rest-of-country							
	Mean	95%CI	Mean	95%CI	Mean	95%CI				
Argentina	88.1	84.0-92.3	38.4	35.9-40.9	2.3	2.1-2.5	†	45.6%	65.8%	Buenos Aires Autonomous City
Bolivia	37.7	31.0-45.6	2.7	1.7-4.0	14.2	9.0-22.5	†	25.7%	83.1%	La Paz Department
Brazil	67.8	58.8-77.7	29.1	28.4-29.8	2.3	2.0-2.7	†	1.5%	3.3%	Federal District
Chile	42.3	37.7-47.4	15.3	13.0-17.8	2.8	2.3-3.4	†	40.4%	65.3%	Metropolitan Region
Colombia	26.7	23.3-30.5	8.9	8.0-9.9	3.0	2.5-3.5	†	16.4%	37.0%	Bogota Capital District
Costa Rica	42.6	33.1-53.9	10.2	7.1-14.3	4.2	2.8-6.3	†	32.8%	67.0%	San Jose Province
El Salvador	28.0	20.8-36.9	1.9	0.9-3.6	14.9	7.3-30.3	†	27.1%	84.7%	San Salvador Department
Guatemala	11.0	7.8-15.1	0.7	0.4-1.4	14.9	7.4-29.8	†	20.4%	79.2%	Guatemala Department
Honduras	24.4	17.3-33.3	4.4	3.0-6.2	5.5	3.5-8.8	†	18.1%	54.9%	Francisco Morazan Department
Mexico	65.4	60.3-70.9	14.0	13.4-14.7	4.7	4.2-5.1	†	7.3%	26.8%	Federal District
Nicaragua	14.1	8.8-21.6	3.6	2.1-5.7	4.0	2.1-7.5	†	23.7%	55.3%	Managua Department
Panama	23.3	17.3-30.7	1.5	0.3-4.5	15.1	4.7-48.5	†	52.4%	94.3%	Panama Province
Paraguay	148.8	117.6-185.7	4.1	2.6-5.9	36.7	23.6-57.2	†	7.6%	75.0%	Asuncion Capital City
Peru	36.5	32.7-40.5	15.1	13.4-16.9	2.4	2.1-2.8	†	32.3%	53.6%	Lima Department
Venezuela	144.3	128.5-161.6	9.5	8.4-10.7	15.2	12.9-17.9	†	6.6%	51.9%	Capital District

2 *ENT: Ear nose and throat specialist*

3 *a Source: National Institute of Statistics   b Source: National Society of ENTs*

4 *†statistically significant departure from equality (i.e. statistically different from zero) at p<0.05 level*

5

6

7

11

1 **Discussion**

2 This study examined the socio-geographic distribution of ENTs between and within

3 15 LA countries. We found that the availability of ENTs across countries of the region

4 is highly variable. Within countries, the distribution was shown to be unequal, with

5 more socially advantaged areas, and capital areas, having a higher concentration of

6 ENT specialists. Despite inequality in countries such as Argentina, Brazil and Chile

7 being up to three times lower than Paraguay and Guatemala, the RCI in all 15

8 countries was at a level WHO considers a high level of relative inequality.[17] This high

9 inequality was reinforced by the rID, which indicates between one in five ENTs in

10 Brazil and two in three ENTs in Paraguay would need to be redistributed to attain

11 socio-geographic equality.

12 The findings of this study concur with previous literature from both the LA region and

13 elsewhere. Wagner et al. (2013) and Stolovitsy et al. (2018) also found that

14 Guatemala had the poorest ratio of ENTs/100,000 population (4 per million), which

15 was only 11% of the ratio in the United States.[10,12] Both studies also found the

16 highest ratio was in Argentina (56 per million). These trends align with our findings,

17 however we found a lower ratio in Guatemala and higher ratio in Argentina which

18 may be explained by population increases, or increases in the numbers of ENTs

19 respectively.[10,12] In 2001, Madriz and colleagues surveyed 15 Latin American and

20 the Caribbean countries to determine the resources available for hearing impairment,

21 including prevalence data, training programmes, and equipment. They found Brazil

22 (5000 ENTs), Argentina (3000 ENTs), and Mexico (2400 ENTs) had the greatest

23 absolute numbers of human resources. Although the survey was published over 15

24 years ago, it appears that there has been little progress in human resource

25 development since this study was conducted.[11] In fact, the number of ENTs in our

26 study was lower in comparison for Argentina, Guatemala, and Mexico. This may be

27 due to differences in data sources, with the 2001 survey using expert opinion across

28 a range of institutions rather than National societal membership.[11] In 2012, the WHO

29 conducted a global survey of availability of human resources to provide ear and

30 hearing care. They demonstrated great variation in availability of ENTs, audiologists,

31 and speech therapists globally, and a clear trend of increased availability with

32 country-income group.[4]

12

1 Despite the trend in increased availability with national income, inequalities in access

2 to services still exist within countries. Within country disparities in availability of ENTs

3 have been less well documented. Westerburg et al. (2018) reports that the

4 geographic distribution of ENTs in North America is inequitable, contributing to poor

5 access for vulnerable populations.[21] In Canada, for example, the majority of

6 providers are located in urban centres, and there are no providers at all in many

7 areas where Aboriginal populations are concentrated.[21] The trends we found in this

8 study have also been observed in eye health. Hong et al. (2016) found that

9 ophthalmologists are more concentrated in socially advantaged areas within

10 countries.[22] However, comparisons to this study highlight that the low coverage of

11 ENTs appears to be more pronounced than in eye health. For example in

12 Venezuela, there are 42 ophthalmologists/million, whereas our analysis found a ratio

13 of 18.5 ENTs/million. Thus, for every ENT in Venezuela there are two

14 ophthalmologists. This is despite comparable burden of impairments (16%

15 hearing;18% vision).[23] The reasons for this difference could allow lessons to be

16 drawn on improving ear and hearing services availability in the country. Compared to

17 ophthalmologists, ENTs in LA also tend to be less equally distributed. There are

18 several possible explanations for this, including the lack of population-based data on

19 need for services, and lack of funding, leading to ear and hearing care not being

20 prioritised by the regional governments.[24]

21 This study has several strengths. Although previous literature has examined

22 numbers of ENTs per population and made comparisons across countries, there has

23 been limited analysis of inequalities within countries. This study adds to the

24 knowledge base by performing a robust, more in-depth analysis of the substantial

25 sub-national inequalities that exist. The three inequality measures used in this

26 analysis take into account the entire population and are population-weighted, thus

27 giving equal weight to each individual's access to ENTs.[16,25] These strengths—along

28 with reflecting the socioeconomic dimension to health inequality—are why WHO

29 recommends the concentration index as a measure of relative inequality.[26] The data

30 coverage of this study was high, representing 96.7% of the LA Spanish and

31 Portuguese speaking countries.

32 There are also limitations which should be taken in to account when interpreting the

33 results. The data were obtained from national ENT societies, which may not be

13

1 representative of all available ENTs within the countries studied as some ENTs may

2 not be society-affiliated. Although ENT specialists are an essential component of

3 functioning ear and hearing care programmes, there are also many other

4 professionals involved in provision of specialist care for hearing loss and ear

5 disease, for instance, audiologists and speech therapists. Further, data on the

6 availability of equipment to enable service provision is not provided. The data also

7 does not capture more nuanced service delivery models common in LMIC, such as

8 surgical outreach to primary and secondary care facilities or telemedicine. This is an

9 area of future research need. Finally, data were not available on the distribution of

10 ENTs in private vs public health services which has an impact on the financial

11 accessibility of the service. Thus, we are unable to draw conclusions on the

12 availability full complement of ear and hearing services. We are also unable to

13 comment on the quality and costs of service provision, which are important

14 components of UHC.[27]

15 This study provides evidence for policy makers to further develop programmes that

16 increase the number of ENTs/million population as well as reduce the inequities in

17 their distribution. The Pan American Health Organisation (PAHO), the regional WHO

18 office for the Americas, has developed a strategy to guide national policies on

19 addressing human resource deficiencies.[28] Some of the key strategies outlined

20 include strengthening governance and leadership, focussing on the number and

21 distribution of personnel according to health needs; partnership with other relevant

22 sectors, such as education, in order to respond to training needs across geographic

23 regions; and implementing staff retention strategies, such as incentives and

24 improved infrastructure.[28] Access to health is required to achieve good health

25 outcomes, however in addressing health inequities, actions must also be taken to

26 address the social determinants of health. As an example, hearing loss and ear

27 disease are linked to poverty, and thus to address the greater burden amongst the

28 poor, a multi-faceted approach is required – beyond a focus on human resource

29 development alone.[29,30]

30 Further research is needed to understand the availability and inequities in distribution

31 of other health professionals relevant to ear and hearing care, including audiologists,

32 and speech therapists, as well as mid-cadre and primary health professionals such

33 as clinical officers that exist in many LMICs. Training primary health workers in ear

14

1 and hearing care has been a key strategy supported by the WHO in order to address

2 the lack of human resources and improve access to services at the community level,

3 in efforts to achieve universal ear and hearing care.[27,31] There is also a need to

4 examine availability of equipment, and other essential elements of service provision.

5 Although this study presents a clear picture of inequalities in distribution of

6 specialists, the need for services is not well understood. There have been very few

7 population-based surveys to determine the prevalence and causes of hearing loss in

8 LA. In LA, there have been three published studies, two of which were in Brazil, and

9 one in Ecuador.[24] Prevalence data are required to plan services according to the

10 population need, including the required number and distribution of specialists.

11 Although global Vision 2020 targets of ophthalmologists per population are

12 contested, they have been used as an advocacy tool to lobby governments for

13 increased resources for eye care. Thus, similar evidence-based targets should be

14 developed for the field of ear and hearing. Vision 2020 has helped garner action to

15 reduce avoidable causes of blindness, at a global and local scale. A similar global

16 initiative for ear and hearing care has been launched in 2018, the World Hearing

17 Forum, which aims to stimulate action and make gains similar to those attained in

18 eye health.[32]

Conclusion

20 This study provides evidence that the availability and distribution of ENTs in LA

21 countries is highly inequitable. A disproportionate number of ENTs are concentrated

22 in more socially advantaged areas, such as capital cities. This evidence on health

23 inequalities, with respect to access to ear and hearing services, can be used to

24 support development of programmes and policies to increase the number and

25 distribution of ear and hearing professionals. Actions to reduce these inequities are

26 essential for efforts towards achieving UHC.

