

## ОРИГІНАЛЬНІ ДОСЛІДЖЕННЯ

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## Survey of Otolaryngology Services in Central America: Need for a Comprehensive Intervention

<sup>1</sup>Global ENT Outreach, Coupeville, WA<sup>2</sup>Division of Otolaryngology, Faculty of Health Sciences, University of Cape Town, South Africa**Abstract**

In the developing world, there exists a scarcity of services and training in otolaryngology, audiology, and speech therapy, which is reflected by the gap between health care delivery in high-income countries and low-income countries. We surveyed, by questionnaire, the countries of Central America, except for Belize, because of the lack of otolaryngology services, on the following issues: availability of otolaryngology, audiology, and speech therapy services and equipment; otolaryngologist, audiologist, and speech therapist training; and availability of services in rural areas. Surveys were distributed via email and by hand at the 2011 Central American Congress of Otolaryngology, in San Salvador, El Salvador, to otolaryngologists, audiologists, and speech therapists. Not to our surprise, there is a shortfall in services and training in all three professions. The data collected and presented in this commentary will provide a basis by which change might take place.

**Keywords:** *otolaryngology, ENT, audiology, speech therapy, developing countries, Central America.*

Development is about transforming the lives of people, not just transforming economies.”<sup>1</sup> This quote by Joseph Stiglitz, a renowned economist, appropriately lays the foundation for the importance of public health and the intense debate around addressing global health problems. Although public health threats emanating from chemical exposure, nuclear accidents, environmental disasters, and terrorism are ever present, they are outweighed by acquired natural diseases such as influenza and diseases of poverty and neglect. Unequal distribution of wealth as seen on a global scale, and along with it suboptimal infrastructure and education, subject developing countries to growing economic disparity. The overall burden of disease, as assessed using the disability-adjusted life-year, a time-based measure that combines years of life lost due to premature mortality and years of life lost due to time lived in states of less than full health, are unequally disproportionate in developing countries.

As pointed out in a previous article, “Survey of Otolaryngology Services in Africa,”<sup>2</sup> this inverse relationship is most evident in Africa. However, other regions, such as Central America, although not frequently studied, have similar challenges. Along similar lines, Paul Farmer identifies that a lack of surgical services on a global proportion is responsible for the deaths of millions of people annually and, along with noncommunicable diseases, receives poor attention by global public health communities.<sup>3</sup>

Epidemiological studies on disabling hearing loss cite that between 5% and 8% of the world’s population is afflicted by some form of ear disease, which ranks it third globally on the list of nonfatal disabling conditions in developing countries.<sup>4</sup> The World Development Report in 1993 found that 51,000 children younger than 5 years died per year from ear disease and its related complications and that even this is an overwhelming underestimation.<sup>5</sup> In the global health arena, agreement exists that there is a need to initiate interventions that will address conditions neglected by global estimates of burden of disease, such as hearing loss.<sup>6</sup>

This survey was conducted to assess the availability of otolaryngology, audiology, and speech therapy services and training in Central America.

**Aims of the Study**

1. Establish a database of otolaryngology, audiology, and speech therapy services in Central America.
2. Improve awareness of the status of these services in Cen-

tral America.

3. Gather data to lobby Central American governments, the Pan American Health Organization, donor countries, and aid organizations.

4. Plan and promote programs that will target support for these services.

5. Help promote the creation of a Developing World Forum for Otolaryngology, Audiology, and Speech Therapy

**Detailed Methods**

There were 8 surveys emailed, and approximately 4 of them were returned. At the 2011 Central American Congress of Otolaryngology, held in San Salvador, El Salvador, the survey was distributed to 40 attendees of the congress, and 21 were returned. The surveys requested information on professional training; specialty demographics; available services in otolaryngology, audiology, and speech therapy, as well as equipment and testing available; and the outlook for the future.

**Results**

Otolaryngologists, audiologists, and speech therapists from the Central American countries of Costa Rica, El Salvador, Honduras, Guatemala, Nicaragua, and Panama were solicited and responded to the survey (Figure 1). Twenty surveys were returned, and data were collectively compiled for this report.

