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Epidemiology in Latin America and the Caribbean: current situation and challenges

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Background This article analyses the epidemiological research developments in Latin America and the Caribbean (LAC). It integrates the series commissioned by the International Epidemiological Association to all WHO Regions to identify global opportunities to promote the development of epidemiology.

Methods Health situations of the regions were analysed based on published data on selected mortality, morbidity and risk factors. Epidemiological publication output by country was estimated by Medline bibliometrics. Internet and literature searches and data provided by key informants were used to describe perspectives on epidemiological training, research and funding.

Findings Despite important advances in recent decades, LAC remains the world's most unequal region. In 2010, 10% of the LAC's people still lived in conditions of multidimensional poverty, with huge variation among countries. The region has experienced fast and complex epidemiological changes in past decades, combining increasing rates of non-communicable diseases and injuries, and keeping uncontrolled many existing endemic and emerging diseases. Overall, epidemiological publications per year increased from 160 articles between 1961 and 1970 to 2492 between 2001 and 2010. The increase in papers per million inhabitants in the past three decades varied from 57% in Panama to 1339% in Paraguay. Universities are the main epidemiological training providers. There are at least 34 universities and other institutions in the region that offer postgraduate programmes at the master's and doctoral levels in epidemiology or public health. Most LAC countries rely largely on external funding and donors to initiate and sustain long-term research efforts. Despite the limited resources, the critical mass of LAC researchers has produced significant scientific contributions.

Future needs The health research panorama of the region shows enormous regional discrepancies, but great prospects. Improving research and human resources capacity in the region will require establishing research partnerships within and outside the region, between rich

and poor countries, promoting collaborations between LAC research institutions and universities to boost postgraduate programmes and aligning research investments and outputs with the current burden of disease.

Keywords Epidemiology, Latin America and Caribbean, health status, health inequality, global health

Region characteristics and main health problems

This article integrates the series commissioned by the International Epidemiological Association to address the current situation of epidemiology in all of the World Health Organization (WHO) Regions. It starts with a brief presentation of the socio-economic and demographic indicators of the Latin America and the Caribbean (LAC) region and by an overview of its current health picture, based on selected indicators of morbidity, mortality and risk factors. It then discusses the status of epidemiological research and training in the region. It closes by highlighting challenges and recommendations.

Socio-economic characteristics and main health problems

The LAC region is formed by 41 countries, varying greatly in size and population. Eight out of the 24 countries in the Caribbean had less than 100 000 inhabitants in 2009. Brazil is the largest country, both in territory and population, with ~191 million inhabitants in 2010. Mexico is the second largest country, with a 110 million inhabitants. The Federation of Saint Kitts and Nevis is the smallest country in territory and population, with less than 50 thousand inhabitants.

The LAC population more than tripled between 1950 and 2010, going from ~167 million to 588 million inhabitants, constituting ~8.5% of the world population. The United Nations Organization estimates that the population in the region will reach 730 million in 2050. Most of its population (81%) now live in urban areas (Table 1). LAC is the developing region with the smallest proportional population growth expected by mid-century, largely due to the fertility declines in several of its largest countries. The regional total fertility rate was about 2.3 in 2010 with a contraceptive prevalence rate of 67%, rivalling that of developed countries.[1]

More than 400 different indigenous groups are estimated to live within the region, ~10% of the total population. They remain poor, powerless, socially excluded and their health care needs are neglected. Almost 90% of them live in only five countries: Bolivia, Guatemala, Peru, Ecuador and Mexico. Each of these countries has between 5 and 13 million indigenous citizens. Proportion-wise, Bolívia and Guatemala rank first and second (71 and 66%, respectively), whereas Brazil and Uruguay rank last (0.2 and 0.03%, respectively).[2]

During the so-called lost decade, between 1980 and 1990, per capita income in the region declined from US$3.620 to US$3.321 and the population living below the poverty line (<US$2.00 a day) rose from 40.5% to 48.3%.[3] During the 1990s, per capita income returned to 1980 levels, with a small reduction in poverty (45.7%). After some oscillation, from 2003, per capita income rose to US$4.597 in 2009 and poverty declined to 34.1%. However, 13.7% of the population were still regarded as being extremely poor.[4,5]

Social inequalities

LAC is widely known as the world's top unequal region. According to UNDP report 2010, inequality in the region has remained virtually unmoved since the 70s, being 65% higher than in high-income countries, 36% above the Far East and 18% higher than Sub-Saharan Africa.[6] The richest fifth of Latin America's population receives nearly three-fifths of total income, whereas the poorest fifth, just 3%, which is the lowest share among all regions of the developing world (Figure 1). Data from 23 Latin American countries show a median Gini coefficient of 0.53, which is far worse than the coefficients of developed (0.32), African (0.43) and Asian (0.30) countries.[7]

Among Caribbean countries, monitoring the reduction in extreme poverty is particularly difficult because data are scanty. Five countries (Guyana, Jamaica, Santa Lucia, Surinam and Trinidad and Tobago) concentrate ~75% of the population and >80% of total poverty in the Caribbean sub-region. Jamaica made the highest progress in poverty reduction between 1980 and 2010 (25–10%), whereas Guyana and Suriname hardly changed. According to the World Bank, the indigenous population in the LAC region earns, on average, 46–60% of the earning of non-indigenous.[8]

Access to education has been expanding at all levels throughout the LAC region, especially to primary education which is now nearly universal in the region, though completion rates vary widely between countries.[9] Progress is also being made in secondary education: in 2010, the net attendance rate for this level

Table 1 Selected World Development indicators for Latin America and Caribbean Region (LAC), 1960–2008

Indicator	1960	1970	1980	1990	2000	2008
Total population	218 045 567	284 417 924	360 583 923	441 272 661	518 543 254	572 556 071
GDP per capita (current US$)	372	614	2134	2631	4125	7623
Urban population (% of total)	48.9	57.0	64.9	70.6	75.3	78.6
Fertility rate, total (births per woman)	6.0	5.3	4.2	3.2	2.7	2.2
Death rate, crude (per 1000 people)	13.0	10.4	8.3	6.8	6.0	6.0
Life expectancy at birth, female (years)	58.2	62.5	67.4	71.6	75.0	76.6
Life expectancy at birth, male (years)	54.3	58.1	61.7	65.1	68.4	70.3
Age dependency ratio (% of working-age population)	86.6	88.0	79.1	70.2	60.6	54.6
Mortality rate, infant (per 1000 live births)	103.4	85.7	63.1	41.8	27.6	19.7
Mortality rate, under 5 years (per 1000)	154.6	121.7	83.1	52.4	33.5	23.5

Source: World Bank, World Development Indicators, 2008.