27

28

Figure Legend

30 **Figure 1:** Availability and distributive inequality of ENT for 15 Latin American countries benchmarked

31 against regional mean values, 2017

32 *Source of population data: National Institute of Statistics*　　　*Source of ENT data: National Society of ENTs*

15

1	*Source of HDI of each country: UNDP 2018*[20]

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3   1   **Acknowledgements:** The authors would like to thank the Interamerican Association
4
5   2   of Paediatric Otorhinolaryngology-IAPO for their assistance in obtaining data for this
6
7   3   study.
8
9   4   **Competing interests:** None to declare.
10
11
12   5   **Funding source:** None
13
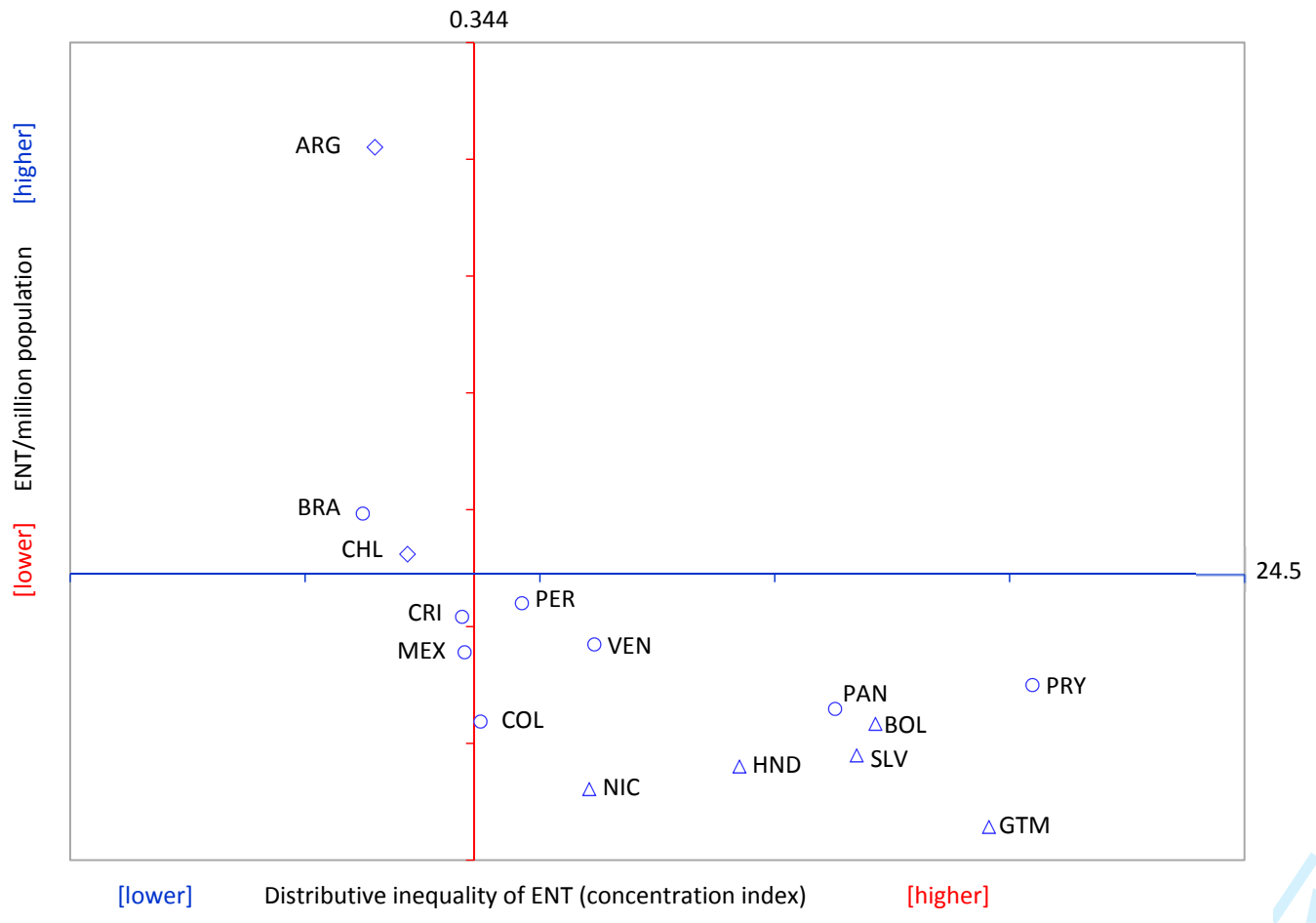14   6   **Data sharing statement:** Data are available upon request.
15
16
17   7   **Patient and public involvement:** It was not appropriate or possible to involve
18
19   8   patients or the public in this work.
20
21   9   **Author contribution:** JCS conceived of the study, facilitated access to data,
22
23   10   interpreted findings and helped draft the manuscript. TB and JR interpreted data and
24
25   11   drafted the manuscript. OM and CM conceived of the study, were responsible for
26
27   12   data analysis and edited the manuscript. CD, AM, EL, ES, DS, SC and AP facilitated
28
29   13   access to data and critically reviewed the manuscript. All authors read and approved
30
31   14   the final manuscript.
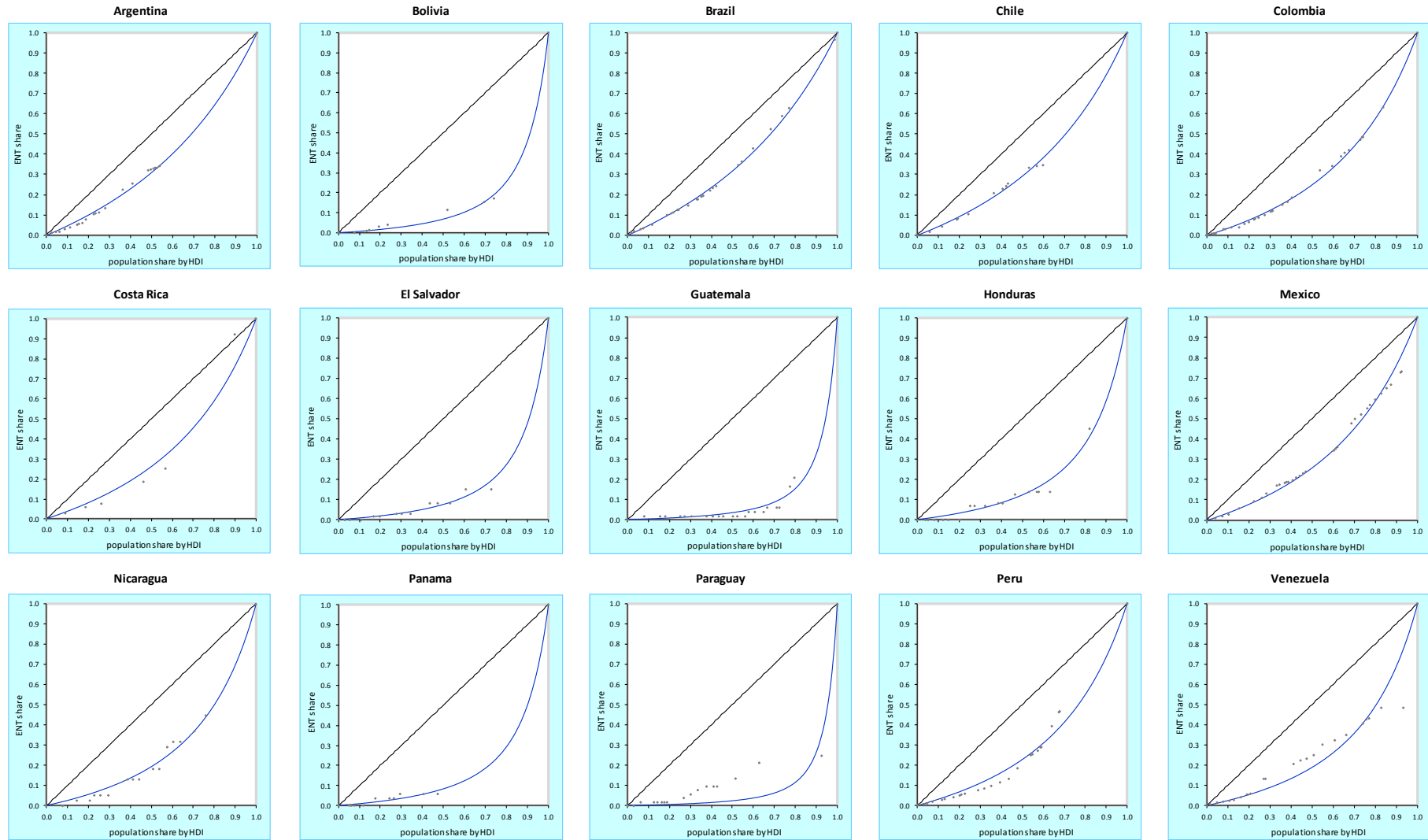32
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36   16   **References**
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Supplementary Figure 1: Concentration curves of distributive inequality of ENTs for 15 Latin American countries, 2017

BMJ Open

Inequality in the distribution of Ear Nose and Throat specialists in 15 Latin American countries

Journal:	*BMJ Open*
Manuscript ID	bmjopen-2019-030220.R1
Article Type:	Research
Date Submitted by the Author:	24-May-2019
Complete List of Authors:	Bright, Tess; London School of Hygiene & Tropical Medicine, CRD Mújica, Oscar; Pan American Health Organization, PAHO/WHO, Intelligence for Action in Health Ramke, Jacqueline; LSHTM, Moreno, Claudia; Pan American Health Organization Der, Carolina ; Clínica Alemana de Santiago, Facultad de Medicina Universidad del Desarrollo Melendez, Amarilis; Hospital Santo Tomas Lara Ovares, Ericka; University of Minnesota , School of Public Health Sandoval Domingues, Edgar; Instituto de Seguridad y Servicios Sociales de los Trabajadores del Estado Santana Hernandez, Diego Jose; CBM Christoffel-Blindenmission Chadha, Shelly; The World Health Organization , WHO Programme for Prevention of Deafness and Hearing Loss Silva, Juan Carlos; Pan American Health Organization Penaranda, Augusto; Fundacion Santafe de Bogota
Primary Subject Heading:	Ear, nose and throat/otolaryngology
Secondary Subject Heading:	Health services research
Keywords:	Health policy < HEALTH SERVICES ADMINISTRATION & MANAGEMENT, Organisation of health services < HEALTH SERVICES ADMINISTRATION & MANAGEMENT, OTOLARYNGOLOGY, Health equity

SCHOLARONE™ Manuscripts

1 **Title: Inequality in the distribution of Ear Nose and Throat specialists in 15**

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1 **Abstract**

2 ***Objective:*** To explore socio-geographic inequalities in the availability and

3 distribution of Ear Nose and Throat specialists (ENTs) in 15 Latin American (LA)

4 countries.

5 ***Design:*** Ecological

6 ***Setting:*** Spanish and Portuguese speaking countries of Latin America

7 The number of registered ENTs in 2017 were obtained from the National ENT

8 Society in each country.

9 ***Outcome measures:*** The ENT rate/million population was calculated at the national

10 and sub-national (e.g. state) level. Three measures were calculated to assess sub-

11 national distributive inequality of ENTs: i) absolute and ii) relative index of

12 dissimilarity; and iii) concentration index (using the Human Development Index as

13 the equity stratifier). Finally, the ratio of ENTs/million population in the capital area

14 compared to the rest of the country was calculated.

15 ***Results:*** There was a more than a 30-fold difference in the number of ENTs/million

16 population across the included countries—from 61.0 in Argentina (95% Confidence

17 Interval (CI) 58.7–63.4) to 2.8 in Guatemala (95%CI 2.1–3.8). In all countries ENTs

18 were more prevalent in advantaged areas and in capital areas. To attain distributive

19 equality, Paraguay would need to redistribute the greatest proportion of its ENT

20 workforce (67.3%; 95%CI 57.8–75.6) and Brazil the least (18.5%; 95%CI 17.6–19.5).

21 ***Conclusions:*** There is high inequality in the number and distribution of ENTs

22 between and within the 15 studied countries in Latin America. This evidence can be

23 used to inform policies that improve access to ear and hearing services in the region,

24 such as scale-up of training of ENTs and incentives to distribute specialists equally.

25 These actions to reduce inequities, alongside addressing the social determinants of

26 ear and hearing health, are essential to realise Universal Health Coverage.

27

2

1 **Strengths and limitations of this study**

2 • This is the first regional-level analysis on the availability and distribution of ENT
3   specialists in Latin America, and includes 15 of the 19 Spanish or Portuguese-
4   speaking countries.

