WORLD VIEW

Blindness and visual impairment in the Americas and the Caribbean

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Aim: To summarise available data on the prevalence and causes of visual impairment and blindness in the Americas and the Caribbean.
Methods: The published literature was searched in Medline and LILACS using the following key words: blindness, visual impairment, prevalence. Articles were reviewed, and the references of the articles were also searched for relevant articles, which were also reviewed.
Results: Using the mortality in children under the age of 5 as an indicator, the overall prevalence of childhood blindness (in the under age 15 group) for the region was estimated at 0.45/1000, with the majority (67%) living in countries with mortality of children under age 5 above 30/1000 live births. Corneal opacities were more common in countries where the under 5 year mortality are above 30/1000 live births and retinopathy of prematurity (ROP) was an important cause in countries with intermediate death rates. For adults, overall blindness rates were not estimated because of the social, economic, and ethnic diversity in the region. The primary causes of visual loss in adults in the Americas were age related eye diseases, notably cataract and glaucoma in the African-American and Hispanic populations, and age related macular degeneration in the white population. Uncorrected refractive error was a significant cause of decreased vision across ages, ethnic groups, and countries.
Conclusion: More data are needed on the magnitude and causes of visual loss for the Caribbean and Latin American countries. Rates of blindness and visual loss from available data within these countries are widely disparate. Prevention and control of avoidable blindness needs to be an ongoing focus in this region.

North, Central, and South America, including the Caribbean, cover a region characterised by extreme diversity. Geographically, the region includes the driest desert in the world (Atacama Desert in Chile, with annual precipitation less than 0.5 inches) and the wettest location outside Antarctica (Mt Waialeale, Hawaiian Islands, with annual precipitation of 37 feet). Population-wise, the region includes the two largest cities in the world, Mexico City with 26 million and Sao Paulo, Brazil, with 24 million, and at the same time island countries where most of the population is in the rural areas in small communities.

The extremes are evident as well in the variation in socioeconomic and health indicators for the populations in this region. Canada has one of the lowest infant death rates in the world, while Haiti has among the worst, over 10 times the rate in Canada.[1] Within the high income countries, there is also quite a disparity, along racial/education/income lines. For example, within the United States, African-Americans have over twice the infant mortality of the white population.

Thus, there should be little surprise at finding a large variation in blindness and visual impairment rates across countries in the Americas. The major surprise, however, is how little is known about the magnitude of the problem in various countries within the region. Data on blindness and visual loss in children are based on models derived from estimates correlated with child mortality. Except for very localised surveys in the United States, there are almost no population based data on adults. This paper summarises the literature, including reports where they could be obtained, on the prevalence and causes of visual loss for the Americas.

METHODS

The published literature was searched in Medline using the following key words: blindness, visual impairment, prevalence. All articles were reviewed, and the references of the articles were also searched for relevant articles, which were also reviewed. A search of a database in Latin America, LILACS (Latin American and Caribbean Literature on Health Sciences), was also carried out using similar key words in Spanish and Portuguese. In addition, reports on blindness surveys in Latin America and the Caribbean where requested through Pan American Health Organization and the Prevention of Blindness representatives. Finally, people thought to have relevant data were approached for permission to cite their findings, if the data were not yet published.

Because of the absence of data on childhood blindness, we adopted the model of Gilbert and Foster,[2] which extrapolates an estimated prevalence rate according to the childhood mortality reported for the country. There are no good comparable models for estimating rates of adult blindness and visual impairment, so the paucity of data in this area is all too evident. There is social, economic, and ethnic diversity in most of these countries which will greatly affect the rates and causes of blindness and visual loss,[3] so it is simply not possible to extrapolate rates from surveys in one country to surveys in another. Therefore, we present adult prevalence rates specific for the country (or area within the country) where the study was conducted.