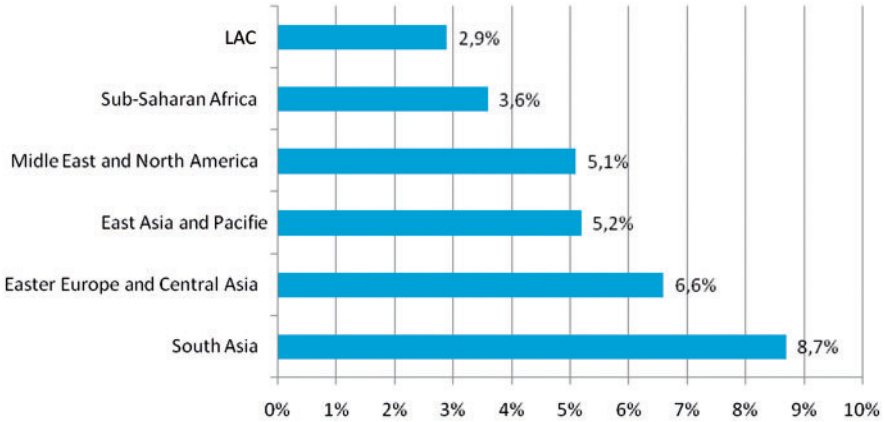

Figure 1 Poorest 20% share of total income by region, 2008. *Source*: World Bank, World Development Indicators, 2008

was 88%, vs 97% for the primary level.[10] However, important disparities in educational development exist not only across countries but also within countries, though men and women have increasingly similar levels of education, particularly in urban areas. A marked stratification is seen by quintile of income per capita: for every 27 young persons from the higher income quintile who complete 5 years of post-secondary studies only one person in the lower income quintile does so. Within Latin America, indigenous and Afro-descended people are clearly over-represented among the least educated and under-represented among the most educated. In the Caribbean, girls and women are outperforming boys and men at every level of the educational system, from primary to tertiary levels.[10]

Between 1980 and 2010, the regional Human Development Index, the UNDP three-dimensional index (life expectancy, schooling and income per capita), rose from 0.573 to 0.704. Despite this increase, the level reached is well below its corresponding figure for OECD countries back in 1980 (0.754).[11] It does, however, approximate to the level established for high human development in 2010, which was defined by UNDP as 0.717. According to the new multidimensional poverty index (MPI),[11] based on 10 indicators of deprivation in health, education and living standards in 104 developing countries, in 2010, 10% of the LAC's people still live in conditions of multidimensional poverty, with huge variations: from 2% in Uruguay to an astonishing 57% in Haiti. Brazil, Mexico and Colombia, the most populous countries of the region, have multidimensional poverty rates of 8.5, 4 and 9.2%, respectively.[12]

Demographic and health situation

In the past 30 years, the LAC region faced noteworthy demographic changes, with a substantial decline of mortality and fertility rates, which dropped from 8.72 to 6.06 per 1000 people and from 4.47 to 2.09, respectively. During the same period, life expectancy has increased ~9 years, from 65 to 74 years, keeping

~6 years difference in favour of women as compared with men.[13] Of note, also, during the same period, LAC experienced a fast shift in populations from rural to urban settings, contributing, as a result, to the formation of mega cities such as Mexico City, Sao Paulo and Buenos Aires.[14] Some indicators of social and demographic trends in the LAC region are presented in Table 1 for the period 1960–2008.

Even though scattered, information on indigenous people indicate that they have higher rates of mortality and morbidity than their non-indigenous counterparts. Infant mortality rates and maternal mortality ratios are higher than national averages.[15] The neglected infectious diseases represent some of the most common infections of the indigenous people in LAC.[16] On the other hand, indigenous communities more integrated into mainstream society also share health problems such as tuberculosis, alcohol misuse as well as obesity and hypertension.[2]

The data displayed below present an overview of the health situation and challenges in LAC based on selected national indicators of morbidity, mortality and risk factors, and are intended neither to represent an integral view of the health needs in the region nor to discuss the specific situation of the indigenous people. Furthermore, national averages tend to cover inequalities by relevant socio-economic and demographic factors as some groups experience the poorest levels of health and the highest levels of risk. Independent of the nature of the health problem, most studies show a clear social patterning of disease burden between and within LAC countries.

Health transition

The region has also experienced fast and complex epidemiological changes in the past decades, combining increasing rates of non-communicable diseases (NCDs) and injuries, while keeping uncontrolled many existing endemic and emerging diseases.[17] Population ageing, urbanization and changes in lifestyles are the main driving forces of the increasing importance of NCDs in LAC countries.[18] However, the balance of the burden between communicable and NCDs varies greatly by country income group. In low-income countries, such as Bolivia, Paraguay and Peru, communicable diseases (CDs) still exert the most important influence on years of life lost.[19]

NCDs

In the LAC region, it is estimated that, by 2000, NCDs were responsible for 55% of the disability-adjusted life-years (DALYs), followed by communicable, maternal, perinatal and nutritional conditions (27%) and injuries (18%).[20] Approximately 50% of all potential years of life lost are related to NCDs, whereas 30% are due to CDs, and 20% to injuries.[20] The proportion of potential years of life lost due to NCDs is higher than the proportion associated with CDs in nearly all countries in LAC.