5 • The three inequality measures used to assess subnational inequality—the
6   relative concentration index, the absolute index of dissimilarity and the relative
7   index of dissimilarity—take into account the entire population and are population-
8   weighted, thus giving equal weight to each individual's access to ENTs.

9 • The data were obtained from national ENT societies, which may not be
10   representative of all available ENTs, as some ENTs may not be society-affiliated.

11 • Data were not available on the distribution of ENTs in private vs public health
12   services. Consequently, our results may overestimate the availability of ENTs for
13   people without the resources to access the private sector.

14

3

1 **Introduction**

2 In 2018 there was an estimated 466 million people with disabling hearing loss, and

3 over 80% of these reside in low and middle income countries (LMICs).[1] The World

4 Health Organization (WHO) has estimated that by 2050 one in ten, or 900 million

5 people, will experience disabling hearing loss unless substantial public health

6 measures are implemented.[1] The predicted increase in prevalence can be attributed

7 to the expected rise in global population, and global ageing.[1]

8 Consequently, there is a need for ear and hearing services, including surgical (e.g.

9 Ear Nose and Throat specialists (ENTs)) and rehabilitative services (e.g.

10 audiologists, and speech therapists), to meet the increasing demand. Indeed, in

11 order to achieve Universal Health Coverage (UHC) for the millions of people with

12 hearing loss globally, equitable access to effective, high quality and affordable ear

13 and hearing services is vital. However, access to these services is extremely low in

14 LMICs,[2] due to a dearth of human resources.[3,4]

15 Latin America (LA) has a combined population of 600 million people, approximately

16 42 million (7%) of whom are estimated to have disabling hearing loss.[1,5] Countries

17 within LA are highly diverse in terms of their historical, economic, political, and

18 sociocultural contexts.[6] As an example, the GDP per capita in Chile is $15,346, more

19 than three times as much as Guatemala ($4,470).[6,7] These vast economic

20 differences have shaped health systems reforms in the region and efforts to achieve

21 UHC.[6,8] As a consequence, countries in the region show variation in terms of human

22 resource shortages for health care.[9] Previous research has found substantial

23 shortages in the number of ENTs in 50% of LA countries.[10] Other professionals

24 involved in ear and hearing care services, such as audiologists and speech

25 therapists, are in even shorter supply.[11] There is also some evidence that within

26 countries, ENTs are unequally distributed, with a higher concentration in urban

27 compared to rural areas.[12] However, these inequities have not been examined in

28 depth.

29 This study aimed to explore socio-geographic inequalities in the availability and

30 distribution of ENTs both within and between 15 LA countries. The study

31 hypothesised that regional variation in the availability of ENT specialists per million

32 population exists. Within countries, ENT specialists were hypothesised to be

4

1   2   3   4   5   6   7   8   9   10   11   12   13   14   15   16   17   18   19   20   21   22   23   24   25   26   27   28   29   30   31   32   33   34   35   36   37   38   39   40   41   42   43   44   45   46   47   48   49   50   51   52   53   54   55   56   57   58   59   60

1 unequally distributed across sub-national regions, with the majority concentrated in

2 areas of higher human development.

3 **Methods**

4 This is an ecological study that assesses the distributive inequality of ENT specialists

5 in 15 countries in LA using standard measures of disproportionality across sub-

6 national social gradients (defined by Human Development Indices). Ethical approval

7 was not sought for this study, which used publicly available population data with

8 organisational practitioner data.

9 **Data sources**

10 *Population*

11 This paper focuses on the Spanish and Portuguese speaking countries of LA, of

12 which there are 17. All LA countries were invited to participate, and 15 responded.

13 The 15 included countries consist of 294 first-order sub-national units (e.g.

14 department, province, state). Population data for these units were obtained from the

15 national institutes of census and statistics of each country. The combined population

16 of the included countries represent 96.7% of people in the LA Spanish and

17 Portuguese speaking countries, and 88.2% of the total Latin America and the

18 Caribbean regional population in 2017.[13]

19 *Personnel*

20 Although ENT specialists alone do not capture the full complement of ear and

21 hearing services necessary to treat and manage hearing loss, they were chosen as a

22 key indicator to measure inequalities in access to ear and hearing services. An "ENT

23 specialist" is defined for the purposes of this paper as a medical doctor who has

24 been trained in the management of ear, nose and throat conditions, through a

25 recognised degree.[4] Hereafter we refer to ENT specialists as ENTs.

26 In each country, data on the number ENTs registered at each of the sub-national

27 units in 2017 were obtained from the National Society of ENTs. Societies were

28 contacted by the Interamerican Association of Paediatric Otorhinolaryngology-IAPO

29 or study authors, either by phone or email. Society membership requires a medical

5

degree, completion of residency at an accredited medical school, and a national practice license.

Human Development Index

The Human Development Index (HDI) was used as the equity stratifier of the sub-national units. The HDI is widely used by the United Nations Development Programme as a composite measure of achievement in three key dimensions of human development—health, education, and standard of living.[14] The HDI score is a value between zero and one which represents the geometric mean of the index of the three dimensions.[14] The most recent HDI for the sub-national units of each country were obtained from UNDP reports from each country. To create the social gradient, within each country, sub-national units were ordered from lowest HDI (most socially disadvantaged) to highest HDI (most socially advantaged).

Analysis

Availability of ENT personnel

The number of ENTs/million population was calculated for each sub-national unit of each country. The mean and 95% confidence interval (CI) of ENTs/million population at the national level were calculated.

Inequality measures

Inequality in the distribution of ENTs was assessed using three common indicators of health inequality[15,16,17]:

- Relative concentration index (RCI)

The RCI is a relative measure of gradient inequality that indicates the extent to which a health indicator is concentrated among the disadvantaged or the advantaged.[17] In this analysis the RCI measures the extent to which the ENT distribution across sub-national units is systematically associated with the social advantage of each sub-national unit (measured by HDI). RCI takes a value between -1 and 1, with 0 indicating no inequality (i.e., equal distribution). A negative value of RCI indicates ENTs are concentrated among more disadvantaged sub-national units, and a positive value indicates ENTs are concentrated among more advantaged sub-national units.

6

1   The RCI was calculated for each country using non-linear optimization to fit a

2   Lorenz concentration curve and calculating the area under the curve.[18] The

3   curve equation fit the observed cumulative proportion of the population (as

4   ranked by the HDI of each sub-national unit) against the cumulative proportion of

5   ENTs.

6   • Absolute index of dissimilarity (aID)

7   The aID quantifies the number of ENTs within a given country who would need to

8   be redistributed for the national rate of ENTs/million population to be achieved in

9   each sub-national unit i.e. equitable distribution. The aID is half the sum of the

10   absolute value of the differences between the national average ENTs and the

11   number of ENTs observed in each unit.

12   • Relative index of dissimilarity (rID)

13   The rID is the relative equivalent of the aID, representing the percentage of ENTs

14   who would have to be redistributed to achieve equitable sub-national distribution.

15   The rID is computed by dividing the aID by the total number of ENTs

16   available.[15,18] The closer rID is to 100%, the greater the inequality.

17

18   *Regional benchmarking*

19   WHO recommends benchmarking within regions to understand one country's level of

20   inequality in relation to others.[17] To benchmark ENT distribution in LA we calculated

21   the regional weighted mean of ENTs/million population and the regional distributional

22   inequality (measured by the RCI). We used these regional averages to construct a

23   framework[19] with four quadrants and mapped each country based on whether its

24   ENT rate and RCI were higher or lower than the regional average. The HDI level of

25   each country[20] was also indicated.

26   *Urban concentration*

27   To assess the extent of urban concentration of ENTs, the ENTs/million population in

28   the capital area for each country (i.e. the sub-national unit that contains the

29   constitutional capital or the seat of government city), as compared to the rate in the

30   rest of the country combined (i.e. all sub-national units apart from the capital area).

31   The ratio of ENTs/million population in the capital compared to the rest of the country

32   was calculated.

7

1

All statistical analyses were performed in MS Excel Solver and ToolPak add-ins
(Microsoft Corp., Redmond, Washington, USA), using a semiautomated analytical
template tool developed by the Pan American Health Organization (PAHO) for
exploratory data analysis of social inequalities in health. Uncertainty was ascertained
by computing 95% CIs for all summary measures of health inequality as well as the
mean number of ENTs/million population.

Results

Between country inequality

In these 15 LA countries, there was large variation in the size of the ENT profession,
the rate of ENTs/million population and the distributive inequality (Table 1). For
example, Brazil had 6,159 registered ENTs while Nicaragua had only 38. When the
population size was taken into account, there was a more than a 30-fold difference in
the number of ENTs/million population—from 61.0 in Argentina (95%CI 58.7–63.4) to
2.8 in Guatemala (95%CI 2.1–3.8) (Table 1). There was also large variation in
distributive inequality. In all countries ENTs were more prevalent in advantaged
areas but the extent of this inequality varied greatly—inequality was lowest in Brazil
(RCI 0.249; 95%CI 0.133–0.365) and highest in Paraguay (RCI 0.819; 95%CI
0.769–0.870) (supplementary figure 1).

Regional benchmarking

The regional variation in the ENT rate and distributive inequality is depicted in Figure
1. The high ENT rate in Argentina—more than twice as high as the rate in the next
highest country—inflated the regional weighted mean of 24.5/million (95%CI 23.3–
25.7) (Figure 1). Brazil and Chile were the only other countries to have an ENT rate
higher than the regional average. These three countries also had lower distributive
inequality than the regional average (RCI 0.344; 95%CI 0.227–0.460), placing them
in the best performing, top left quadrant of Figure 1. In contrast, the countries in the
bottom right quadrant had a lower ENT rate and higher inequality compared to the
regional average, with Guatemala arguably furthest behind other countries in the
region.

8

1 The ENT rate tended to reflect the national HDI level. Countries with very high HDI

2 had the highest ENT rate, followed by countries with high HDI, and then countries

3 with medium HDI tending to have the lowest ENT rate. Distributive inequality was

4 similar with two exceptions—Paraguay and Panama are high HDI countries but had

5 distributive inequality more equivalent to countries of medium HDI (Figure 1).

6 *Within country inequality*

7 The redistributive potential to achieve equality mirrored the RCI results, with Brazil

8 needing to redistribute the lowest proportion of their ENTs to achieve distributive

9 equality (rID 18.5%; 95%CI 17.6–19.5) and Paraguay the highest (rID 67.3%; 95%CI

10 57.8–75.6) (Table 1). Due to the size of the respective workforce, this equates to

11 redistributing 1,142 ENTs in Brazil and 70 in Paraguay (aID; Table 1).

12 <u>Urban concentration</u>

13 In all countries, even when the population size was taken into account, ENTs were more

14 concentrated in capital areas (Table 2). Argentina fared best, but the ENT rate in the

15 capital area remained over twice as high as the rest of the country (C:R ratio 2.3; 95%

16 CI 2.1–2.5).

17 The largest inequality between capital and other areas was seen in Paraguay (C:R ratio

18 36.7; 95%CI 23.6–57.2), Venezuela (C:R ratio 15.2; 95%CI 12.9–17.9) and Panama

19 (C:R ratio 15.1; 95%CI 4.7–48.5). The high C:R inequality observed in Paraguay and

20 Venezuela was driven by high ENT rates in the capital. In turn, these rates were driven

21 by the low proportion of the national population residing in the capital area (7.6% and

22 6.6% respectively), combined with the majority of ENTs being located there (75.0% and

23 51.9% respectively). In contrast, the high C:R inequality in Panama was driven by the

24 very low ENT rates in the rest of the country, with only three of the country's 53 ENTs

25 (5.7%) stationed outside the capital (Table 2).