RESULTS

Childhood blindness

Magnitude of blindness

Information on the prevalence of blindness in children is scarce and difficult to obtain because of its relatively low occurrence. Population based studies that could yield results with reasonable precision are very expensive to conduct, so alternative ways to assess the magnitude of the problem have been used. Based on data from blind registers in Europe and the few available population based surveys from Asia and

Table 1 Magnitude of blindness in children age 0–15, estimated as a function of under 5 years mortality (1999)

Region	Mortality for children under 5 years/1000 live births	Estimated prevalence of blindness/1000	Countries	Estimated population under 15 years (in millions)	Estimated number of blind
North America	30 and under	0.3	Canada, USA	67.0	20 100
Central America	30 and under	0.3	Costa Rica, Panama	2.1	630
	31–94	0.6	Belize, El Salvador, Guatemala, Honduras, Mexico, Nicaragua	44.7	26 820
South America	30 and under	0.3	Argentina, Chile, Colombia, Paraguay, Uruguay, Venezuela	38.7	11 610
	31–94	0.6	Bolivia, Brazil, Ecuador, Guyana, Peru	62.8	37 680
Caribbean	30 and under	0.3	Aruba, Bahamas, Barbados, Cayman Island, Cuba, Dominica, Grenada, Jamaica, Netherlands Antilles, Puerto Rico, St Kitts Nevis, St Lucia, St Vincent, Trinidad Tobago, Virgin Islands	5.1	1530
	31–94	0.6	Dominican Republic	2.7	1620
	95–170	0.9	Haiti	3.0	2700
Total		0.45	All countries	226.1	102 690

Africa that included children, Foster *et al* proposed an algorithm to estimate the magnitude of blindness in children age 0–15 using the mortality in children under 5 as an indicator.[2] Table 1 shows estimates of the magnitude of prevalence of childhood blindness for the Americas and the Caribbean by applying Foster's paradigm to population and mortality data from the year 1999.[1 4]

Approximately 100 000 out of the 226 million children under 15 years of age were blind in the Americas and the Caribbean. The overall prevalence was 0.45/1000, the majority of them (67%) living in countries with under 5 death rates above 30/1000 live births.

Causes

As is the case for the estimation of the magnitude of childhood blindness, accurate data (population based) on the distribution of causes of blindness and severe visual impairment in childhood are not available. An alternative approach is to examine the causes in an identifiable group of blind children. Blind registers and schools for the blind have served as the primary source to look at the aetiology, although these two sources are subject to selection and survival bias. Recognising they are likely to under-represent the poor, and blind children with other disabilities, they could provide a starting point to determine the main causes.[5] To be able to compare results across studies, the World Health Organization (WHO) recommends a standard methodology for reporting causes of childhood blindness based on two criteria—anatomical site of the abnormality and underlying aetiology.[6] However, only the more recent studies have used this approach making it difficult to summarise all available data using the recommended criteria. In this review we present causes using the anatomical site whenever possible. The four more frequently reported causes of blindness and severe visual impairment for schools for the blind throughout countries from the regions are shown in Table 2. The observed distributions agree with the patterns described by others in terms of the specific causes being associated with different levels of economic development.[2 5 17]

Corneal opacities were more common in countries where the under 5 year death rates are above 30 per 1000 live births. In Bolivia, Dominican Republic, and Peru around 20% of the blindness is attributable to corneal opacities in contrast with none or very few cases in the United States, Chile, and Argentina (Table 2). Although it was difficult to establish the aetiology of the corneal opacity, evidence from studies elsewhere suggests that the main causes are likely to be corneal ulceration after measles, herpes simplex infection, vitamin A deficiency, and ophthalmia neonatorum.[16 18]

Retinopathy of prematurity (ROP) was an important cause of blindness in countries with intermediate mortality where the survival of low birthweight infants has increased but technology for neonatal care is problematic. ROP as a cause of blindness was rare in Bolivia, Dominican Republic, and Peru, very probably because of the lower survival rate of premature babies[2 10] (Table 2). More than one third of the blind or severely visually impaired children attending blind schools in Argentina, Cuba, and Paraguay had ROP as a primary cause of visual loss. In contrast, a lower frequency was observed in studies from the United States (8%–19%), probably the result of improvements in intensive neonatal care.

Cataract in childhood as a cause of blindness was reported from all countries, with a lower frequency in the United States, where only one of the four studies reported any childhood cataract as a frequent cause. The most frequent underlying causes of childhood cataract are congenital acquired rubella and genetic disease.[19]

Adult blindness and visual impairment

Magnitude

The prevalence of blindness and visual impairment based on population surveys, using standard acuity test that have been published in the past three decades from the Americas and the Caribbean are shown in Table 3. The definition of blindness and visual impairment varied across studies; when available, both the WHO blindness definition (visual acuity 20/400 or worse) and legal blindness in the United States (visual acuity 20/200 or worse) were presented. Only a few studies also incorporated blindness based on visual field loss alone, and we did not include those data. Some studies reported presenting acuity (with habitual correction) in the better eye instead of best corrected acuity. Consequently, the prevalence of blindness and visual impairment for those studies tended to be higher because they included uncorrected refractive error.