Among the NCD deaths, cardiovascular disease takes the highest toll, whereas mental illness is responsible for the greatest proportion of NCD DALYs. For the entire LAC region, 31% of all deaths are attributable to cardiovascular disease.[20] Mortality due to cerebrovascular diseases was 2- to 4-fold higher in Latin America (except Puerto Rico) than in North America, and recent falls in these rates in most countries of the region were less favourable than in those in the USA and Canada.[21,22] Poverty and income inequality are also driving premature mortality from NCD. Thirty per cent of the premature deaths from cerebrovascular diseases are in the poorest quintile of the population, whereas only 13% of the premature deaths are concentrated in the richest quintile.[23] Despite the limited data on surveillance for NCDs in the region, the rate of ischaemic heart disease in the LAC region can be forecast to double in the next years, along with stroke and diabetes. Deaths from lung, breast and prostate cancer are also on the rise.[14]

Obesity. In parallel with demographic and epidemiological changes, the LAC region also faces an important and rapid nutritional transition. The characteristics and stages of development in the transition differ among the various countries. However, one point stands out, namely the marked increase in the prevalence of obesity in the various population sub-groups in nearly all Latin America and a decline in undernutrition in most countries.[24–26]

The prevalence of obesity [body mass index (BMI) $\geqslant 30\,kg/m^2$] ranged from 13.3% in Havana, Cuba, to 37.6% in Montevideo, Uruguay.[27] The ongoing epidemic of obesity with its multiple related health problems is likely to overstretch the LAC public health agenda with its related health problems.[28] Based on the results of 57 prospective studies totalling about 900 000 people, each $5\,kg/m^2$ higher BMI was associated, on average, with ~30% higher overall mortality. The corresponding increases in mortality due to specific causes were 40% for vascular diseases, 60–120% for diabetes, kidney and liver diseases, 10% for cancer and 20% for respiratory diseases and all other causes.[29]

Tobacco. Smoking rates are declining in the region, but remain a concern as many actions to prevent and control smoking have not yet been taken. Recent data show that 17% of women in the LAC region smoke, but there are wide variations across the sub-regions. The Southern Cone has the highest percentage of women smokers (30%) and Central America the lowest (4%). The prevalence of smoking among men is higher, 31%, ranging from a low of 18% in the Latin Caribbean to a high of 44% in the Southern Cone.[11]

Injuries

LAC has also one of the highest rates of injury mortality in the world. Injury is the leading cause of death among men aged 15–59 years.[30] Intentional

injuries account for 57% of adult mortality due to injuries, and motor vehicle accidents for 25%. Pedestrians are the most common victims.[31,32] They represent 23% of traffic deaths in the Americas as a whole, but account for 43% in the Andean countries, 32% in Central America and 31% in the Southern Cone (Argentina, Chile, Paraguay and Uruguay). In parts of Peru, pedestrians represent 80% of traffic deaths, even though the country ranks with Guatemala, El Salvador and Ecuador among nations with fewer than 100 vehicles per 100 000 inhabitants.[33,34]

One-quarter of the 600 000 global homicides occur in Latin America.[22] However, the rates of violence differ markedly across countries in LAC.[35] Low deaths rates due to violence are found in countries such as Argentina, Chile, Costa Rica and Uruguay; moderate rates in Peru, Nicaragua, Ecuador, Dominican Republic, Panama and Paraguay; and high to extremely high rates in Brazil, Mexico, Colombia, El Salvador, Honduras and Venezuela. Social inequalities, unemployment, urban segregation, drug markets and widespread use of alcohol are among the main factors associated with high violence in LAC.[36]

The predominance of NCDs and injuries over infectious diseases is expected to rise significantly by 2020, when the ratio of deaths from these causes to deaths from infectious disease might increase from 2.2 to 8.1; likewise, the corresponding increase regarding DALYs is expected to be from 1.8 to 6.9.[37]

CDs

In spite of these projections, CDs are still a major health concern in the region.[38] In 2000–04, the mortality rate from CD was 58/100 000 population, and more in the poorer countries. In Haiti, the incidence of tuberculosis (TB) is seven times that of the LAC region. In 2006, 50% of all dengue cases in LAC occurred in Brazil. Malaria is endemic in 21 countries. HIV/AIDS is also a significant and a growing problem, the Caribbean being the second most affected area worldwide.

The estimated adult HIV prevalence is 1.0% and AIDS is the leading cause of death among young adults. Still in this sub-region, it is estimated that 1.6% of women and 0.7% of men between 15 and 24 years of age are infected with HIV, rates lower only than those found in sub-Saharan Africa.[39]

Along with Africa and Asia, the LAC region is also affected by neglected infectious diseases (NIDs). The NIDs, a diverse group of more than 20 CDs, are clearly related to poverty, especially for those living in the poorest rural areas and in deprived urban or peri-urban communities with unsafe water, poor sanitation and the proliferation of rodent animal reservoirs and vectors.[40] Based on their prevalence and healthy life-years lost from disability, hookworm infection, other soil-transmitted helminth infections and Chagas disease are the most important NIDs in the region.[41] The total burden of these NIDs in LAC may exceed the disease burdens from malaria or tuberculosis, and according to some estimates, it exceeds that of HIV/AIDS.[16]

Health systems

The national health care systems of countries in the LAC region are very diverse in terms of their organizational structure or institutional configuration and the principles guiding the public and private sectors roles in the provision (financing and/or delivery) of health care services.[42] The national health systems range from predominantly public, as in Cuba, Jamaica and Mexico, to a wide variety of mixed systems, as in Brazil, Ecuador and Peru. In all countries, private expenditures, including direct out-of-pocket expenditures and voluntary contributions to privately managed prepaid health plans and health insurance schemes are the largest component of national health care expenditures, ranging from 66% in Brazil to ~50% in Ecuador, Jamaica and Peru.[43] Although per capita health expenditure on health (combined public and private expenditures) has increased between 2000 and 2005 in all country-income groups, they fall far short of the expenditure levels in high-income countries.[19]

Overall, access to health care services has improved dramatically in LAC since the 1950s, both in terms of the number and share of the population who can get treated for their health problems and the range and effectiveness of health services for treating them. The Unified Health System, created in Brazil in 1989, is a comprehensive tax-based universal health system that provides free health care at primary, secondary and tertiary levels.[44] However, in the region as a whole, inequity in health care utilization is still great. In Bolivia, for example, 97.9% of the people in the highest income quintile have access to health care services, but in the lowest quintile only 19.8% have access. In Peru, 96.7% of the highest income quintiles have access, compared with 14.3% in the lowest. And in Guatemala, the figures are 91.5% and 9.3%, respectively.[17] In some countries, some new strategies to finance health expenditure have been developed, specifically in Mexico, a governmental strategy called 'Seguro Popular' now covers over 45 million persons avoiding out of pocket expenditure and providing health services with more than 250 health interventions.[45]