All of the Central American countries studied have otolaryngology, audiology, and speech therapy services. Table 1 presents the numbers of otolaryngology surgeons, audiologists, and speech therapists per country, presents the ratio of population to practitioners, and compares it to the United States; the United



Figure 1. Six countries that participated in the survey

**Table 1.** Comparison of otolaryngology surgeons, audiologists, and speech therapists/100,000 people, with the United States.

Country	Population (millions)	Otolaryngology Surgeons		Audiologists		Speech Therapists	
		Number	Per 100,000	Number	Per 100,000	Number	Per 100,000
Costa Rica	4.7	83	1.76	10	0.212	100	2.12
El Salvador	6.2	75	1.2	5	0.08	5	0.08
Guatemala	14.7	60	0.4	1	0.007	50	0.34
Honduras	7.7	64	0.83	4	0.052	10	0.13
Nicaragua	5.9	56	0.94	2	0.034	2	0.034
Panama	3.6	70	1.94	65	1.8	10	0.28
United States	311.6	10917	3.5	11969	3.84	126219	40.5

**Table 2.** Training programs.

Country	Medical Schools		Otolaryngology Surgery	Audiology	Speech
	Total Number	Number with Otolaryngology Training	Number of Otolaryngology Who Qualify per Annum	Training Program?	Training Program?
Costa Rica	8		4	Yes	Yes
El Salvador	5		1	No	No
Guatemala	4	1	2	No	Yes
Honduras	2	1	2	No	No
Nicaragua	3		3	No	No
Panama	4		3	Yes	Yes

**Table 3.** Countries with access to hearing-related services.

	Availability in State Services							
	None		Poor		Good		Excellent	
	Country	Total	Country	Total	Country	Total	Country	Total
Audiology and otologic surgery	G, N, ES	3	H	1	CR, P	2		
Auditory brainstem response	H, N, ES	3	G	1	CR, P	2		
Hearing screening: newborn	G, H, N, ES	4	P	1				
Hearing screening: schools	G, H, N, ES	4	P	1				
Hearing screening: industry	G, H, N, ES	4	P, CR	2				
Hearing aids	N	1	G, P, ES	3	CR, H	2		
Myringotomies-ventilation tubes			N, ES	2	CR, G, H	3	P	1
Tympanoplasty			G, N, ES	3	H	1	P, CR	2
Mastoidectomy for cholesteatoma			G, H, N, ES	4	P	1	CR	1
Mastoidectomy for mastoiditis			G, H, N, ES	4	P	1	CR	1
Acoustic neuroma	H, N, ES	3	G, P	2	CR	1		
Middle ear prosthesis	G, ES	2	H, N	2	CR, P	2		
Bone-anchored hearing aids	G, H, N, ES, P	5	CR	1				
Cochlear implants	G, H, N, ES	4	P	1	CR	1		

Abbreviations: CR, Costa Rica; ES, El Salvador; G, Guatemala; H, Honduras; N, Nicaragua; P, Panama.

**Table 4.** Countries with modern otolaryngology equipment.

Equipment Services	Availability in State Services							
	None		Poor		Good		Excellent	
	Country	Total	Country	Total	Country	Total	Country	Total
Flexible nasopharyngoscopes			E, G, N	3	H, P	2	C	1
Operating microscope			E, G, N	3	H, P	2	C	1
Otologic drill			E, H, N	3	G, P	2	C	1
CO <sub>2</sub> laser	E, G, H, N, P	5			C	1		
Ultrasound of neck	G	1	E, H, N	3	C, P	2		
Computed tomography			G, N	2	E, H	2	C, P	2
Magnetic resonance imaging	H		G, N	2	E	1	C, P	2
Positron emission tomography	E, C, G, H, N, P	6						
Radiation therapy			E, G, H, N	4	C	1	P	1

Abbreviations: CR, Costa Rica; ES, El Salvador; G, Guatemala; H, Honduras; N, Nicaragua; P, Panama.

States has a far superior ratio per 100,000 people compared with the Central American countries polled.

Although Costa Rica and Panama had the best ratios of otolaryngology surgeons/100,000, this represented only 55% and 50% of the US ratio, respectively. Guatemala has the biggest deficit of otolaryngology surgeons, equating to only 11% of the US ratio.

There is a big shortage of audiologists in the six Central American countries (Table 1). Panama has the best ratio to population (47%) compared with the United States, followed by Costa Rica (6%); Guatemala has a ratio of only 0.7% compared with the United States.