Blindness and visual impairment estimates for North America came from the United States, because of the absence of data from Canada, except based on self report.[37 38] Within the United States, the aetiology and prevalence of blindness varied by ethnic group, location (rural/urban), and year of the survey, with more recent studies reporting lower rates. Temporal trends that affect blindness rates include increasing demand for cataract surgery to correct visual loss, using techniques with much better visual rehabilitation.[39]

Studies carried out before 1990 reported blindness rates (best corrected visual acuity 20/200 or worse) in white people age 40 and older ranging from 0.5% in Beaver Dam to 1.1% in the rural community of Mud Creek Valley.[30 31] For black people, the Baltimore Eye Survey estimated a blindness rate of 1.5%.[29] In 1994, the Salisbury Eye Evaluation examined black and white people, and the reported prevalence of blindness among ages 65–84 was 1.7% and 0.5% respectively. A recent study of Mexican-Americans age 40 and older estimated blindness rates at 0.3%, although most of the population was less than age 60. Age adjusted comparisons showed rates in Mexican-Americans midway between white and black people.[35]

Table 2 Causes of childhood blindness as reported from schools for the blind

Country	Year	Location	No	Four most frequent causes of blindness and severe visual impairment							
				Category 1	%	Category 2	%	Category 3	%	Category 4	%
Argentina[7]	1993	School for the blind	573	ROP	35	Other retina	16	Optic nerve	10	Cataract	8
Bolivia[8]	1988	School for the blind	78	Cornea	23	Retina	23	Cataract	21	Optic nerve	10
Brazil[9]	1998	School for the blind		Glaucoma	15	Cataract	14	Chorioretinitis	13	Optic atrophy	12
Chile[7]	1992	10 schools for the blind	267	Other retina	29	ROP	18	Optic nerve	13	Cataract	9
Colombia[10]	1991–6	Three schools for the blind*	94	ROP	11	–	–	–	–	–	–
Cuba[10]	1991–6	All school for the blind 2 regions*	70	ROP	39	–	–	–	–	–	–
Dominican Republic[7]	1992	School for the blind	51	Cataract	31	Cornea	18	Glaucoma	18	Other retina	10
Ecuador[10]	1991–6	All school for the blind*	142	ROP	14	–	–	–	–	–	–
Guatemala[10]	1991–6	All school for the blind*	73	ROP	4	–	–	–	–	–	–
Jamaica[11]	1986	School for the blind	108	Cataract	39	Optic nerve	18	Glaucoma	15	Retina	15
Paraguay[10]	1991–6	All school for the blind*	36	ROP	33	–	–	–	–	–	–
Peru[12]	1990	School for the blind	202	Cornea	18	Glaucoma	12	Cataract	12	Retinal degeneration	12
Uruguay[7]	1986	School for the blind	220	Cataract	25	Other retina	24	Optic nerve	12	ROP	9
USA[13]	1981–95	Low vision clinic	762	Cortical visual impairment	8	ROP	8	Optic atrophy	7	nystagmus	7
USA[14]	1996–7	Alabama school for the blind	123	Optic atrophy	13	Cataract	13	Albinism	13	Congenital malformations	12
USA[15]	1998	20 schools for the blind	2553	Cortical	19	ROP	13	Optic nerve	7	Albinism	7
USA[16]	1998	School for visually impaired	62	ROP	19	Optic atrophy	19	Retinitis pigmentosa	15	Optic nerve hypoplasia	13

*Other causes of blindness not reported.

In Central and South America, the studies from Brazil, Chile, and Peru suggested a higher prevalence of blindness than the prevalence reported among Hispanics in studies in North America.[21–23] Comparing two surveys, both carried out in the late 1980s using similar age groups (40 and older), 2.9% of the population had bilateral best corrected acuity 20/200 or worse in Peru[23] compared to 0.9 % and 1.9% for white and black people in the Baltimore Eye Survey.[28 29]

The only data on blindness prevalence available for the Caribbean comes from the Barbados Eye Study.[20] In this predominantly black population, age adjusted blindness rates were twice as high as the rates reported for black people in the Baltimore Eye Survey (3.0% *v* 1.5%).