Millennium development health goals

According to the UNDP, the LAC region as a whole has already reached or is able to reach five out of the eight millennium development health goal (MDG) targets by 2015. The region needs to speed up the

current pace of progress in order to reach the targets of reducing extreme poverty, achieving universal primary education and reducing maternal mortality.[46]

Within the region, while some countries, such as Cuba and Chile, are progressing well and are on track, some other countries still have a long way to go to fully achieve the MDGs. Cuba continues to rank among the top 5% of 125 developing countries on indicators of social and health development such as life expectancy, infant and maternal mortality, adult literacy, primary and secondary school enrolment and many others.[14]

The fourth MDG is to reduce by two-thirds the mortality of children <5 years of age, between 1990 and 2015. Although under-five mortality in the region is lower than in most regions, there are large inequities between countries, and causes of death that are completely avoidable—such as diarrhoea or pneumonia—still account for a sizable proportion of child mortality.[47] In 2005, one-third of the countries had under-five mortality rates of 30 per 1000 live births; these countries accounted for 60% of deaths, with perinatal and infectious diseases accounting for >60% and 25% of them, respectively.[48]

Reducing the maternal mortality ratio (MMR) by three-quarters and reversing the spread of HIV/AIDS, malaria and TB are the other health MDGs. LAC ranks second from the bottom on the rates of MMR in developing nations. In 2005, LAC had 130 maternal deaths per 100 000 live births, a significant reduction from the level seen in 1990. Bolivia presents one of the highest MMR in the region, with 229 maternal deaths per 100 000 live births in 2009.[11] MMRs also vary widely within countries, being 10–44 times higher in the poorest provinces of several countries in Latin America.[7]

In 2004, a total of 2.4 million people were estimated to be living with HIV in LAC, 21% of whom were living in the Caribbean.[49] Of the 27 countries in Latin America and the Caribbean that have reported on HIV/AIDS, there are now 11 with an adult HIV prevalence of over 1%, including five countries with rates of over 2%. Eight of the 11 high-incidence nations in the region are in the Caribbean, including Haiti, Guyana and Belize.[46]

Some progress has been made in controlling TB in the region. It is estimated that, as of 2003, 76% of all contagious tuberculosis sufferers had been diagnosed, and 81% of them had been cured. From 1995 to date, 17 million people have been treated. According to PAHO, Peru, Haiti and Bolivia are the countries with the largest incidence rate of tuberculosis in LAC.[50]

With respect to malaria, 21 out of the 35 countries and territories which are members of the PAHO/WHO report that they have areas of active transmission of this disease. Brazil and the Andean countries account for >80% of the 715 000 cases reported to PAHO in 2003.[46]

Peer-reviewed epidemiological publications

In order to ensure comparability with the previously published article of this series (Blake *et al*., 2011), the following search strategy of Medline-indexed journal articles was applied to the analysis of peer-reviewed publications in the field of epidemiology in LAC: (i) all papers with 'epidemiology' as a MeSH heading or 'epidemiol*' in the title or abstract, with countries in the LAC either included as a MeSH heading or appearing in the title or abstract of the paper; (ii) papers with any mention of the most relevant diseases or group of diseases listed in the Global Burden of Disease[51] both as MESH heading of appearing in the title or abstract, with LAC countries also as MESH or mentioned in the title of abstract, with and without 'epidemiol*' mentioned at the title or abstract. For the years 1990, 1995, 2000 and 2005, the first strategy was made more specific by adding to the search the name of the country as the first author's institution. Further details on the search strategies adopted are available on request from authors.

Table 2 shows a steady and rapid increase in the absolute numbers of epidemiological publications from 1960 to 2010 for most LAC countries, an average increase of 20% per decade. In the region as a whole, the number of papers published has increased from 160 per year between 1961 and 1970 to 2492 per year between 2001 and 2010. The 10 countries with highest number of articles published in absolute terms in descending order were: Brazil, Mexico, Argentina, Chile, Colombia, Peru, Venezuela, Cuba, Jamaica and Uruguay. The first four countries listed earlier concentrate 65% of all papers published in the region in 2010, which is mainly due to their population size (about 63% of the region). Figure 2 presents the 50-year trends in absolute number of Medline-indexed papers with 'epidemiology' as a MeSH heading or 'epidemiol*' in the title or abstract for the 10 countries with the highest publication number between 2001 and 2010.

Table 2 also shows the percentage of articles first-authored by someone affiliated with an institution based in the assigned LAC country. Among the countries listed, eight presented over 50% of papers first-authored by someone affiliated with an institution in the country: Argentina, Brazil, Chile, Colombia, Jamaica, Trinidad and Tobago and Venezuela. As a whole, 57.3% of papers in the region are first-authored by a LAC institution.

Table 3 shows the rate of published papers per million inhabitants for the years 1980, 1985, 1990, 1995, 2000, 2005 and 2010 by country. The increase in papers per million inhabitants in these years varies from as low as 57% in Panama to as high as 1339% in Paraguay. The 10 countries with highest publication numbers per head of population in 2010 shows a stronger presence of Caribbean countries than the list

Table 2 Absolute growth rate of published articles between 1961–2010 by country and percentage of articles with first author affiliated with a country institution

Country	Total number (1961–2010)	Annual growth rate (%)	First author affiliated with a country institution (2001–2010) (%)
Argentina	2748	29.2	61.3
Bahamas	65	72.5	17.2
Barbados	271	192.5	28.6
Belize	90	6.8	0.0
Bolivia	596	38.5	15.5
Brazil	15 170	66.6	75.5
Chile	3073	25.9	61.9
Colombia	1826	28.5	57.0
Costa Rica	687	34.9	32.7
Cuba	1495	192.5	46.9
Dominican Republic	422	590.0	1.7
Ecuador	679	28.7	28.2
El Salvador	253	21.1	9.7
Guatemala	693	12.3	8.2
Guyana	225	17.0	6.3
Haiti	927	72.3	6.9
Honduras	274	19.0	18.6
Jamaica	1216	11.7	57.2
Mexico	10 123	40.1	46.1
Netherlands Antilles	140	14.2	2.0
Nicaragua	348	79.5	31.4
Panama	534	11.2	22.4
Paraguay	249	46.8	19.1
Peru	1696	39.6	32.5
Suriname	332	19.0	2.6
Trinidad and Tobago	539	19.3	57.3
Uruguay	696	35.1	38.2
Venezuela	1336	18.5	56.8
Total (*n*)	46 703	38.8	57.3

based on absolute numbers of published papers presented earlier. In descending order, they are: Suriname, Barbados, Jamaica, Trinidad and Tobago, Guyana, Haiti, Uruguay, Chile, Costa Rica and Brazil.