There is an even bigger shortage of speech therapists. Costa Rica has the best ratio/100,000 people, but only 5% of the US ratio, followed by Guatemala and Nicaragua, both with a ratio of 0.08% compared with the United States.

If one were to apply the current ratios of otolaryngology surgeons, audiologists, and speech therapists in the United States to the total population (42.8 million) of the countries surveyed, then the shortages of personnel in these 6 countries is as follows: otolaryngology,  $1498\ 2\ 408 = 1090$ ; audiology,  $1643\ 2\ 87 = 1556$ ; speech therapy,  $17,334\ 2\ 177 = 17,157$ .

Table 2 presents a summary of otolaryngology, audiology, and speech therapy training programs. All 6 countries have otolaryngology training programs; however, only Costa Rica and Panama have audiology training programs, and speech therapy training is available only in Guatemala, Costa Rica, and Panama.

Table 3 indicates that Costa Rica and Panama have the best public otologic surgical services; all other countries were considered "poor" to "good." Hearing aids are not available to public patients in Nicaragua and are only poorly available in Guatemala, Panama, and El Salvador; auditory brainstem response is not available in Honduras, Nicaragua, or El Salvador in state services. There is no hearing screening in Honduras, Guatemala, El Salvador, and Guatemala. Costa Rica is the only country where acoustic neuroma and cochlear implantation surgery are done at state hospitals.

Table 4 summarizes the availability of modern otolaryngology equipment at state facilities. Costa Rica and Panama maintain the highest standards of modern equipment, whereas El Salvador, Nicaragua, and Guatemala are all considered "poor"; this includes basic otolaryngology equipment such as flexible nasopharyngoscopes, operating microscopes, and otologic drills. Radiation therapy is only poorly available in 4 of 6 counties, and positron emission tomography is not available in any of the countries in the state sector. CO<sub>2</sub> laser was available only in Costa Rica.

Not tabulated were the data on head and neck oncology surgery. Costa Rica and Panama are the most advanced in terms of head and neck surgical procedures. Costa Rica is the only country that has a CO<sub>2</sub> laser. Partial laryngectomy and voice restoration prostheses are nonexistent in Guatemala, Honduras, and El Salvador, and neither pedicled nor free flaps are done in El Salvador.

With regard to the access that patients have to sinus and rhinologic surgery, endoscopic sinus surgery is considered to be excellent in Panama and Costa Rica compared with all other countries surveyed.

In all of the countries surveyed, we noted that the overwhelming majority of people depend on state health services. According to 2011 World Bank data (<http://data.worldbank.org/topic/agriculture-and-rural-development>), a significant percentage of the population in Central America lives in rural areas: Guatemala (50%), Honduras (48%), Nicaragua (42%), El Salvador and Costa Rica (35%), and Panama (25%). Yet otolaryngology services for the most part are restricted to major cities (Table 3), and access was considered to be either poor or very poor outside of the major cities.

## Discussion

This project represents the second report of otolaryngology,

audiology, and speech therapy services in developing world countries.<sup>2</sup> The first author (R. W.) has taught otology and done otologic surgery in Central America for a number of years. Based on his personal experience and the data presented in this study, there are clearly both disparities and similarities of otolaryngology-related services in Central American countries. Panama and Costa Rica have the highest levels of care and resources available in the state-run health care systems in Central America. Costa Rica, interestingly, is the only Central American country without a military and a military budget.<sup>7</sup> Both Costa Rica and Panama spend 4 to 5 times the amount in dollars on health at purchasing power parity per capita than the rest of the countries.<sup>8</sup>

Although specialty training in otolaryngology is available in all of the countries surveyed, there are enormous shortfalls of otolaryngology surgeons, as well as audiologists and speech therapists, when compared with the neighboring United States. Each country sets its own standards and does not follow uniform educational criteria and standards such as those set forth by the American Board of Otolaryngology or its European equivalent.