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1 **Table 1:** Distributive inequality of ENTs per million population in 15 Latin American countries, 2017

Country	Populationa	Number of ENTsb	Number of sub-national units (e.g. states)a	ENTs per million population		Relative Concentration Index (RCI)c		Absolute index of dissimilarity		Relative index of dissimilarity	
				Mean	95%CI	Mean	95%CI	Mean	95%CI	Mean (%)	95%CI
Argentina	44,044,811	2,688	23	61.0	58.7-63.4	0.259	0.128-0.391	575	534-618	21.4	19.9-23.0
Bolivia	11,145,770	130	9	11.7	9.7-13.8	0.686	0.507-0.864	75	64-86	57.7	49.1-65.8
Brazil	207,660,929	6,159	27	29.7	28.9-30.4	0.249	0.133-0.365	1,142	1,083-1,203	18.5	17.6-19.5
Chile	17,598,287	461	13	26.2	23.9-28.7	0.287	0.058-0.517	115	98-134	24.9	21.2-29.1
Colombia	49,291,609	584	33	11.8	10.9-12.8	0.349	0.262-0.437	155	135-177	26.5	23.1-30.3
Costa Rica	4,947,481	103	7	20.8	17.0-25.2	0.334	-0.065-0.732	35	26-45	34.0	25.6-43.6
El Salvador	6,581,940	59	14	9.0	6.8-11.6	0.670	0.546-0.794	34	27-41	57.6	44.9-69.4
Guatemala	16,924,191	48	22	2.8	2.1-3.8	0.782	0.749-0.816	32	25-38	66.7	52.5-78.3
Honduras	8,866,351	71	18	8.0	6.3-10.1	0.570	0.441-0.699	36	28-44	50.7	39.3-62.0
Mexico	124,041,731	2,207	32	17.8	17.1-18.6	0.336	0.238-0.433	631	590-673	28.6	26.7-30.5
Nicaragua	6,262,703	38	17	6.1	4.3-8.3	0.442	0.291-0.593	16	11-22	42.1	27.9-57.8
Panama	4,098,135	53	12	12.9	9.7-16.9	0.651	0.564-0.738	22	16-29	41.5	29.3-54.9
Paraguay	6,941,905	104	18	15.0	12.2-18.2	0.819	0.769-0.870	70	60-79	67.3	57.8-75.6
Peru	29,381,884	646	25	22.0	20.3-23.7	0.385	0.276-0.494	213	190-237	33.0	29.5-36.7
Venezuela	31,428,916	580	24	18.5	17.0-20.0	0.446	0.307-0.586	275	252-299	47.4	43.4-51.5
All countries	569,216,643	13,931	294	24.5	23.3-25.7	0.344	0.227-0.460	3,426	3,139-3,725	28.5	25.5-31.5

2 *ENT: Ear nose and throat specialist*

3 *a Source: National Institute of Statistics   b Source: National Society of ENTs*
4 *c The Relative Concentration Index departs from equity for all countries, except Costa Rica (i.e. the confidence intervals do not overlap with zero)*
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1   **Table 2:** Number of ENTs per million population in the capital area compared to the rest of the country in 15 Latin American countries, 2017

| Country | ENTs per million population | | | | Ratio of ENT rate Capital: Rest-of-country (C:R ratio) | | Proportion of population in Capital area (%)[a] | Proportion of ENTs in Capital area (%)[b] | Capital area description |
| | Capital area | | Rest-of-country | | | | | | |
	Mean	95%CI	Mean	95%CI	Mean	95%CI			
Argentina	88.1	84.0-92.3	38.4	35.9-40.9	2.3	2.1-2.5	45.6%	65.8%	Buenos Aires Autonomous City
Bolivia	37.7	31.0-45.6	2.7	1.7-4.0	14.2	9.0-22.5	25.7%	83.1%	La Paz Department
Brazil	67.8	58.8-77.7	29.1	28.4-29.8	2.3	2.0-2.7	1.5%	3.3%	Federal District
Chile	42.3	37.7-47.4	15.3	13.0-17.8	2.8	2.3-3.4	40.4%	65.3%	Metropolitan Region
Colombia	26.7	23.3-30.5	8.9	8.0-9.9	3.0	2.5-3.5	16.4%	37.0%	Bogota Capital District
Costa Rica	42.6	33.1-53.9	10.2	7.1-14.3	4.2	2.8-6.3	32.8%	67.0%	San Jose Province
El Salvador	28.0	20.8-36.9	1.9	0.9-3.6	14.9	7.3-30.3	27.1%	84.7%	San Salvador Department
Guatemala	11.0	7.8-15.1	0.7	0.4-1.4	14.9	7.4-29.8	20.4%	79.2%	Guatemala Department
Honduras	24.4	17.3-33.3	4.4	3.0-6.2	5.5	3.5-8.8	18.1%	54.9%	Francisco Morazan Department
Mexico	65.4	60.3-70.9	14.0	13.4-14.7	4.7	4.2-5.1	7.3%	26.8%	Federal District
Nicaragua	14.1	8.8-21.6	3.6	2.1-5.7	4.0	2.1-7.5	23.7%	55.3%	Managua Department
Panama	23.3	17.3-30.7	1.5	0.3-4.5	15.1	4.7-48.5	52.4%	94.3%	Panama Province
Paraguay	148.8	117.6-185.7	4.1	2.6-5.9	36.7	23.6-57.2	7.6%	75.0%	Asuncion Capital City
Peru	36.5	32.7-40.5	15.1	13.4-16.9	2.4	2.1-2.8	32.3%	53.6%	Lima Department
Venezuela	144.3	128.5-161.6	9.5	8.4-10.7	15.2	12.9-17.9	6.6%	51.9%	Capital District

2   *ENT: Ear nose and throat specialist*

3   *a Source: National Institute of Statistics   b Source: National Society of ENTs*

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1 **Discussion**

2 This study examined the socio-geographic distribution of ENTs between and within

3 15 LA countries. We found that the availability of ENTs across countries of the region

4 is highly variable. Within countries, the distribution was shown to be unequal, with

5 more socially advantaged areas, and capital areas, having a higher concentration of

6 ENT specialists. Despite inequality in countries such as Argentina, Brazil and Chile

7 being up to three times lower than Paraguay and Guatemala, the RCI in all 15

8 countries was at a level WHO considers a high level of relative inequality.[17] This high

9 inequality was reinforced by the rID, which indicates between one in five ENTs in

10 Brazil and two in three ENTs in Paraguay would need to be redistributed to attain

11 socio-geographic equality.

12 The findings of this study concur with previous literature from both the LA region and

13 elsewhere. Wagner et al. (2013) and Stolovitsy et al. (2018) also found that

14 Guatemala had the poorest ratio of ENTs/100,000 population (4 per million), which

15 was only 11% of the ratio in the United States.[10,12] Both studies also found the

16 highest ratio was in Argentina (56 per million). These trends align with our findings,

17 however we found a lower ratio in Guatemala and higher ratio in Argentina which

18 may be explained by population increases, or increases in the numbers of ENTs

19 respectively.[10,12] In 2001, Madriz and colleagues surveyed 15 Latin American and

20 the Caribbean countries to determine the resources available for hearing impairment,

21 including prevalence data, training programmes, and equipment. They found Brazil

22 (5000 ENTs), Argentina (3000 ENTs), and Mexico (2400 ENTs) had the greatest

23 absolute numbers of human resources. Although the survey was published over 15

24 years ago, it appears that there has been little progress in human resource

25 development since this study was conducted.[11] In fact, the number of ENTs in our

26 study was lower in comparison for Argentina, Guatemala, and Mexico. This may be

27 due to differences in data sources, with the 2001 survey using expert opinion across

28 a range of institutions rather than National societal membership.[11] In 2012, the WHO

29 conducted a global survey of availability of human resources to provide ear and

30 hearing care. They demonstrated great variation in availability of ENTs, audiologists,

31 and speech therapists globally, and a clear trend of increased availability with

32 country-income group.[4]

12

1 Despite the trend in increased availability with national income, inequalities in access

2 to services still exist within countries. Within country disparities in availability of ENTs

3 have been less well documented. Westerburg et al. (2018) reports that the

4 geographic distribution of ENTs in North America is inequitable, contributing to poor

5 access for vulnerable populations.[21] In Canada, for example, the majority of

6 providers are located in urban centres, and there are no providers at all in many

7 areas where Aboriginal populations are concentrated.[21] The trends we found in this

8 study have also been observed in eye health in the region. Hong et al. (2016) found

9 that ophthalmologists are more concentrated in socially advantaged areas within

10 countries.[22] However, comparisons to this study highlight that the low coverage of

11 ENTs appears to be more pronounced than in eye health. For example in

12 Venezuela, there are 42 ophthalmologists/million, whereas our analysis found a ratio

13 of 18.5 ENTs/million. Thus, for every ENT in Venezuela there are two

14 ophthalmologists. This is despite comparable burden of impairments (16%

15 hearing;18% vision).[23] The reasons for this difference could allow lessons to be

16 drawn on improving ear and hearing services availability in the country. Compared to

17 ophthalmologists, ENTs in LA also tend to be less equally distributed. There are

18 several possible explanations for this, including the lack of population-based data on

19 need for services, and lack of funding, leading to ear and hearing care not being

20 prioritised by the regional governments.[24] The reasons for the concentration of ENTs

21 in more socially advantaged areas likely include better availability of equipment,

22 facilities, and specialist training centres.

23 This study has several strengths. Although previous literature has examined

24 numbers of ENTs per population and made comparisons across countries, there has

25 been limited analysis of inequalities within countries. This study adds to the

26 knowledge base by performing a robust, more in-depth analysis of the substantial

27 sub-national inequalities that exist. The three inequality measures used in this

28 analysis take into account the entire population and are population-weighted, thus

29 giving equal weight to each individual's access to ENTs.[16,25] These strengths—along

30 with reflecting the socioeconomic dimension to health inequality—are why WHO

31 recommends the concentration index as a measure of relative inequality.[26] The data

32 coverage of this study was high, representing 96.7% of the LA Spanish and

33 Portuguese speaking countries.

13

1 There are also limitations which should be taken into account when interpreting the

2 results. The data were obtained from national ENT societies, which may not be

3 representative of all available ENTs within the countries studied as some ENTs may

4 not be society-affiliated. Although ENT specialists are an essential component of

5 functioning ear and hearing care programmes, there are also many other

6 professionals involved in provision of specialist care for hearing loss and ear

7 disease, for instance, audiologists and speech therapists. Further, data on the

8 availability of equipment to enable service provision is not provided. In addition, we

9 have assumed that ENTs in LMICs deliver the full range of ear and hearing services.

10 However, it is possible that some ENT specialists are subspecialised and provide

11 services for only one of ears, nose or throat. The data also do not capture more

12 nuanced service delivery models common in LMICs, such as surgical outreach to

13 primary and secondary care facilities or telemedicine. This is an area of future

14 research need. Finally, data were not available on the distribution of ENTs in private

15 vs public health services which has an impact on the financial accessibility of the

16 service. Thus, we are unable to draw conclusions on the availability full complement

17 of ear and hearing services.