The search of publications by conditions listed in the Global Burden of Disease 2004 under the headings of CDs, maternal and perinatal conditions, nutritional deficiencies, NCDs and injury in the period 1981–2010 shows that 91% of published articles match one or more of these conditions, being 35% related to CDs, 9% to maternal and perinatal conditions, 4% to nutritional deficiencies, 36% to NCDs and 6% to injury. Between 1980 and 2010 there was a slight shift in the distribution of published articles towards an increase in publications related to NCDs and decrease in those related to CDs. A poor correlation between the main causes of disease burden and the research conducted in the LAC can also be seen by examining results of published randomized controlled trials in Latin America, as NCD and injuries are seldom addressed.[52]

In contrast to the observed distribution of total DALYs by major groups of causes in LAC countries in the year 2000, as estimated by the Global Burden of Disease Study,[11] the percentage of published articles in the past decade shows an over-representation of CDs, maternal and perinatal and nutritional deficiencies (49% of the published material vs 27% of

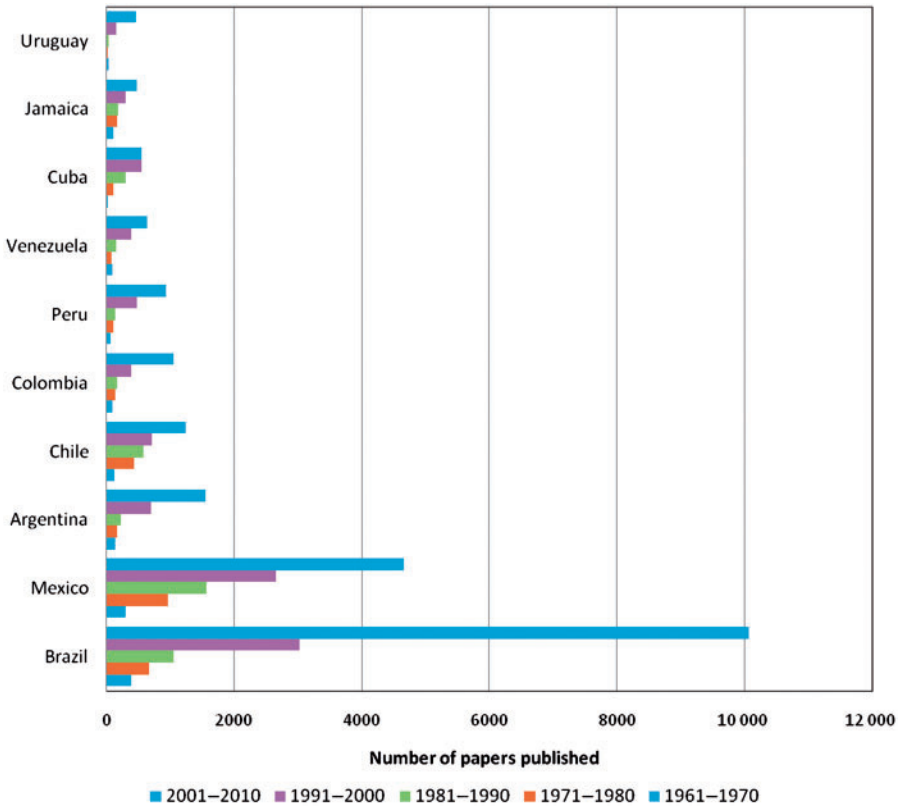

Figure 2 Fifty-year trend in number of published epidemiological articles among the 10 LAC countries with highest publication in 2010–2011

total DALYs in 2000), whereas NCDs and injuries are under scored (43% vs 55% and 7% vs 18% of DALYs, respectively) (Figure 3). Haiti, El Salvador, Saint Lucia and Nicaragua are the countries with highest percentage of publications addressing injuries in the past decade (15, 15, 15 and 13%, respectively). Antigua and Barbuda, Dominica, The Netherlands Antilles, Costa Rica and Barbados are the countries with half or more of their published material referring to NCDs. The percentage of publications addressing CDs is highest (>50%) in Paraguay, Guyana, Panama, Belize and Bolivia.

Epidemiological training and research capacity in LAC

Strengthening research capacity is one of the most powerful, cost-effective and sustainable means of advancing health and development.[53] It is also a key strategy for equity in development within and between countries.[54] Developing countries account for >80% of the world's population, but only ~30% of the researchers live in these countries. In a bibliometric analysis of articles published (1995–2003) in ISI-indexed journals in the fields of infectious diseases–microbiology, cardiopulmonary diseases and public health–epidemiology, LAC ranked better than Africa, Oceania and Eastern Europe in the overall production per GDP, but it was placed much behind when considering only the field of epidemiology and public health.[55]

According to the Report from the Network on Science and Technology Indicators (RICYT), also called the Observatory on Science, Technology and Society,[56] the LAC account for ~2% of the world's investment in research and development (R&D) and is followed by Africa and Oceania (0.3%). This is far behind the USA (39%), Europe (31%) and Asia (26%). Brazil heads this LAC list, with over 31 000 publications in the Science Citation Index (SCI)(representing a global percentage of 2.32%), according to RICYT data for 2008. It is followed by Mexico (0.64%), Argentina (0.49%) and Chile (0.27%).[57] These four countries contribute with about 90% of the total investment in research and development in the region and are near to approaching the 2% of the national public health budget on research, as recommended by the Commission on Health Research for development in 1990.[58] Attempts to evaluate research capacity of specific fields in the region confirm the overall picture described earlier. For instance, despite being a major health problem in the LAC, mental health research is

Table 3 Epidemiological publication rates per million inhabitants by country in Latin American and Caribbean for selected years (990, 1995, 2000, 2005 and 2010)