Fellowship training is not available in any of the subspecialties laryngology, otology, head and neck surgery, or rhinology. Head and neck surgery in many of the countries is performed by general surgeons, such as in El Salvador in particular. Otology is available only in the capitals or the largest cities and is performed by those who were trained outside the country. Although otosclerosis is quite prevalent in El Salvador, such patients only rarely undergo surgery due to lack of implants and skilled surgeons. Graduates who wish to further their specialist education upon completion of otolaryngology residency usually do so in Mexico, Argentina, Spain, or Columbia. Only recently has the younger generation of otolaryngology surgeons been interested in ear disease and in going overseas for training.

There is a great need for audiology and speech therapy training other than in Panama and Costa Rica, where programs already exist. Since 2000, there has essentially been little improvement in terms of access to training in these fields.<sup>9</sup> The shortage of audiologists results in poorly trained technicians doing the bulk of the testing. In many Central and South American countries, like in some parts of Europe, otolaryngology specialists who hold the title of "auditory physician" practice audiology as their sole profession. The deaf do not have access to speech therapists because of their short supply.

Health care is delivered at three levels in Central America. The first level is the public level, which includes hospitals and clinics. The second level is the social security system, which generally has a higher level of care due to its funding from taxes paid by the working class; here, the infrastructure and resources are generally more abundant. The third level of care is the private sector, where the infrastructure and medical technology is in many cases on a par with the developed world; less than 20% of the population in Central America has private insurance.<sup>10</sup> Most professionals, be they otolaryngologists, audiologists, or speech therapists, allocate morning hours to working in public or state-run health institutions; the remainder of the day is spent in the private sector, where they earn the majority of their income.

It is common knowledge that Central American countries have an enormous otolaryngology-related burden of disease. This audit presents a disturbing picture of underresourced, understaffed, and outdated otolaryngology, audiology, and speech therapy services in Central America. Mortality from simple otolaryngology infections, such as cholesteatoma and curable cancers, is ever present, and access to the most basic hearing tests or hearing rehabilitation is limited. Also highlighted is the lack of training facilities, critical to improving the shortage of qualified staff.

Central America is geographically small, and the 6 countries surveyed have only 42 million inhabitants. A turnaround strategy to improve otolaryngology, audiology, and speech therapy services is therefore far simpler to implement than for the vast continent of Africa.<sup>2</sup> A multinational collective approach is required to address the challenges identified in this study. Mea-

tures may include the following: otolaryngology training should be standardized for all of these countries, and a common board examination should be administered; training programs should be developed in countries that lack audiologist and speech therapists; and countries with existing training programs should either develop programs in countries lacking such programs or open their doors to foreigners.

## References

1. Stiglitz J. Making Globalization Work. New York, NY: W. W. Norton & Company; 2006.
2. Fagan J. Survey of otolaryngology services in Africa: need for a comprehensive intervention. *Glob Health Action*. 2009;2. <http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2779942/>. March 19, 2009.
3. Farmer PE, Kim JY. Surgery and global health: a view from beyond the OR. *World J Surg*. 2008;32:533–536.
4. Pascolini D, Smith A. Hearing impairment in 2008: a compilation of available epidemiological studies. *Int J Audiol*. 2009; 48:473–485.
5. World Development Report 1993. New York, NY: Oxford University Press; 1993:224–225. <http://bjp.rcpsych.org/content/165/1/9.citation>.
6. Garrett L. The challenges of global health. *Foreign Aff*. January/February 2007. <http://foreignaffairs.com/articles/62268/laurie-garrett/the-challenge-of-global-health>.
7. World Bank Data. Military expenditure (% of GDP). 2012. <http://data.worldbank.org/indicator/MS.MIL.XPND.GD.ZS>.
8. World Bank Data. Agriculture & rural development. 2011. <http://data.worldbank.org/topic/agriculture-and-rural-development>. 2011.
9. Madriz JJ. Hearing impairment in Latin America: an inventory of limited options and resources. *Audiology*. 2000;39:212–220.

10. World Health Organization. World health statistics 2012. [http://www.who.int/gho/publications/world\\_health\\_statistics/2012/en/](http://www.who.int/gho/publications/world_health_statistics/2012/en/). p. 133.