Causes of visual loss

As Table 3 shows, the primary causes of visual loss in adults in the Americas were age related eye diseases, notably cataract and glaucoma in the African-American and Hispanic populations, and age related macular degeneration in the white population. In younger age groups, and in high risk populations, diabetic retinopathy was a leading cause of visual loss.

The excess risk of blindness in the Latino-American surveys was probably the result of unoperated cataract. An estimated 72%–74% of the blindness in Chimbote, Peru and Campinas, Brazil[23] was cataract related compared to the highest proportion reported for the United States, 27% in black people in the Baltimore Eye Survey. In another two studies in Chile[21] and Brazil[22] the proportion of blindness due to cataract was 55% and 62% respectively, also much higher than in North America.

In the Caribbean, data from the Barbados Eye Study showed that cataract and glaucoma were responsible for almost 60% of the blindness,[20] with each contributing equally. Prevalence of blindness from glaucoma was higher than the prevalence reported for black people in the United States. This high proportion of blindness due to glaucoma is consistent with the high prevalence of open angle glaucoma reported in the region.[40–43]

Uncorrected refractive error is an important cause of visual loss in all ages, and one not captured by studies reporting rates of best corrected acuity loss. Table 4 shows the significance of uncorrected refractive error as a cause of visual impairment in several population groups. A significant number of those who have visual loss would not be classified as impaired with appropriate refractive correction. Studies in children in the United States, Chile, and Colombia suggested that almost half of the children with decreased visual acuity would no longer be impaired with appropriate refractive correction.[44–46] Similarly, data from adults showed that close to 20% of the people aged 40 and older with presenting acuity 20/200 or worse improved to better than 20/200 after refraction.[28] In Proyecto VER, 73% of the individuals with presenting acuity worse than 20/40 improved after refraction.[35]

There are populations, particularly in Central and South America, living in extremely impoverished and politically disenfranchised circumstances that continue to foster eye disease long since banished from most of the Americas. Six countries report onchocerciasis in localised areas affecting the poorest of the poor (Brazil, Colombia, Ecuador, Guatemala, Mexico, and Venezuela).[48 49] The Onchocerciasis Elimination Program for the Americas (OEPA) has been active in these countries since 1990. According to the last report from the ninth Inter-American Conference on Onchocerciasis, semiannual treatments with ivermectin have been successful, accomplishing good to excellent coverage.[48] In fact, Colombia, Ecuador, and Mexico have treatment programmes that reportedly have reached full coverage.[48] However, distribution programmes in Guatemala and Brazil are performing below their annual treatment objectives, and in Venezuela the national programme has just completed plans for mass treatment

Table 3 Prevalence and causes of blindness and visual impairment in the adult population