Country	Number of articles per million inhabitants					Growth rate 1990–2010 (%)
	1990	1995	2000	2005	2010	
Argentina	1.20	1.29	3.11	3.61	5.14	428
Barbados	26.96	27.13	31.79	55.28	23.45	87
Bolivia	0.60	2.00	2.52	2.72	3.14	524
Brazil	1.20	1.50	2.84	5.30	6.33	526
Chile	8.19	3.75	4.86	2.09	7.78	95
Colombia	0.84	1.01	1.33	2.42	2.32	275
Costa Rica	5.20	3.74	3.82	8.09	6.99	134
Cuba	4.44	5.41	5.77	5.81	5.09	115
Ecuador	1.07	1.84	1.87	2.68	3.38	315
El Salvador	0.75	1.40	1.85	2.15	1.78	238
Guatemala	0.90	2.20	1.07	2.12	2.35	262
Guyana	4.00	2.64	9.26	13.09	11.80	295
Haiti	3.38	2.16	3.24	3.51	9.07	269
Honduras	0.41	1.43	1.12	2.18	2.41	591
Jamaica	11.30	16.94	11.59	12.83	18.52	164
Mexico	2.97	2.51	2.97	4.39	6.15	207
Nicaragua	1.21	2.79	2.35	3.48	5.57	461
Panama	9.12	8.23	4.07	5.26	5.21	57
Paraguay	0.24	1.67	1.12	1.69	3.15	1339
Peru	1.33	1.63	1.62	3.41	4.77	358
Dominican Republic	1.90	0.49	2.83	2.52	2.28	120
Suriname	7.38	13.77	14.98	24.01	26.94	365
Trinidad and Tobago	11.49	9.49	13.90	15.93	17.93	156
Uruguay	2.58	3.73	5.45	12.10	8.07	313
Venezuela	1.62	0.82	2.10	2.41	1.97	122

still incipient in the region. Analysis of mental health research in 30 LAC countries found that indexed publications were concentrated in six countries: Argentina, Brazil, Chile, Colombia, Mexico and Venezuela.[59]

The trends presented in Figure 2 show a steady increase in LAC publications as a percentage of global publications in Medline and SCI from 1980 to 2008. This picture, based on RCYT data, agrees with the bibliometric analysis of peer-reviewed publications shown in the previous section, and leaves no doubt that research capacity and training in public health and epidemiology have also increased substantially in the LAC. Based on our Medline search, between 1990 and 2010 the number of papers published grew by 3.5%, from 883 to 3069 (Table 2).

It is also worth mentioning that part of the Latin American medical and public health literature is only indexed in the Latin American and Caribbean Literature in Health Sciences (LILACS), an internet-accessible database maintained by the regional library of medicine in Brazil (BIREME) and supported by the Pan American Health Organization (PAHO). Although LILACs has improved access to the Latin American biomedical and public health literature, it usually does not provide translation of Spanish or Portuguese abstracts into English.[60] For instance, social medicine has provided a critical framework and a proposal to change the classic form of public health in Latin America by transforming it into a tool for change and social justice.[61] However, most of this historical and pioneering contribution of LAC scientists remains untranslated into English.[62,63]

Publication numbers are very strong indicators of research capacity, but the whole picture of R&D includes also training, research funding and human resources. Together, these indicators provide essential information to evaluate current situations and needs and to portray future scenarios.

Scientific and research training

In the LAC, public universities are the institutions where most local scientific and technological R&D is carried out, and where most students in these fields receive their formal training. The ratio of researchers to total population is between 50 researchers per million inhabitants in Ecuador and 720 in Brazil; whereas Japan has 5300 researchers per million of inhabitants and the US 4600.[64]

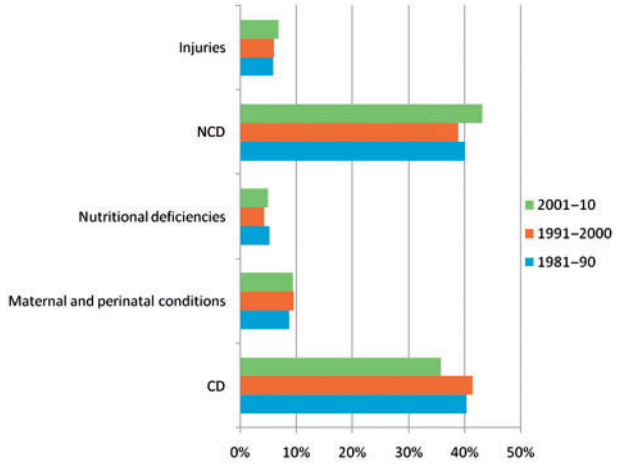

Figure 3 Distribution of published articles in LAC countries in three decades according to subject area as grouped by the Burden of Disease Study

Figure 5a and b shows the number of master graduates and doctorates in LAC in the period 1990–2008 by research area using data provided by the Network for Science and Technology Indicators (RICYT). The medical sciences area, where epidemiology and public health is probably located, shows important increase, especially of doctorates, though it is not the most prominent area.

Training in epidemiology

As we could not identify any comprehensive survey addressing epidemiological and public health training more specifically, we wrote to IEA members and authors' networks asking them to respond to a short questionnaire. We obtained information from 16 countries (Argentina, Barbados, Bolivia, Brazil, Colombia, Cuba, Dominican Republic, Grenada, Haiti, Jamaica, Mexico, Peru, Puerto Rico, St Kitts and Nevis, Suriname and Trinidad and Tobago) about epidemiological training, funding for research projects, presence of epidemiological societies and conferences held in epidemiology. Although there are many ongoing initiatives related to hands-on epidemiology training, most of them linked to outbreak response,[65] the focus of the survey was on training at the postgraduate level.