18 While not a limitation of our study, we acknowledge that distribution of personnel is

19 only one aspect of access to hearing care, Productivity of these personnel, as well

20 as the quality and costs of hearing services are also important components that

21 require attention to realise universal hearing care.[27]

22 This study provides evidence for policy makers to further develop programmes that

23 increase the number of ENTs/million population as well as reduce the inequities in

24 their distribution. The Pan American Health Organisation (PAHO), the regional WHO

25 office for the Americas, has developed a strategy to guide national policies on

26 addressing human resource deficiencies.[28] Some of the key strategies outlined

27 include strengthening governance and leadership, focussing on the number and

28 distribution of personnel according to health needs; partnership with other relevant

29 sectors, such as education, in order to respond to training needs across geographic

30 regions; and implementing staff retention strategies, such as incentives and

31 improved infrastructure.[28] We acknowledge there is no definitive 'right' number of

32 ENTs/ million population, and instead countries must consider all of these elements.

33 Access to health is required to achieve good health outcomes, however in

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1   addressing health inequities, actions must also be taken to address the social

2   determinants of health. As an example, hearing loss and ear disease are linked to

3   poverty, and thus to address the greater burden amongst the poor, a multi-faceted

4   approach is required – beyond a focus on human resource development alone.[29,30]

5   Further research is needed to understand the availability and inequities in distribution

6   of other health professionals relevant to ear and hearing care, including audiologists,

7   and speech therapists, as well as mid-cadre and primary health professionals such

8   as clinical officers that exist in many LMICs. Training primary health workers in ear

9   and hearing care has been a key strategy supported by the WHO in order to address

10   the lack of human resources and improve access to services at the community level,

11   in efforts to achieve universal ear and hearing care.[27,31] There is also a need to

12   examine availability of equipment, and other essential elements of service provision.

13   Although this study presents a clear picture of inequalities in distribution of

14   specialists, the need for services is not well understood. There have been very few

15   population-based surveys to determine the prevalence and causes of hearing loss in

16   LA. In LA, there have been three published studies, two of which were in Brazil, and

17   one in Ecuador.[24] Prevalence data are required to plan services according to the

18   population need, including the required number and distribution of specialists.

19   Although global Vision 2020 targets of ophthalmologists per population are

20   contested, they have been used as an advocacy tool to lobby governments for

21   increased resources for eye care. Thus, similar evidence-based targets should be

22   developed for the field of ear and hearing. Vision 2020 has helped garner action to

23   reduce avoidable causes of blindness, at a global and local scale. A similar global

24   initiative for ear and hearing care has been launched in 2018, the World Hearing

25   Forum, which aims to stimulate action and make gains similar to those attained in

26   eye health.[32]

Conclusion

27

28   This study provides evidence that the availability and distribution of ENTs in LA

29   countries is highly inequitable. A disproportionate number of ENTs are concentrated

30   in more socially advantaged areas, such as capital cities. This evidence on health

31   inequalities, with respect to access to ear and hearing services, can be used to

32   support development of programmes and policies to increase the number and

15

1 distribution of ear and hearing professionals. Actions to reduce these inequities are

2 essential for efforts towards achieving UHC.

3

4

5 **Figure Legend**

6 **Figure 1:** Availability and distributive inequality of ENT for 15 Latin American countries benchmarked

7 against regional mean values, 2017

8 *Source of population data: National Institute of Statistics*   *Source of ENT data: National Society of ENTs*

9 *Source of HDI of each country: UNDP 2018[20]*

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18 **Data sharing statement:** The data used in this study include (for the 15 countries):

19 i) the number of members of national ENT societies at the national and subnational

20 level; ii) the population distribution at the subnational level; and iii) the calculated

21 inequality indices. These data are available on reasonable request from Dr Juan

22 Carlos Silva ORCID ID: 0000-0003-4855-5008.

23 **Patient and public involvement:** It was not appropriate or possible to involve
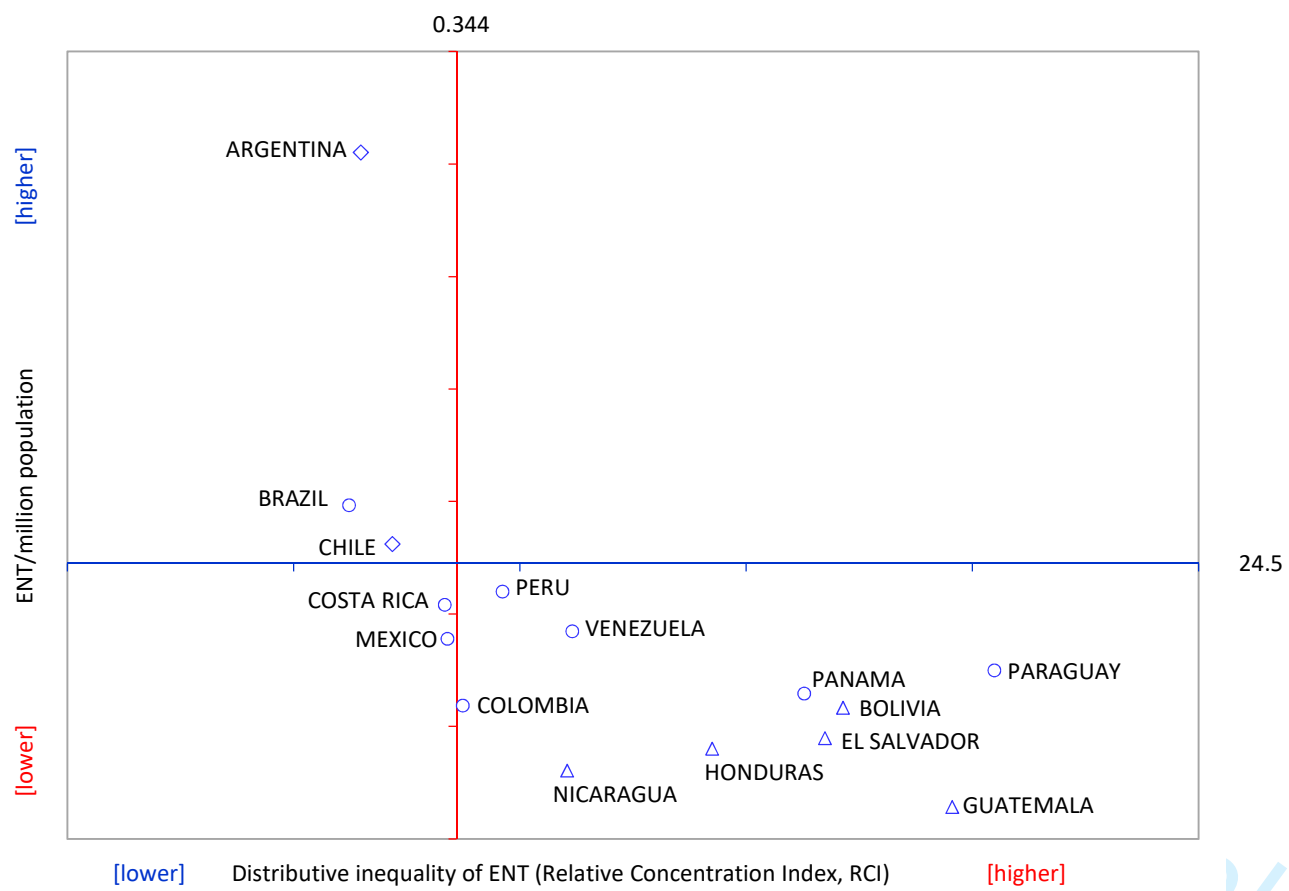
24 patients or the public in this work.

25 **Author contribution:** JCS conceived of the study, facilitated access to data,

26 interpreted findings and helped draft the manuscript. TB and JR interpreted data and

27 drafted the manuscript. OM and CM conceived of the study, were responsible for

28 data analysis and edited the manuscript. CD, AM, EL, ES, DS, SC and AP facilitated

29 access to data and critically reviewed the manuscript. All authors read and approved

30 the final manuscript.

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3   1   **References**
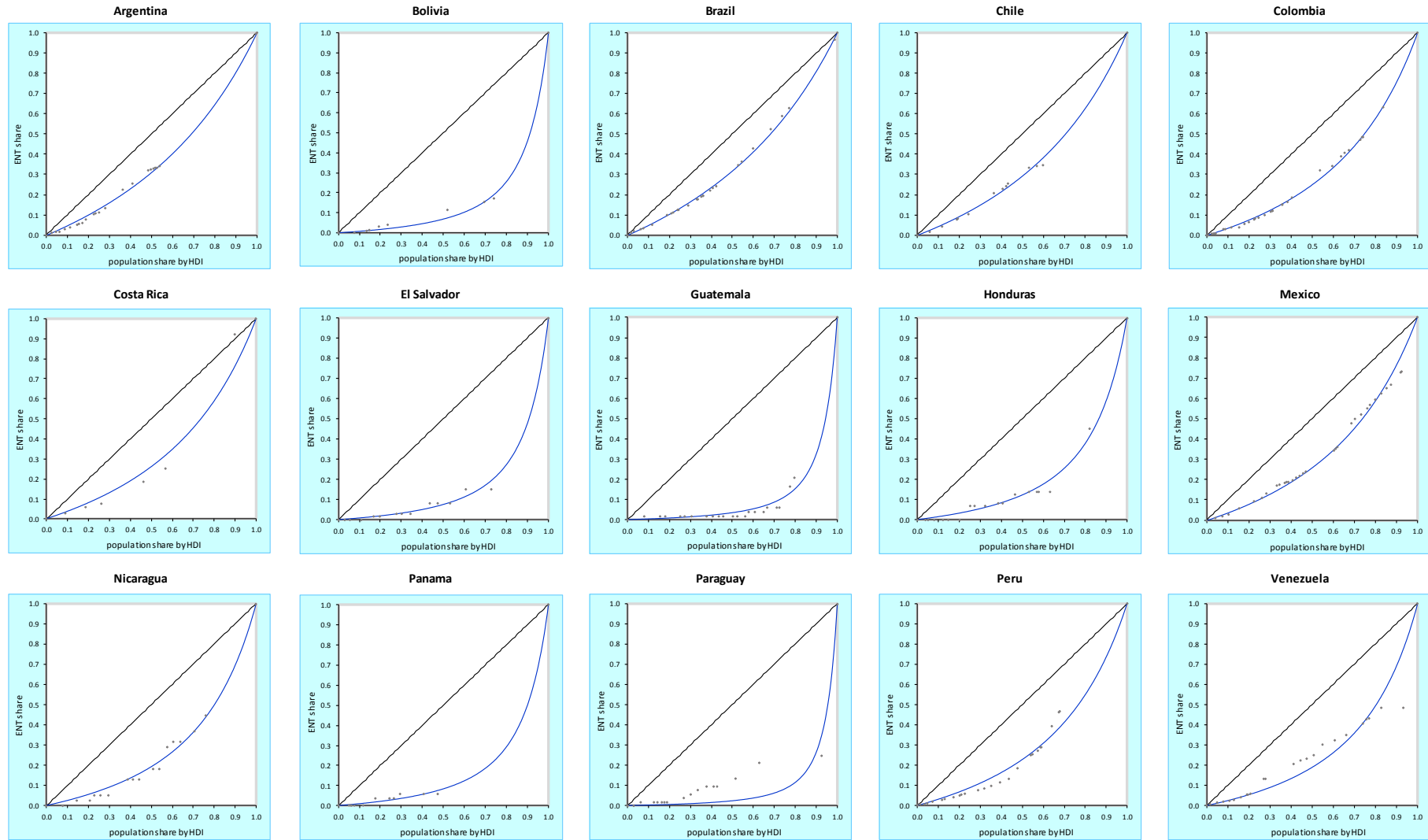4
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Supplementary Figure 1: Concentration curves of distributive inequality of ENTs for 15 Latin American countries, 2017

