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Estimating the burden of disease and the economic cost attributable to chikungunya, Colombia, 2014

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Background: Chikungunya (CHIK) virus disease is expected to be a considerable cause of disability and economic burden in Latin America given its chronic sequelae, particularly its chronic inflammatory rheumatism. There have been no previous studies assessing CHIK costs and disability in Latin America.

Methods: We calculated incidence rates for CHIK during the 2014 outbreak in Colombia using epidemiological data provided by the Colombian National Institute of Health, using demographic data from the National Administrative Department of Statistics. The burden of disease was estimated through disability adjusted life years (DALYs) lost and the costs were estimated based on the national recommendations for CHIK acute and chronic phase attention.

Results: There were a total of 106 592 cases, with incidence rates ranging from 0 to 1837.3 cases/100 000 population in different departments. An estimate was made of total DALYs lost of 40.44 to 45.14 lost/100 000 population. The 2014 outbreak estimated costs were at least US$73.6 million.

Conclusions: Our estimates raise concerns about the effects of continued CHIK spread in Colombia and other Latin-American countries. The lack of transmission control for this disease and potential for spread means that there will be significant acute and chronic disability and related costs in the short and long term for Latin American health care systems.

Keywords: Burden of illness, Chikungunya, Colombia, Disability, Illness cost, Latin America

Introduction

Chikungunya (CHIK) virus disease emerged in Latin America in 2013, originally as an epidemic that rapidly progressed to an endemic disease in those countries with suitable ecoepidemiological conditions, including Colombia.[1] CHIK has many health implications which include considerable disability with a consequent economic burden to health care systems in Latin America. Disease expansion is associated with lack of transmission control and the frequency with which patients develop chronic sequelae, including post-chikungunya chronic inflammatory rheumatism (pCHIK-CIR).[2,3]

Although disease costs in the region have not yet been estimated and published, reports of previous epidemics in India showed that direct and indirect costs may be as high as US$13.7 million at the first administrative level.[4] However, as our estimates indicate, the disease burden in newly endemic areas in Latin America may be expected to be higher than that reported in India with consequent greater disease costs for the region.[2,5] An important context for this is that the costs associated with dengue are already high, with an abundant vector and higher attack rates for CHIK compared to dengue. The number of territories and populations which may be affected are also considerable in our region.[6–10]

There are no specific therapeutic measures for treating and preventing CHIK, no risk factors for severe or chronic forms of the disease have yet exhaustively been identified and good quality studies have not yet been published which will improve the management of disease sequelae.[11] Recently, non-biological disease modifying anti-rheumatic drugs (DMARDS) and doses have been

proposed (Table 1), based on national[12] and international[13] recommendations.

Furthermore, even though previous studies report disability rates which cause concern, these may be under-estimates because disability associated with the acute phase of the disease was not considered. Mortality is now being reported in Colombia and surrounding countries in 2015.[14–16] Reliable estimates of disability adjusted life years (DALYs) lost and the costs of the disease in Latin American countries are unknown, and there is insufficient information regarding accurate estimates of disease evolution, management, and the proportion of atypical, complicated and/or congenital cases. New cost estimates need to be prepared for the effect that the CHIK epidemic may have on the new endemic areas in Latin America, bearing in mind that 2015 may be worse than 2014 in terms of morbidity and mortality, and probably in DALYs and health care costs.[17]

The aim of our study was to estimate DALYs lost for the year 2014 in Colombia attributable to CHIK considering both the acute phase of the disease and chronic disability caused by pCHIK-CIR. Cost estimations were based on national guidelines for CHIK clinical management and pCHIK-CIR chronic sequelae, and used data from three hospitals in Colombia that have cared for patients with complicated CHIK who required hospitalization.

Methods

Epidemiological and demographic data

Colombia is located in the northwest of South America, bordered to the northwest by Panama, to the east by Venezuela and Brazil,

Table 1. Parameters used to calculate direct and indirect economic costs of CHIK, Colombia, 2014

Costs	Phase	Parameters	Total cost (COP$)	Total cost (US$)[k]	Cost per year (COP$)	
Direct					1st	2nd
	Acute and subacute		204 984	76.61	204 984	NA
		Consultations[a]	75 100	28.07	75 100	NA
		Drugs[b]	73 717	27.55	73 717	NA
		Diagnostic tests[c]	56 167	20.99	56 167	NA
	Chronic					
		Scenario 1	3 644 696	1 362.13	2 051 598	1 593 098
		Consultations[d]	403 200	150.69	240 800	162 400
		Drugs[e]	2 255 396	842.91	1 127 698	1 127 698
		Diagnostic tests[f]	986 100	368.53	683 100	303 000
		Scenario 2	7 281 636	2 721.36	3 870 068	3 411 568
		Consultations[g]	471 200	176.10	274 800	196 400
		Drugs[h]	5 824 336	2 176.73	2 912 168	2 912 168
		Diagnostic tests[f]	986 100	368.53	683 100	303 000
		Scenario 3	8 883 309	3 319.96	4 670 905	4 212 405
		Consultations[g]	471 200	176.10	274 800	196 400
		Drugs[i]	7 426 009	2 775.32	3 713 005	3 713 005
		Diagnostic tests[f]	986 100	368.53	683 100	303 000
Indirect						
	Sick leave during acute phase[j]		161 088	60.20	161 088	N/A
Total medical costs		Scenario 1	3 849 680	1 438.74	2 256 582	1 593 098
		Scenario 2	7 486 620	2 797.97	4 075 052	3 411 568
		Scenario 3	9 088 293	3 396.57	4 875 889	4 212 405