In almost all countries, universities are the main epidemiological training providers. There are at least 34 universities and others institutions in the region

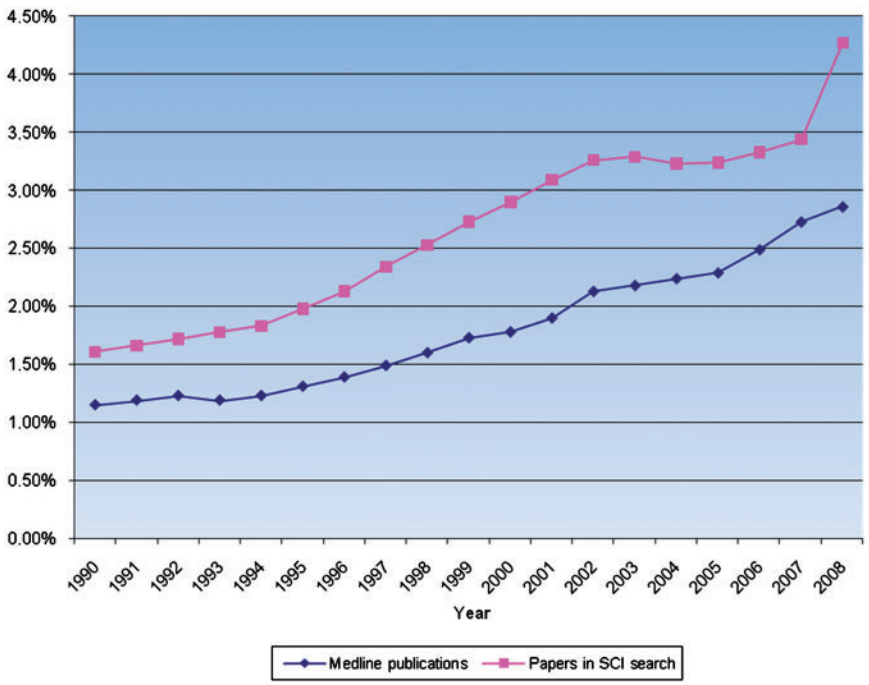

Figure 4 Global percentage of LAC scientific publications in Medline and SCI from 1990 to 2008. *Source*: Network for Science and Technology Indicators (RICYT). Based on data for the following countries: Argentina, Barbados, Bolivia, Brazil, Chile, Colombia, Costa Rica, Cuba, Dominican, Ecuador, Guatemala, Guyana, Honduras, Haiti, Jamaica, México, Nicaragua, Panamá, Peru, Paraguay, El Salvador, Trinidad and Tobago, Uruguay, Venezuela

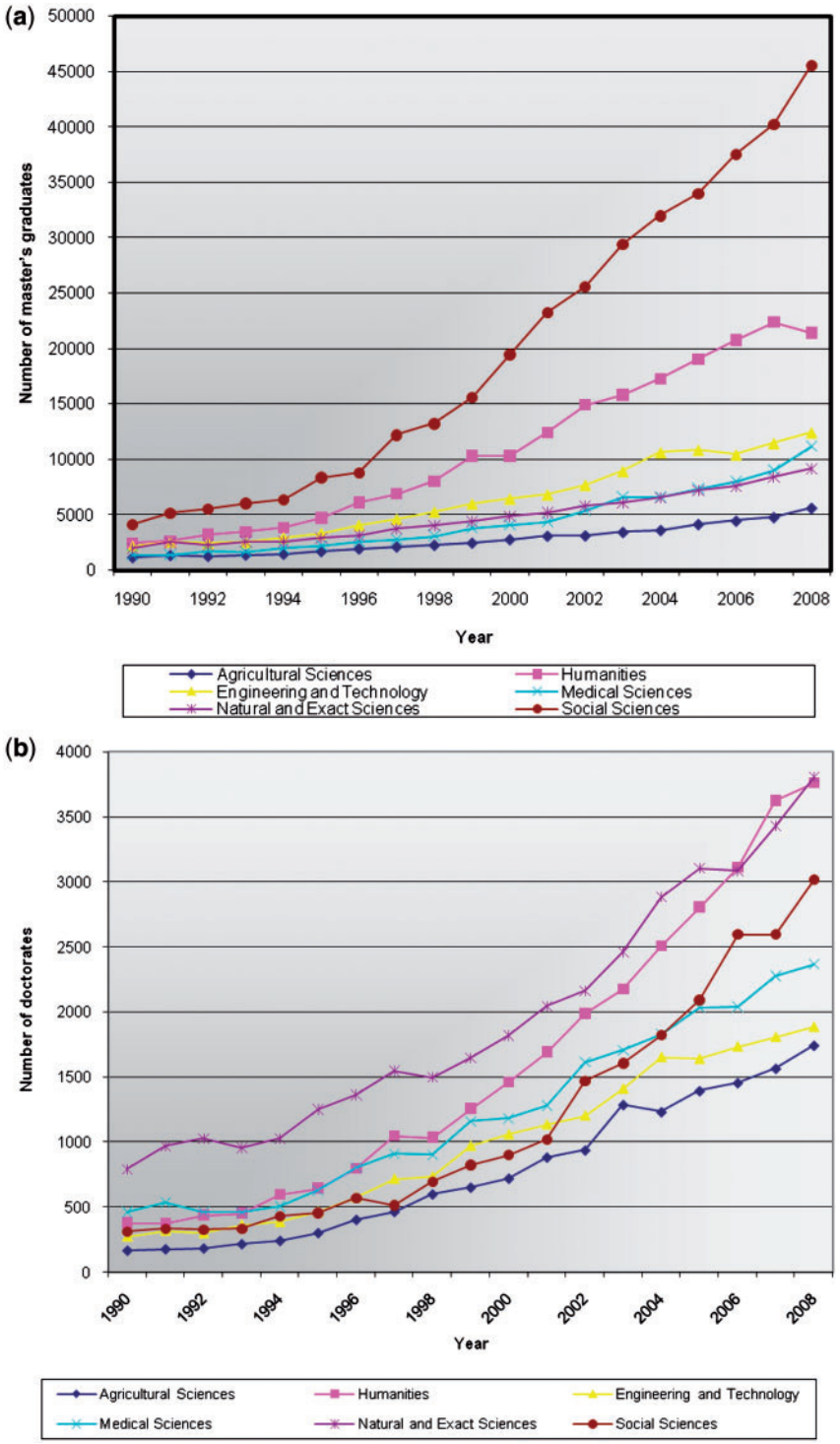

Figure 5 Number of master's (**a**) and doctorate graduates (**b**) per year according to research area in Latin America in the period 1990–2008 according to the Network for Science and Technology Indicators (RICYT). *Source:* www.ricyt.org

that offer postgraduate programmes at the master's and doctoral levels, either in epidemiology or in public health with a concentration in epidemiology. In total, key respondents reported the existence, between master's and doctorates, of at least 119 Programmes. According to them, epidemiological training through a Master in Public Health is the most common finding. Brazil is the country that leads in numbers of master's and doctorate programmes (50) followed by Mexico (32). In the same

vein, Brazil also has more doctorate programs (21) than the sum of all other countries (10). Among the Caribbean countries, Cuba and Jamaica are the most advantaged with a total of 11 programmes.