Country	Year	Study design	Race	Age group	No	Type*	Visual acuity in the better eye	Prevalence	Primary causes
Barbados[20]	1987–92	Simple random sample	Black	40–84	4303	B	⩽20/200	3.0%	Glaucoma, cataract, retinal/choroidal diseases
							⩽20/400	1.7%	
							<20/60–>20/400	5.9%	
Chile[21]	1988	Community based rural	Hispanic	⩾60	664	B	⩽20/200	4.4%	Cataract, glaucoma, retinal (not AMD)
Brazil[22] Sao Paulo	1986–7	Stratified random sample	Hispanic	⩾65	120	P	⩽20/400	6.8%	Cataract, myopic degeneration, glaucoma
Brazil[23] Capinas	1986–7	Community based	Hispanic	⩾50	7452	B	⩽20/200	2.8%	74% Cataract was involved
Brazil[24] Porto Alegre	1992–4	Community based	Hispanic	All ages	All residents neighbourhood	B	⩽20/200	0.1%	Cataract, retinal, diabetic retinopathy
Peru[23] Chimbote	1986–7	Community based	Hispanic	⩾40	12193	B	⩽20/200	2.9%	72% Cataract was involved
USA									
Framingham, MA[25]	1973–5	Community based	White	⩾55	2631	B	⩽20/200	0.6%	Cataract, ARMD, glaucoma, diabetic retinopathy
				75–84	394			2.0%	
National Health and Nutrition Examination[26 27]	1974–5	Multistage random sample		25–74		P	⩽20/200		Not reported
			Black		250			0.2%	
			White		2660			0.4%	
Hispanic Health and Nutrition Examination[26 27]	1982–4	Multistage random sample		25–74		P	⩽20/200		Not reported
			Cuban		396			1.0%	
			Mexican		1381			0.9%	
			Puerto Rican		513			0.2%	
Baltimore, MD[28 29]	1985–8	Stratified random sample	White	⩾40	2913	B	⩽20/400	0.5%	ARMD, cataract
							⩽20/200	0.9%	
							<20/60–>20/200	1.3%	Cataract, glaucoma
			Black		2395		⩽20/400	0.9%	
							⩽20/200	1.5%	
							<20/60–>20/200	1.9%	
Mud Creek Valley, KY[30]	1988	Community based	White	⩾40	1136	B	⩽20/200	1.1%	Cataract, ARMD, diabetic retinopathy, glaucoma
							<20/60–>20/200	1.5%	
Beaver Dam, WI[31]	1987–8	Community based	99% White	⩾43	4897	B	⩽20/200	0.5%	Not reported
							<20/60–>20/200	0.8%	
3 communities in MA, CT, IO[32]	1990	Community based	94% White	⩾71	5335	P	⩽20/200	4.7%	Not reported
							<20/60–>20/200	14.4%	
							<20/40–>20/60	14.1%	
Salisbury, MD[33 34]	1994–5	Community based random sample	White	65–84	1853	B	⩽20/400	0.2%	Cataract, ARMD, diabetic retinopathy
							⩽20/200	0.5%	
							<20/60–>20/200	1.2%	
			Black		666		⩽20/400	0.8%	Cataract, diabetic retinopathy, glaucoma
							⩽20/200	1.7%	
							<20/60–>20/200	2.6%	
Tucson and Nogales, AZ[35 36]	1997–9	Community based random sample	Hispanic	⩾40	4774	B	⩽20/400	0.2%	Cataract, ARMD, diabetic retinopathy
							⩽20/200	0.3%	
							<20/60–>20/200	0.9%	

*P = presenting acuity, B = best corrected.

Table 4 Proportion of decreased vision as a result of uncorrected refractive error

Country	Year	Type of survey	Race	Age group	Definition	% of decreased visual acuity due to uncorrected refractive error
Children						
Chile, La Florida[44]	1998	Cluster random sample	Hispanic	5–15	≤20/40	55
Colombia, Medellin[45]	1993	20% random sample from 88 000 children screened all public schools	Hispanic	5–14	Not specified	50
USA, California[46]	1979–88	First graders in a school district	(>50% Hispanic)	6–7	≤20/40	65
Adults						
Chile[47]	1990	Community screening for blindness	Hispanic	≥60	≤20/200	48
Brazil,[22] Sao Paulo	1986–7	Stratified random sample	Hispanic	≥65	≤20/25	49
Brazil,[23] Capinas	1986–7	Community based	Hispanic	≥50	≤20/200	34
Brazil,[24] Porto Alegre	1992–4	Community screening for blindness	Hispanic	All ages	≤20/200	44
Peru,[23] Chimbote	1986–7	Community based	Hispanic	≥40	≤20/200	15
USA Baltimore, MD[29]	1985–8	Stratified random sample	White	≥40	≤20/200	21
			Black	≥40	≤20/200	18
USA, Salisbury, MD[34]	1994–5	Community based random sample	White	65–84	<20/40	34
			Black	65–84	<20/40	23
USA, Tucson and Nogales, AZ[35]	1997–9	Community based random sample	Hispanic	≥40	<20/40	73

programmes in all affected communities to be active by the year 2001.[49]

In the past 15 years, there have been studies showing the existence of pockets of endemic trachoma in Brazil, Mexico, and Peru.[50–64] In South America, the Amazonian region and the bordering states of northwest Brazil seem to be the most affected, with prevalence of active disease ranging from 5% to 42%.[53 54 56 58] While trachoma has been found in urban areas in other states of Brazil,[51 52 55] the low prevalence of active disease (<10%) in children, and no signs of scars and trichiasis in adults were reported, suggested blinding trachoma was not yet a problem.