BMJ Open

Inequality in the distribution of Ear Nose and Throat specialists in 15 Latin American countries: an ecological study

Journal:	*BMJ Open*
Manuscript ID	bmjopen-2019-030220.R2
Article Type:	Research
Date Submitted by the Author:	18-Jun-2019
Complete List of Authors:	Bright, Tess; London School of Hygiene & Tropical Medicine, CRD Mújica, Oscar; Pan American Health Organization, PAHO/WHO, Intelligence for Action in Health Ramke, Jacqueline; LSHTM, Moreno, Claudia; Pan American Health Organization Der, Carolina ; Clínica Alemana de Santiago, Facultad de Medicina Universidad del Desarrollo Melendez, Amarilis; Hospital Santo Tomas Lara Ovares, Ericka; University of Minnesota , School of Public Health Sandoval Domingues, Edgar; Instituto de Seguridad y Servicios Sociales de los Trabajadores del Estado Santana Hernandez, Diego Jose; CBM Christoffel-Blindenmission Chadha, Shelly; The World Health Organization , WHO Programme for Prevention of Deafness and Hearing Loss Silva, Juan Carlos; Pan American Health Organization Penaranda, Augusto; Fundacion Santafe de Bogota
Primary Subject Heading:	Ear, nose and throat/otolaryngology
Secondary Subject Heading:	Health services research
Keywords:	Health policy < HEALTH SERVICES ADMINISTRATION & MANAGEMENT, Organisation of health services < HEALTH SERVICES ADMINISTRATION & MANAGEMENT, OTOLARYNGOLOGY, Health equity

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1 **Title: Inequality in the distribution of Ear Nose and Throat specialists in 15**

2 **Latin American countries: an ecological study**

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1

1 **Abstract**

2 *Objective:* To explore socio-geographic inequalities in the availability and

3 distribution of Ear Nose and Throat specialists (ENTs) in 15 Latin American (LA)

4 countries.

5 *Design:* Ecological

6 *Setting:* Spanish and Portuguese speaking countries of Latin America

7 The number of registered ENTs in 2017 were obtained from the National ENT

8 Society in each country.

9 *Outcome measures:* The ENT rate/million population was calculated at the national

10 and sub-national (e.g. state) level. Three measures were calculated to assess sub-

11 national distributive inequality of ENTs: i) absolute and ii) relative index of

12 dissimilarity; and iii) concentration index (using the Human Development Index as

13 the equity stratifier). Finally, the ratio of ENTs/million population in the capital area

14 compared to the rest of the country was calculated.

15 *Results:* There was more than a 30-fold difference in the number of ENTs/million

16 population across the included countries—from 61.0 in Argentina (95% Confidence

17 Interval (CI) 58.7–63.4) to 2.8 in Guatemala (95%CI 2.1–3.8). In all countries, ENTs

18 were more prevalent in advantaged areas and in capital areas. To attain distributive

19 equality, Paraguay would need to redistribute the greatest proportion of its ENT

20 workforce (67.3%; 95%CI 57.8–75.6) and Brazil the least (18.5%; 95%CI 17.6–19.5).

21 *Conclusions:* There is high inequality in the number and distribution of ENTs

22 between and within the 15 studied countries in Latin America. This evidence can be

23 used to inform policies that improve access to ear and hearing services in the region,

24 such as scale-up of training of ENTs and incentives to distribute specialists equally.

25 These actions to reduce inequities, alongside addressing the social determinants of

26 ear and hearing health, are essential to realise Universal Health Coverage.

27

2

1   **Strengths and limitations of this study**

2   • This is the first regional-level analysis on the availability and distribution of ENT
3   specialists in Latin America, and includes 15 of the 17 Spanish or Portuguese-
4   speaking countries.
5   • The three inequality measures used to assess subnational inequality—the
6   relative concentration index, the absolute index of dissimilarity and the relative
7   index of dissimilarity—take into account the entire population and are population-
8   weighted, thus giving equal weight to each individual's access to ENTs.
9   • The data were obtained from national ENT societies, which may not be
10   representative of all available ENTs, as some ENTs may not be society-affiliated.
11   • Data were not available on the distribution of ENTs in private vs public health
12   services, so our results may overestimate the availability of ENTs for people
13   without the resources to access the private sector.

14

3

1 **Introduction**

2 In 2018 there was an estimated 466 million people with disabling hearing loss, and

3 over 80% of these reside in low and middle income countries (LMICs).[1] The World

4 Health Organization (WHO) has estimated that by 2050 one in ten, or 900 million

5 people, will experience disabling hearing loss unless substantial public health

6 measures are implemented.[1] The predicted increase in prevalence can be attributed

7 to the expected rise in global population, and global ageing.[1]

8 Consequently, there is a need for ear and hearing services, including surgical (e.g.

9 Ear Nose and Throat specialists (ENTs)) and rehabilitative services (e.g.

10 audiologists, and speech therapists), to meet the increasing demand. Indeed, in

11 order to achieve Universal Health Coverage (UHC) for the millions of people with

12 hearing loss globally, equitable access to effective, high quality and affordable ear

13 and hearing services is vital. However, access to these services is extremely low in

14 LMICs,[2] due to a dearth of human resources.[3,4]

15 Latin America (LA) has a combined population of 600 million people, approximately

16 42 million (7%) of whom are estimated to have disabling hearing loss.[1,5] Countries

17 within LA are highly diverse in terms of their historical, economic, political, and

18 sociocultural contexts.[6] As an example, the GDP per capita in Chile is $15,346, more

19 than three times as much as Guatemala ($4,470).[6,7] These vast economic

20 differences have shaped health systems reforms in the region and efforts to achieve

21 UHC.[6,8] As a consequence, countries in the region show variation in terms of human

22 resource shortages for health care.[9] Previous research has found substantial

23 shortages in the number of ENTs in 50% of LA countries.[10] Other professionals

24 involved in ear and hearing care services, such as audiologists and speech

25 therapists, are in even shorter supply.[11] There is also some evidence that within

26 countries, ENTs are unequally distributed, with a higher concentration in urban

27 compared to rural areas.[12] However, these inequities have not been examined in

28 depth.

29 This study aimed to explore socio-geographic inequalities in the availability and

30 distribution of ENTs both within and between 15 LA countries. The study

31 hypothesised that regional variation in the availability of ENT specialists per million

32 population exists. Within countries, ENT specialists were hypothesised to be

4

unequally distributed across sub-national regions, with the majority concentrated in areas of higher human development.

Methods

This is an ecological study that assesses the distributive inequality of ENT specialists in 15 countries in LA using standard measures of disproportionality across sub-national social gradients (defined by Human Development Indices). Ethical approval was not sought for this study, which used publicly available population data with organisational practitioner data.

Data sources

Population

This paper focuses on the Spanish and Portuguese speaking countries of LA, of which there are 17. All LA countries were invited to participate, and 15 responded. The 15 included countries consist of 294 first-order sub-national units (e.g. department, province, state). Population data for these units were obtained from the national institutes of census and statistics of each country. The combined population of the included countries represent 96.7% of people in the LA Spanish and Portuguese speaking countries, and 88.2% of the total Latin America and the Caribbean regional population in 2017.[13]

Personnel

Although ENT specialists alone do not capture the full complement of ear and hearing services necessary to treat and manage hearing loss, they were chosen as a key indicator to measure inequalities in access to ear and hearing services. An "ENT specialist" is defined for the purposes of this paper as a medical doctor who has been trained in the management of ear, nose and throat conditions, through a recognised degree.[4] Hereafter we refer to ENT specialists as ENTs.

In each country, data on the number ENTs registered at each of the sub-national units in 2017 were obtained from the National Society of ENTs. Societies were contacted by the Interamerican Association of Paediatric Otorhinolaryngology (IAPO) or study authors, either by phone or email. Society membership requires a medical

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degree, completion of residency at an accredited medical school, and a national practice license.

Human Development Index

The Human Development Index (HDI) was used as the equity stratifier of the sub-national units. The HDI is widely used by the United Nations Development Programme (UNDP) as a composite measure of achievement in three key dimensions of human development—health, education, and standard of living.[14] The HDI score is a value between zero and one which represents the geometric mean of the index of the three dimensions.[14] The most recent HDI for the sub-national units of each country were obtained from UNDP reports from each country. To create the social gradient, within each country, sub-national units were ordered from lowest HDI (most socially disadvantaged) to highest HDI (most socially advantaged).

Analysis

Availability of ENT personnel

The number of ENTs/million population was calculated for each sub-national unit of each country. The mean and 95% confidence interval (CI) of ENTs/million population at the national level were calculated.

Inequality measures

Inequality in the distribution of ENTs was assessed using three common indicators of health inequality[15,16,17]:

- Relative concentration index (RCI)

The RCI is a relative measure of gradient inequality that indicates the extent to which a health indicator is concentrated among the disadvantaged or the advantaged.[17] In this analysis the RCI measures the extent to which the ENT distribution across sub-national units is systematically associated with the social advantage of each sub-national unit (measured by HDI). RCI takes a value between -1 and 1, with 0 indicating no inequality (i.e., equal distribution). A negative value of RCI indicates ENTs are concentrated among more disadvantaged sub-national units, and a positive value indicates ENTs are concentrated among more advantaged sub-national units.

6

1   The RCI was calculated for each country using non-linear optimization to fit a

2   Lorenz concentration curve and calculating the area under the curve.[18] The

3   curve equation fit the observed cumulative proportion of the population (as

4   ranked by the HDI of each sub-national unit) against the cumulative proportion of

5   ENTs.

6   • Absolute index of dissimilarity (aID)

7   The aID quantifies the number of ENTs within a given country who would need to

8   be redistributed for the national rate of ENTs/million population to be achieved in

9   each sub-national unit i.e. equitable distribution. The aID is half the sum of the

10   absolute value of the differences between the national average ENTs and the

11   number of ENTs observed in each unit.

12   • Relative index of dissimilarity (rID)

13   The rID is the relative equivalent of the aID, representing the percentage of ENTs

14   who would have to be redistributed to achieve equitable sub-national distribution.

15   The rID is computed by dividing the aID by the total number of ENTs

16   available.[15,18] The closer rID is to 100%, the greater the inequality.

17

18   *Regional benchmarking*

19   WHO recommends benchmarking within regions to understand one country's level of

20   inequality in relation to others.[17] To benchmark ENT distribution in LA we calculated

21   the regional weighted mean of ENTs/million population and the regional distributional

22   inequality (measured by the RCI). We used these regional averages to construct a

23   framework[19] with four quadrants and mapped each country based on whether its

24   ENT rate and RCI were higher or lower than the regional average. The HDI level of

25   each country[20] was also indicated.

26   *Urban concentration*

27   To assess the extent of urban concentration of ENTs, the ENTs/million population in

28   the capital area for each country (i.e. the sub-national unit that contains the

29   constitutional capital or the seat of government city), as compared to the rate in the

30   rest of the country combined (i.e. all sub-national units apart from the capital area).

31   The ratio of ENTs/million population in the capital compared to the rest of the country

32   was calculated.