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## Огляд отоларингічних послуг у Центральній Америці: Потреба у комплексному втручанні

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**Резюме.** У світі, що розвивається, існує дефіцит у послугах отоларингологів і нестача закладів, що їх готують, а також спеціалістів з аудіології та мовної терапії. Це підтверджується різницею у якості надання медичної допомоги між країнами з високим рівнем заробітку і країнами з низьким рівнем заробітку. За допомогою анкет, ми досліджували країни Центральної Америки (за винятком держави Беліз) і виявили наступні проблеми: наявність послуг та обладнання з отоларингології, аудіології і мовної терапії; наявність цих послуг у сільських місцевостях. Анкети були розповсюджені електронною поштою і людьми. На конгресі з отоларингології у Центральній Америці у 2011 році в Сан Сальвадорі, Ель Сальвадорі їх отримали отоларингологи, аудіологи і мовні терапевти. Ми не здивувались, коли дізнались про нестачу у послугах, які надаються представниками цих трьох професій, а також про нестачу навчальних закладів, що готують цих фахівців. Дані, зібрані й представлені у цьому дослідженні, стануть основою для впровадження подальших змін.

**Ключові слова:** отоларингологія, ВГН, аудіологія, мовна терапія, країни, що розвиваються, Центральна Америка.

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## Purification of Ku70, Ku80, Rad51 and Rad52 proteins in *Arabidopsis thaliana* and generation of anti-Ku70 and anti-Rad51 antibodies

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**Summary:** Successful techniques of genetic engineering and gene targeting depend on high activity of homologous recombination repair. Strand breaks in plant and animal somatic cells are primarily repaired by non-homologous end joining, a competitor of homologous recombination pathway. The objective of this study was to shift the naturally occurring balance of double strand break DNA repair in cells away from non-homologous end joining and towards homologous recombination. We hypothesized that this will improve the current methods for genetic engineering and ultimately practical applications like gene therapy. We amplified full cDNA copies of the proteins Ku70, Ku80, Rad51 and Rad54 using cDNA from *Arabidopsis*. The cDNA were overexpressed in Rosetta cells and the proteins were sent away to GenScript to obtain polyclonal antibodies. Generated antibodies were tested for recognition of *Arabidopsis* Ku70 and Rad51 proteins. We hypothesized that introducing the anti-Ku70 antibodies into cells would deplete the amount of Ku70 and this would result in the shift of strand break repair towards homologous recombination. In the future, we will use cell-penetrating peptide to deliver the antibody and to test the level of homologous recombination.

**Key words:** Ku70, Ku80, Rad51 and Rad52 proteins, generation of anti-Ku70 and anti-Rad51 antibodies.

**Introduction.** Altering the balance between non-homologous end joining (NHEJ) frequency and homologous recombination (HR) frequency has been the focused direction of this work. NHEJ involves among other proteins Ku70 and Ku80, while homologous recombination utilizes Rad51 and Rad54 [7]. In *S. cerevisiae* Ku70 and Ku80 work in conjunction with ligase IV and XRCC4 to ensure proper DNA repair via the NHEJ path-

way [7]. In vertebrate cells Ku70 and Ku80 form a heterodimer that has a strong penchant for DNA ends and consequently binds with the damaged DNA [3]. The DNA bound Ku70/Ku80 heterodimer associates with, stabilizes, and activates the DNA-PKcs a catalytic subunit to form DNA-PK (DNA-dependent protein kinase), a necessary component of the non-homologous end joining pathway [9]. In studies investigating cell lines deficient in Ku proteins, little if any DNA-PK activity is seen indicating that the cell requires the presence of the Ku70/Ku80 for proper DNA-PK functioning and therefore also non-homologous end joining [15]. The role of Ku proteins has been linked to the detection of damaged DNA in all eukaryotic cells. Rad51 and Rad54 are also conserved in eukaryotic cells and necessary elements of the homologous recombination DNA repair pathway [2]. Rad51 is very important for the HR DNA repair process because it catalyses the exchange of DNA between homologous strands by encouraging the association of the damaged DNA strand to its respective complementary, template strand [7]. Rad51 requires interaction with Rad54 for optimal efficiency and proper functioning [11]. Animal studies have shown that inactivation of Rad51 through artificial means results in early death of developing embryos while knockout studies of Rad54 show only an increased sensitivity to agents that induce double stranded breaks in DNA which emphasizes the essentialness of Rad51 and the complementary actions of Rad54 [4].

The success of genetic engineering and gene targeting in particular depends directly upon the activity of homologous re-