In Central America, trachoma is endemic in pockets of southern Mexico and Guatemala.[59–61] Two population based studies reported prevalence of active disease in children around 25%, and in some of the communities almost all examined adults (aged 40 and older) had signs of conjunctival scars. The area affected is mostly rural, inhabited by farmers of Mayan descent with limited access to public services including health care.

Trachoma was endemic until recently in the native Americans in the United States, with trachoma reported in 1982 at 1% among Navaho children.[65] Trachoma was reported as a cause of blindness in a recent review of the medical records from the Indian Health Services.[66] There may well be other indigenous populations with trachoma in the Americas, but surveys have not been carried out.

DISCUSSION

The region of the Americas encompasses an extremely diverse set of nations. Even within nations, the populations can range from well educated, wealthy members who have access to the most sophisticated eye care available, to very poor minority populations, isolated with little or no access to, or understanding of how to access, reasonable eye care. A simple summary of data on visual loss in the Americas does not do justice to this diversity.

First of all, it is clear that more data are needed on the magnitude and causes of visual loss, particularly in the Caribbean nations and other countries of central and southern America. Some surveys are currently planned, or the data collected but not yet available. Clearly, from the socioeconomic indicators and the estimates of childhood blindness, there will be pronounced differences within different countries. Such data are essential to plan and implement national programmes for blindness prevention. Where there may be populations at high risk for onchocerciasis or trachoma, special surveys to identify these groups and national will to plan targeted interventions are a special priority.

Secondly, attention must be paid to the growing problem of ROP in children. Control of childhood blindness is a high priority set by the Vision 2020 agenda.[67] Although the total number of blind children is lower than that of adults, the personal and social costs are higher,[68] because of the life expectancy. In fact, the number of "blind years" due to childhood blindness is estimated to be similar to the number of "cataract blind years" in adults.[17] The proportion of blindness due to ROP in the developed countries ranges from 6–18%.[10] However, in middle income countries, there is an epidemic of ROP, due in part to the increased survival of low birthweight infants where there is suboptimal neonatal care.[10]

The problem of blindness due to cataract will continue to be an issue in the future, as the population ages and risk factors for cataract, such as diabetes, become even more prevalent. The rates of blindness and visual loss are higher in Latin America than in comparable age groups in the United States, due in large part to the proportion blind from cataract. The data from Chimbote and Campinas[23 69] suggested that only two thirds of people who were offered cataract surgery were operated. No apparent reasons for refusal were reported, although fear of surgery, acceptance of visual loss as a consequence of old age, and poor outcomes were reasons in other studies.[70–75] Data from another study in US based Hispanics suggested that economic barriers, such as no insurance, were barriers to having cataract surgery.[76] The estimated cataract surgery rate per million population per year is fivefold higher in North America compared to the rest of the Americas.[77 78] It is clear that the barriers blocking access to cataract surgery need to be identified, and improvements instituted, in order to reduce the burden of blindness in Latin America.

One of the main causes of blindness in younger people is diabetic retinopathy. Prevalence of diabetes in the Hispanic and native American populations is very high; a recent study in a population of Mexican-Americans in the United States reported one in five people over age 40 had diabetes, and almost half had evidence of diabetic retinopathy.[79] This includes the 15% of people with diabetes who were not aware of their condition. Adequate control and early treatment of diabetes have been shown to be cost effective for controlling diabetic retinopathy, but this will continue to be a significant public health problem in populations where access to treatment is poor.

Finally, the problem of uncorrected refractive error as a cause of visual loss is starting to be recognised. While the impact on quality of life of people with uncorrected refractive error is not as large as the impact from cataract or other ocular pathology,[80] it is easily avoidable. The size of the problem is underappreciated because many of the studies report visual loss only after best correction. Uncorrected refractive error is not only an issue in children, where visual screening ought to be part of preparation for schooling. Older people have significant uncorrected, or poorly corrected, refractive error as well.

In summary, there are few data on the rates of blindness and visual loss within countries in the Americas, and the data which do exist shows widely disparate rates, as expected. Although many countries have socioeconomic markers that place them as high to middle income countries, there are populations within these countries that do not enjoy the same freedom from visual loss as their compatriots. Prevention and control of avoidable blindness needs to be an ongoing focus in this region.

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