Examples of between-countries collaboration are the postgraduate programmes in Clinical Epidemiology and Evidence Based Health, which are offered in Chile, Colombia, Argentina and Peru (Latin American Clinical Epidemiology network). These programmes are also offered as a full e-learning modality since 2004 to students from different LAC countries.[66]

Other postgraduate training worth mentioning in LAC is the Field Epidemiology Training Program (FETP), based on the Centers for Disease Control and Prevention Epidemic Intelligence Service (CDC EIS).[67] Currently, the FETP initiative includes Argentina, Brazil, Colombia, Costa Rica, Dominican Republic, El Salvador, Guatemala, Honduras, Mexico, Panamá and Peru (http://programs.tephinet.org/).

Funding for research projects, epidemiological societies and conferences

The e-mail survey also showed that epidemiological research is funded mainly by foreign international sources (e.g. US National Institutes of Health) followed by governmental support. In contrast, private institutions were not identified as a source of financial support for research projects.

With regards to the existence of an established organization that congregates epidemiologists, it is not possible to draw conclusions for Caribbean countries because of the limited information collected. For the other countries, several organizations were mentioned, including ABRASCO—Associação Brasileira de Saúde Coletiva (Brazil), ASOCEPI—Asociación Colombiana de Epidemiología (Colombia), La Asociación de Salud Pública de Haití (Haiti), Sociedad Mexicana de Salud Pública (Mexico) and Sociedad Peruana de Epidemiología (Peru). However, for Argentina and Bolivia no specific epidemiological association was reported. Although the information gathered records the presence/absence of such entity, it does not explore in depth the breadth of activities, membership participation and representation that these entities convey.

Future challenges

Strengthening research capacity

As shown in the previous sections, the critical mass of LAC researchers has produced significant scientific contribution, despite the limited resources, mostly in terms of funding, available. Whereas Brazil, Cuba and other few countries have well established local support for science, as demonstrated by the scope of training provided, the majority of LAC countries rely largely on external funding and donors to initiate and sustain long-term research efforts.[58,65,68]

Behind the financial factor, and equally important, is the human capacity factor. The diaspora of scientists from LAC to developed countries has always been present—and difficult to measure. Nevertheless, well-established research teams can be identified in the region in several areas relevant to epidemiology.[69] One of the traditional patterns that keep such sustained development has been the maintenance of links between people returning from a period of training abroad with their counterparts. Today, with the ease of communications, such networking links have become broader, both in geographical outreach and breadth of collaborative research fields. One example of networking is the Latin American Studies Consortium in Obesity (LASO).[70]

As most research support comes from international funding agencies, in the recent decades funding from major scientific funding bodies has promoted the establishment of centres of excellence in the region, aiming to strengthen research activities together with a training and capacity-building component. This is the case, for instance, of the Wellcome Trust funding in Brazil, Costa Rica and Jamaica;[71] the National Heart, Lung and Blood Institute, National Institutes of Health and United Health (NHLBI/UH) centres of excellence in chronic diseases in Guatemala, the US-Mexican border, Argentina and Peru[72,73]; as well as the long-standing participation of the Fogarty International Center from the National Institutes of Health in the region.[74]

South-to-South collaborations

Even though unequally distributed, the LAC region has highly qualified health and academic human resources. It also has two important advantages in relation to other WHO Regions: similar cultural identity and a common language for most of the population. Furthermore, it has the SCIELO—Scientific Electronic Library Online, created in 1997, a pioneering initiative which offers open access to selected scientific journals in three languages: Portuguese, English and Spanish. Due to its policy and equity strategy, it granted visibility to scientific production from Latin America and the Caribbean.

Important advances in regional agreements and policies to develop countries' health research agendas and strengthen their capacities are starting following the first Latin American Conference on Research and Innovation for Health[75] held in Brazil, in 2008.[76] For instance, Paraguay is working towards a formal health research system; El Salvador has included a section on health research in its national health policy; Guatemala has established a coordinating office for health research within the Ministry of Health; and Uruguay has announced the launch of a sectoral fund for health research. Other countries are implementing strategies that strengthen coordination

and communication, and are sharing and learning from each other's experience.[77]

MERCOSUR, an economic block created in 1991 by Argentina, Brazil, Paraguay and Uruguay to eliminate tariffs and commercial restrictions on their products (Bolivia, Chile, Colombia Ecuador, Peru and Venezuela are associate members) began supporting S&T collaboration. PROSUL the South American Program was launched to support S&T cooperation in the region.[78] The cooperation established between Cuba and Brazil in health biotechnology is a good example of South-to-South collaboration that can be a useful tool for promoting capacity in science-intensive fields, with positive results for both sides. Cuba has been able to transfer its technologies under favourable terms, and Brazil has been able to supply important biotechnology products to its national public health programmes.[79]

Challenges ahead

The epidemiological and public health research panorama presented shows clear insufficiency, enormous regional discrepancies, but great prospects. Based on this scenario and the undisputable importance of health research to solve the region's health problems, to improve health services and to reduce social inequalities in health, we selected six topics as the main challenges to improve research and human resources capacity in the LAC region:

(1) To strengthen communication between researchers and policy makers and to establish research partnerships within and outside the region, between rich and poor countries.
(2) To increase the national public health budget on research to 2%, as recommended by the Commission on Health Research for development in 1990.[52]
(3) To establish, support and develop formal forums to promote collaborations between LAC research institutions and universities. The IEA could have an important role in this initiatives, organizing, for instance a LAC conference on epidemiology in the near future.
(4) To boost international collaborative master's and doctoral programmes. They can be created by establishing a consortium of universities in which students may register in one university, but have access to a wider pool of universities, tutors and researchers. This might be facilitated by the fact that, throughout the region, the great majority of the population speaks Spanish. Some examples of these collaborative training networks are available in European settings.[80,81]
(5) To align research investments and outputs with the analysis of the burden of diseases and their determinants, in order to identify and set priorities for the problems in the region. This means, for instance, increasing funding and research capacity in NCDs and violence, the major causes of disease burden in the region.
(6) To expand research networks and funding on common health problems, such as some neglected infectious diseases still prevalent in many LAC countries, of remote interest to most developed countries.

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