7

1

2 All statistical analyses were performed in MS Excel Solver and ToolPak add-ins

3 (Microsoft Corp., Redmond, Washington, USA), using a semiautomated analytical

4 template tool developed by the Pan American Health Organization (PAHO) for

5 exploratory data analysis of social inequalities in health. Uncertainty was ascertained

6 by computing 95% CIs for all summary measures of health inequality as well as the

7 mean number of ENTs/million population.

8

9 **Results**

10 *Between country inequality*

11 In these 15 LA countries, there was large variation in the size of the ENT profession,

12 the rate of ENTs/million population and the distributive inequality (Table 1). For

13 example, Brazil had 6,159 registered ENTs while Nicaragua had only 38. When the

14 population size was taken into account, there was a more than a 30-fold difference in

15 the number of ENTs/million population—from 61.0 in Argentina (95%CI 58.7–63.4) to

16 2.8 in Guatemala (95%CI 2.1–3.8) (Table 1). There was also large variation in

17 distributive inequality. In all countries ENTs were more prevalent in advantaged

18 areas but the extent of this inequality varied greatly—inequality was lowest in Brazil

19 (RCI 0.249; 95%CI 0.133–0.365) and highest in Paraguay (RCI 0.819; 95%CI

20 0.769–0.870) (supplementary figure 1).

21 Regional benchmarking

22 The regional variation in the ENT rate and distributive inequality is depicted in Figure

23 1. The high ENT rate in Argentina—more than twice as high as the rate in the next

24 highest country—inflated the regional weighted mean of 24.5/million (95%CI 23.3–

25 25.7) (Figure 1). Brazil and Chile were the only other countries to have an ENT rate

26 higher than the regional average. These three countries also had lower distributive

27 inequality than the regional average (RCI 0.344; 95%CI 0.227–0.460), placing them

28 in the best performing, top left quadrant of Figure 1. In contrast, the countries in the

29 bottom right quadrant had a lower ENT rate and higher inequality compared to the

30 regional average, with Guatemala arguably furthest behind other countries in the

31 region.

8

1 The ENT rate tended to reflect the national HDI level. Countries with very high HDI
2 had the highest ENT rate, followed by countries with high HDI, and then countries
3 with medium HDI tending to have the lowest ENT rate. Distributive inequality was
4 similar with two exceptions—Paraguay and Panama are high HDI countries but had
5 distributive inequality more equivalent to countries of medium HDI (Figure 1).

6 *Within country inequality*

7 The redistributive potential to achieve equality mirrored the RCI results, with Brazil
8 needing to redistribute the lowest proportion of their ENTs to achieve distributive
9 equality (rID 18.5%; 95%CI 17.6–19.5) and Paraguay the highest (rID 67.3%; 95%CI
10 57.8–75.6) (Table 1). Due to the size of the respective workforce, this equates to
11 redistributing 1,142 ENTs in Brazil and 70 in Paraguay (aID; Table 1).

12 Urban concentration

13 In all countries, even when the population size was taken into account, ENTs were more
14 concentrated in capital areas (Table 2). Argentina fared best, but the ENT rate in the
15 capital area remained over twice as high as the rest of the country (C:R ratio 2.3; 95%
16 CI 2.1–2.5).

17 The largest inequality between capital and other areas was seen in Paraguay (C:R ratio
18 36.7; 95%CI 23.6–57.2), Venezuela (C:R ratio 15.2; 95%CI 12.9–17.9) and Panama
19 (C:R ratio 15.1; 95%CI 4.7–48.5). The high C:R inequality observed in Paraguay and
20 Venezuela was driven by high ENT rates in the capital. In turn, these rates were driven
21 by the low proportion of the national population residing in the capital area (7.6% and
22 6.6% respectively), combined with the majority of ENTs being located there (75.0% and
23 51.9% respectively). In contrast, the high C:R inequality in Panama was driven by the
24 very low ENT rates in the rest of the country, with only three of the country's 53 ENTs
25 (5.7%) stationed outside the capital (Table 2).

26

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Table 1: Distributive inequality of ENTs per million population in 15 Latin American countries, 2017

Country	Population[a]	Number of ENTs[b]	Number of sub-national units (e.g. states)[a]	ENTs per million population		Relative Concentration Index (RCI)[c]		Absolute index of dissimilarity		Relative index of dissimilarity	
				Mean	95%CI	Mean	95%CI	Mean	95%CI	Mean (%)	95%CI
Argentina	44,044,811	2,688	23	61.0	58.7-63.4	0.259	0.128-0.391	575	534-618	21.4	19.9-23.0
Bolivia	11,145,770	130	9	11.7	9.7-13.8	0.686	0.507-0.864	75	64-86	57.7	49.1-65.8
Brazil	207,660,929	6,159	27	29.7	28.9-30.4	0.249	0.133-0.365	1,142	1,083-1,203	18.5	17.6-19.5
Chile	17,598,287	461	13	26.2	23.9-28.7	0.287	0.058-0.517	115	98-134	24.9	21.2-29.1
Colombia	49,291,609	584	33	11.8	10.9-12.8	0.349	0.262-0.437	155	135-177	26.5	23.1-30.3
Costa Rica	4,947,481	103	7	20.8	17.0-25.2	0.334	-0.065-0.732	35	26-45	34.0	25.6-43.6
El Salvador	6,581,940	59	14	9.0	6.8-11.6	0.670	0.546-0.794	34	27-41	57.6	44.9-69.4
Guatemala	16,924,191	48	22	2.8	2.1-3.8	0.782	0.749-0.816	32	25-38	66.7	52.5-78.3
Honduras	8,866,351	71	18	8.0	6.3-10.1	0.570	0.441-0.699	36	28-44	50.7	39.3-62.0
Mexico	124,041,731	2,207	32	17.8	17.1-18.6	0.336	0.238-0.433	631	590-673	28.6	26.7-30.5
Nicaragua	6,262,703	38	17	6.1	4.3-8.3	0.442	0.291-0.593	16	11-22	42.1	27.9-57.8
Panama	4,098,135	53	12	12.9	9.7-16.9	0.651	0.564-0.738	22	16-29	41.5	29.3-54.9
Paraguay	6,941,905	104	18	15.0	12.2-18.2	0.819	0.769-0.870	70	60-79	67.3	57.8-75.6
Peru	29,381,884	646	25	22.0	20.3-23.7	0.385	0.276-0.494	213	190-237	33.0	29.5-36.7
Venezuela	31,428,916	580	24	18.5	17.0-20.0	0.446	0.307-0.586	275	252-299	47.4	43.4-51.5
All countries	569,216,643	13,931	294	24.5	23.3-25.7	0.344	0.227-0.460	3,426	3,139-3,725	28.5	25.5-31.5

ENT: Ear nose and throat specialist

a Source: National Institute of Statistics   b Source: National Society of ENTs
c The Relative Concentration Index departs from equity for all countries, except Costa Rica (i.e. the confidence intervals do not overlap with zero)

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1   **Table 2:** Number of ENTs per million population in the capital area compared to the rest of the country in 15 Latin American countries, 2017

Country	ENTs per million population				Ratio of ENT rate Capital: Rest-of-country (C:R ratio)		Proportion of population in Capital area (%)[a]	Proportion of ENTs in Capital area (%)[b]	Capital area description
	Capital area		Rest-of-country						
	Mean	95%CI	Mean	95%CI	Mean	95%CI			
Argentina	88.1	84.0-92.3	38.4	35.9-40.9	2.3	2.1-2.5	45.6%	65.8%	Buenos Aires Autonomous City
Bolivia	37.7	31.0-45.6	2.7	1.7-4.0	14.2	9.0-22.5	25.7%	83.1%	La Paz Department
Brazil	67.8	58.8-77.7	29.1	28.4-29.8	2.3	2.0-2.7	1.5%	3.3%	Federal District
Chile	42.3	37.7-47.4	15.3	13.0-17.8	2.8	2.3-3.4	40.4%	65.3%	Metropolitan Region
Colombia	26.7	23.3-30.5	8.9	8.0-9.9	3.0	2.5-3.5	16.4%	37.0%	Bogota Capital District
Costa Rica	42.6	33.1-53.9	10.2	7.1-14.3	4.2	2.8-6.3	32.8%	67.0%	San Jose Province
El Salvador	28.0	20.8-36.9	1.9	0.9-3.6	14.9	7.3-30.3	27.1%	84.7%	San Salvador Department
Guatemala	11.0	7.8-15.1	0.7	0.4-1.4	14.9	7.4-29.8	20.4%	79.2%	Guatemala Department
Honduras	24.4	17.3-33.3	4.4	3.0-6.2	5.5	3.5-8.8	18.1%	54.9%	Francisco Morazan Department
Mexico	65.4	60.3-70.9	14.0	13.4-14.7	4.7	4.2-5.1	7.3%	26.8%	Federal District
Nicaragua	14.1	8.8-21.6	3.6	2.1-5.7	4.0	2.1-7.5	23.7%	55.3%	Managua Department
Panama	23.3	17.3-30.7	1.5	0.3-4.5	15.1	4.7-48.5	52.4%	94.3%	Panama Province
Paraguay	148.8	117.6-185.7	4.1	2.6-5.9	36.7	23.6-57.2	7.6%	75.0%	Asuncion Capital City
Peru	36.5	32.7-40.5	15.1	13.4-16.9	2.4	2.1-2.8	32.3%	53.6%	Lima Department
Venezuela	144.3	128.5-161.6	9.5	8.4-10.7	15.2	12.9-17.9	6.6%	51.9%	Capital District

2   *ENT: Ear nose and throat specialist*

3   *a Source: National Institute of Statistics   b Source: National Society of ENTs*

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1 **Discussion**

2 This study examined the socio-geographic distribution of ENTs between and within

3 15 LA countries. We found that the availability of ENTs across countries of the region

4 is highly variable. Within countries, the distribution was shown to be unequal, with

5 more socially advantaged areas, and capital areas, having a higher concentration of

6 ENT specialists. Despite inequality in countries such as Argentina, Brazil and Chile

7 being up to three times lower than Paraguay and Guatemala, the RCI in all 15

8 countries was at a level WHO considers a high level of relative inequality.[17] This high

9 inequality was reinforced by the rID, which indicates between one in five ENTs in

10 Brazil and two in three ENTs in Paraguay would need to be redistributed to attain

11 socio-geographic equality.

12 The findings of this study concur with previous literature from both the LA region and

13 elsewhere. Wagner et al. (2013) and Stolovitsy et al. (2018) also found that

14 Guatemala had the poorest ratio of ENTs/100,000 population (4 per million), which

15 was only 11% of the ratio in the United States.[10,12] Both studies also found the

16 highest ratio was in Argentina (56 per million). These trends align with our findings,

17 however we found a lower ratio in Guatemala and higher ratio in Argentina which

18 may be explained by population increases, or increases in the numbers of ENTs

19 respectively.[10,12] In 2001, Madriz and colleagues surveyed 15 countries in Latin

20 American and the Caribbean to determine the resources available for hearing

21 impairment, including prevalence data, training programmes, and equipment. They

22 found Brazil (5000 ENTs), Argentina (3000 ENTs), and Mexico (2400 ENTs) had the

23 greatest absolute numbers of human resources. Although the survey was published

24 over 15 years ago, it appears that there has been little progress in human resource

25 development since this study was conducted.[11] In fact, the number of ENTs in our

26 study was lower in comparison for Argentina, Guatemala, and Mexico. This may be

27 due to differences in data sources, with the 2001 survey using expert opinion across

28 a range of institutions rather than National societal membership.[11] In 2012, the WHO

29 conducted a global survey of availability of human resources to provide ear and

30 hearing care. They demonstrated great variation in availability of ENTs, audiologists,

31 and speech therapists globally, and a clear trend of increased availability with

32 country-income group.[4]

12

1 Despite the trend in increased availability with national income, inequalities in access

2 to services still exist within countries. Within country disparities in availability of ENTs

3 have been less well documented. Westerburg et al. (2018) reports that the

4 geographic distribution of ENTs in North America is inequitable, contributing to poor

5 access for vulnerable populations.[21] In Canada, for example, the majority of

6 providers are located in urban centres, and there are no providers at all in many

7 areas where Aboriginal populations are concentrated.[21] The trends we found in this

8 study have also been observed in eye health in the region. Hong et al. (2016) found

9 that ophthalmologists are more concentrated in socially advantaged areas within

10 countries.[22] However, comparisons to this study highlight that the low coverage of

11 ENTs appears to be more pronounced than in eye health. For example in

12 Venezuela, there are 42 ophthalmologists/million, whereas our analysis found a ratio

13 of 18.5 ENTs/million. Thus, for every ENT in Venezuela there are two

14 ophthalmologists. This is despite comparable burden of impairments (16%

15 hearing;18% vision).[23] The reasons for this difference could allow lessons to be

16 drawn on improving ear and hearing services availability in the country. Compared to

17 ophthalmologists, ENTs in LA also tend to be less equally distributed. There are

18 several possible explanations for this, including the lack of population-based data on

19 need for services, and lack of funding, leading to ear and hearing care not being

20 prioritised by the regional governments.[24] The reasons for the concentration of ENTs

21 in more socially advantaged areas likely include better availability of equipment,

22 facilities, and specialist training centres.

23 This study has several strengths. Although previous literature has examined

24 numbers of ENTs per population and made comparisons across countries, there has

25 been limited analysis of inequalities within countries. This study adds to the

26 knowledge base by performing a robust, more in-depth analysis of the substantial

27 sub-national inequalities that exist. The three inequality measures used in this

28 analysis take into account the entire population and are population-weighted, thus

29 giving equal weight to each individual's access to ENTs.[16,25] These strengths—along

30 with reflecting the socioeconomic dimension to health inequality—are why WHO

31 recommends the concentration index as a measure of relative inequality.[26] The data

32 coverage of this study was high, representing 96.7% of the LA Spanish and

33 Portuguese speaking countries.

13

1   There are also limitations which should be taken into account when interpreting the

2   results. The data were obtained from national ENT societies, which may not be

3   representative of all available ENTs within the countries studied as some ENTs may

4   not be society-affiliated. Although ENT specialists are an essential component of

5   functioning ear and hearing care programmes, there are also many other

6   professionals involved in provision of specialist care for hearing loss and ear

7   disease, for instance, audiologists and speech therapists. Further, data on the

8   availability of equipment to enable service provision is not provided. In addition, we

9   have assumed that ENTs in LMICs deliver the full range of ear and hearing services.

10 However, it is possible that some ENT specialists are subspecialised and provide

11 services for only one of ears, nose or throat. The data also do not capture more

12 nuanced service delivery models common in LMICs, such as surgical outreach to

13 primary and secondary care facilities or telemedicine. This is an area of future

14 research need. Finally, data were not available on the distribution of ENTs in private

15 vs public health services which has an impact on the financial accessibility of the

16 service. Thus, we are unable to draw conclusions on the availability full complement

17 of ear and hearing services.

18 While not a limitation of our study, we acknowledge that distribution of personnel is

19 only one aspect of access to hearing care. Productivity of these personnel, as well

20 as the quality and costs of hearing services are also important components that

21 require attention to realise universal hearing care.[27]

22 This study provides evidence for policy makers to further develop programmes that

23 increase the number of ENTs/million population as well as reduce the inequities in

24 their distribution. The Pan American Health Organisation (PAHO), the regional WHO

25 office for the Americas, has developed a strategy to guide national policies on

26 addressing human resource deficiencies.[28] Some of the key strategies outlined

27 include strengthening governance and leadership, focussing on the number and

28 distribution of personnel according to health needs; partnership with other relevant

29 sectors, such as education, in order to respond to training needs across geographic

30 regions; and implementing staff retention strategies, such as incentives and

31 improved infrastructure.[28] We acknowledge there is no definitive 'right' number of

32 ENTs/ million population, and instead countries must consider all of these elements.

33 Access to health is required to achieve good health outcomes, however in

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1   addressing health inequities, actions must also be taken to address the social

2   determinants of health. As an example, hearing loss and ear disease are linked to

3   poverty, and thus to address the greater burden amongst the poor, a multi-faceted

4   approach is required – beyond a focus on human resource development alone.[29,30]

5   Further research is needed to understand the availability and inequities in distribution

6   of other health professionals relevant to ear and hearing care, including audiologists,

7   and speech therapists, as well as mid-cadre and primary health professionals such

8   as clinical officers that exist in many LMICs. Training primary health workers in ear

9   and hearing care has been a key strategy supported by the WHO in order to address

10 the lack of human resources and improve access to services at the community level,

11 in efforts to achieve universal ear and hearing care.[27,31] There is also a need to

12 examine availability of equipment, and other essential elements of service provision.

13 Although this study presents a clear picture of inequalities in distribution of

14 specialists, the need for services is not well understood. There have been very few

15 population-based surveys to determine the prevalence and causes of hearing loss in

16 LA. In LA, there have been three published studies, two of which were in Brazil, and

17 one in Ecuador.[24] Prevalence data are required to plan services according to the

18 population need, including the required number and distribution of specialists.

19 Although global Vision 2020 targets of ophthalmologists per population are

20 contested, they have been used as an advocacy tool to lobby governments for

21 increased resources for eye care. Thus, similar evidence-based targets should be

22 developed for the field of ear and hearing. Vision 2020 has helped garner action to

23 reduce avoidable causes of blindness, at a global and local scale. A similar global

24 initiative for ear and hearing care has been launched in 2018, the World Hearing

25 Forum, which aims to stimulate action and make gains similar to those attained in

26 eye health.[32]

Conclusion

28 This study provides evidence that the availability and distribution of ENTs in LA

29 countries is highly inequitable. A disproportionate number of ENTs are concentrated

30 in more socially advantaged areas, such as capital cities. This evidence on health

31 inequalities, with respect to access to ear and hearing services, can be used to

32 support development of programmes and policies to increase the number and

15

1 distribution of ear and hearing professionals. Actions to reduce these inequities are

2 essential for efforts towards achieving UHC.

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5 **Figure Legend**

6 **Figure 1:** Availability and distributive inequality of ENT for 15 Latin American countries benchmarked

7 against regional mean values, 2017

8 *Source of population data: National Institute of Statistics*   *Source of ENT data: National Society of ENTs*

9 *Source of HDI of each country: UNDP 2018[20]*

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18 **Data sharing statement:** The data used in this study include (for the 15 countries):

19 i) the number of members of national ENT societies at the national and subnational

20 level; ii) the population distribution at the subnational level; and iii) the calculated

21 inequality indices. These data are available on reasonable request from Dr Juan

22 Carlos Silva ORCID ID: 0000-0003-4855-5008.

23 **Patient and public involvement:** It was not appropriate or possible to involve

24 patients or the public in this work.

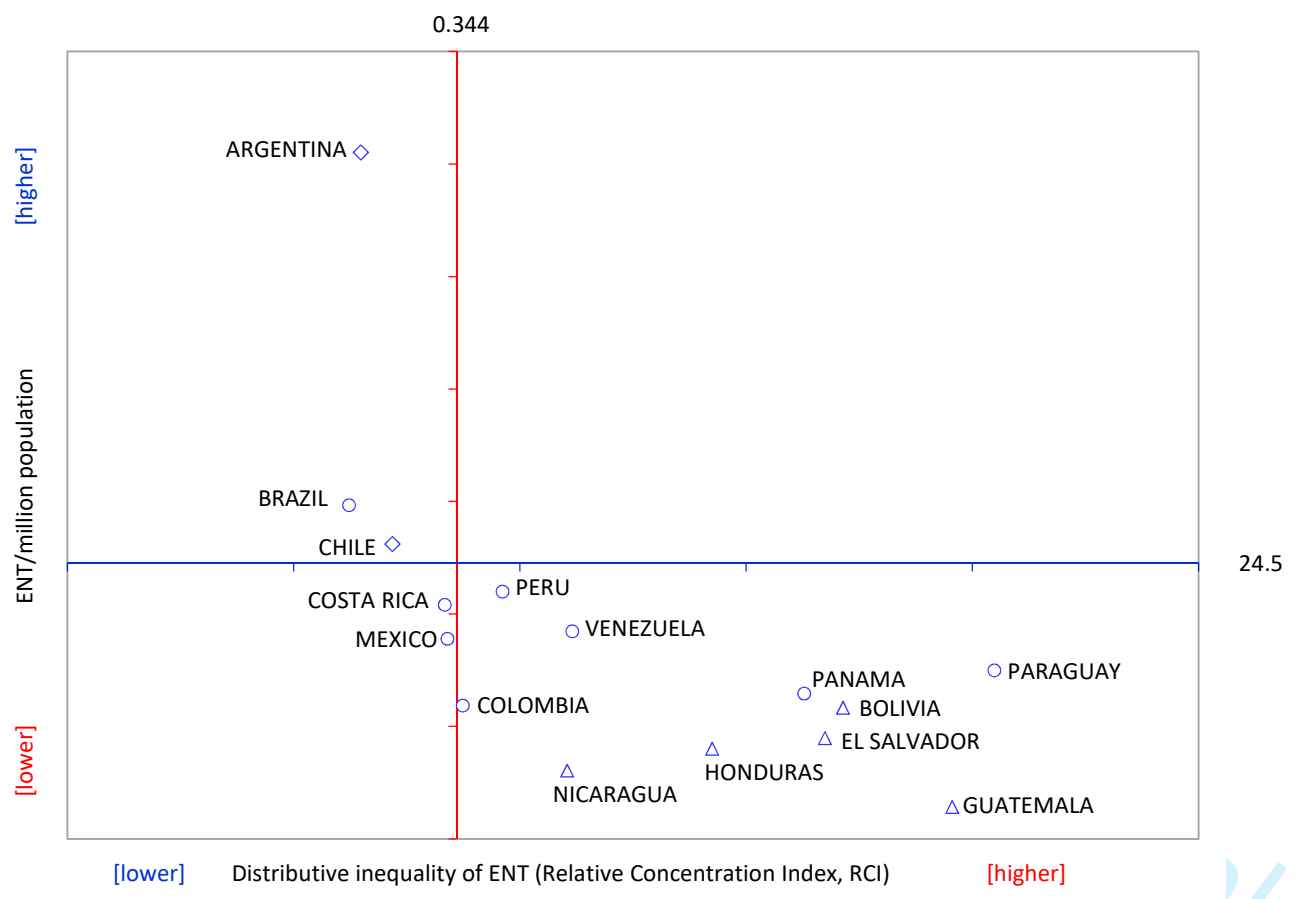25 **Author contribution:** JCS conceived of the study, facilitated access to data,

26 interpreted findings and helped draft the manuscript. TB and JR interpreted data and

27 drafted the manuscript. OM and CM conceived of the study, were responsible for

28 data analysis and edited the manuscript. CD, AM, EL, ES, DS, SC and AP facilitated

29 access to data and critically reviewed the manuscript. All authors read and approved

30 the final manuscript.

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Supplementary Figure 1: Concentration curves of distributive inequality of ENTs for 15 Latin American countries, 2017