NA: not applicable.
[a] One per emergency room/outpatient with a general physician plus one with internal medicine/rheumatology.
[b] Acetaminophen (4 g/day, adult) during first 3 days, followed by ibuprofen (400 mg) plus omeprazole (20 mg).
[c] Complete blood counts (CBC) plus serological tests.
[d] First consultation at internal medicine/rheumatology, control with rheumatology and with a general physician.
[e] Prednisolone 5mg/day, metotrexate 15 mg/week (plus folic acid), sulfasalazine 1.5g/day.
[f] First year: rheumatic factor, C-reactive protein, Erythrocyte sedimentation rate, epitope HLA DRB1, radiography of hands and feet; Both years: CBC, urine, creatinine, alanine transaminase, aspartate transaminase.
[g] First consultation at internal medicine/rheumatology, control with rheumatology and with a general physician. Also with an ophthalmologist (due to chloroquine).
[h] Prednisolone 7.5mg/day, leflunomide 100mg/week, sulfasalazine 1.5g/day, hydroxichloroquine 200mg/day.
[i] Leflunomide 100mg/week, sulfasalazine 3g/day, hydroxichloroquine 200mg/day, prednisolone 10mg/day.
[j] Assuming an absentee day based in the costs of the minimum salary of the country (2014).
[k] Assuming the current exchange rate (June 2015, US$1=COP$2675.73).

and to the south by Ecuador and Peru (Figure 1). This constitutional republic comprises 32 departments (first administrative level) and 1119 municipalities (second administrative level). Antioquia (125), Boyacá (123) and Cundinamarca (116) are the departments with the greatest number of municipalities in the country. In 2014 Colombia had an estimated population of 47 661 368 (50.6% female) of whom 36.2% were <20 years old, in a territory covering 1 141 748 km^2. From an ecological point of view, this tropical country has suitable conditions for vector borne diseases, including dengue and chikungunya. The insect vector for them, *Aedes* sp., is widely distributed in the country.

Chikungunya case definitions

CHIK incidence was calculated using both clinically and laboratory confirmed cases reported to the national surveillance system in Colombia, assessed and corrected by the National Institute of Health, Ministry of Health of Colombia,[18] according to the National Ministry of Health operative definition for CHIK.[19] The operative definition used by the Ministry of Health is the same as that adopted by the Pan American Health Organization for surveillance purposes: a clinically confirmed case (a patient with fever, sudden onset of severe arthralgia or arthritis and rash, not explained by other medical conditions, living in a municipality where previously there was confirmation of CHIK circulation by virological methods); and a laboratory confirmed case (by viral isolation, RT-PCR, IgM serology, or fourfold increase in the IgG in paired samples with 15 days of difference between them). Demographic data was provided by the National Administrative Department of Statistics of Colombia [DANE] (http://www.dane.gov.co/).

Estimation of DALYs related to CHIK

We estimated DALYs for CHIK using the method adopted by Murray for estimating the global burden of diseases (DALYs=years of life lost [YLL]+years lost due to disability [YLD]; YLL=0 assuming no deaths reported in 2014; YLD=I*DW*L [where I is incidence of cases progressing to chronic disease; DW is disability weight; L is duration of chronic disease]).[2,5,20] Although no DW is yet available for CHIK and pCHIK-CIR, for the acute phase of the disease we used the DW utilized for dengue (0.172) and for the chronic rheumatic sequelae the DW for rheumatoid arthritis (0.233), was utilized. In these calculations, we were not able to use age weighting or discounting giving the fact we have no access to case by case information of age for each individual. This has been used in previous estimates for CHIK DALYs.[2,4,5,21,22] The expected incidence of cases progressing to chronic disease (I) and duration of chronic disease (L) was assumed as previously reported in 2015.[3] It was expected that 47.6% (95% CI 45.08–50.13) of infected patients that would develop pCHIK-CIR, in a median time of 20.12 months as estimated in a recent report. These estimates were based on pooled data (n=1544), and subsequent weighting took account of the final follow-up time related to the population size in selected studies.[3] Non-linear regression models were run to estimate the cumulative proportion of pCHIK-CIR over time, and median time during which 50% of patients could present pCHIK-CIR).[3] DALYs lost were reported by department, municipality and country adjusted by 100 000 population rates. Sensitivity analysis was performed calculating the respective 95% CI using the software Epi Dat 3.1 (Xunta de Galicia, Spain), according to the technique provided by Armitage and Berry.[23]

Cost estimation of 2014 CHIK epidemics in Colombia

Costs were divided in direct and indirect costs, direct being those attributable to hospital care and treatment. Direct costs included hospitalization, in-patient procedures, rehabilitation, medication and diagnostic tests. During 2014 deaths were not reported and specific data regarding age, gender and hospitalized or atypical cases in Colombia were not available for most admissions. For the purpose of this study all cases were assumed to be typical, non-severe and in adult, non-pregnant patients.

Direct cost needs were estimated using the proposed clinical protocols of the National Ministry of Health for CHIK management[19] from the perspective of payers. There is a lack of information regarding the proportion of patients evolving to subacute

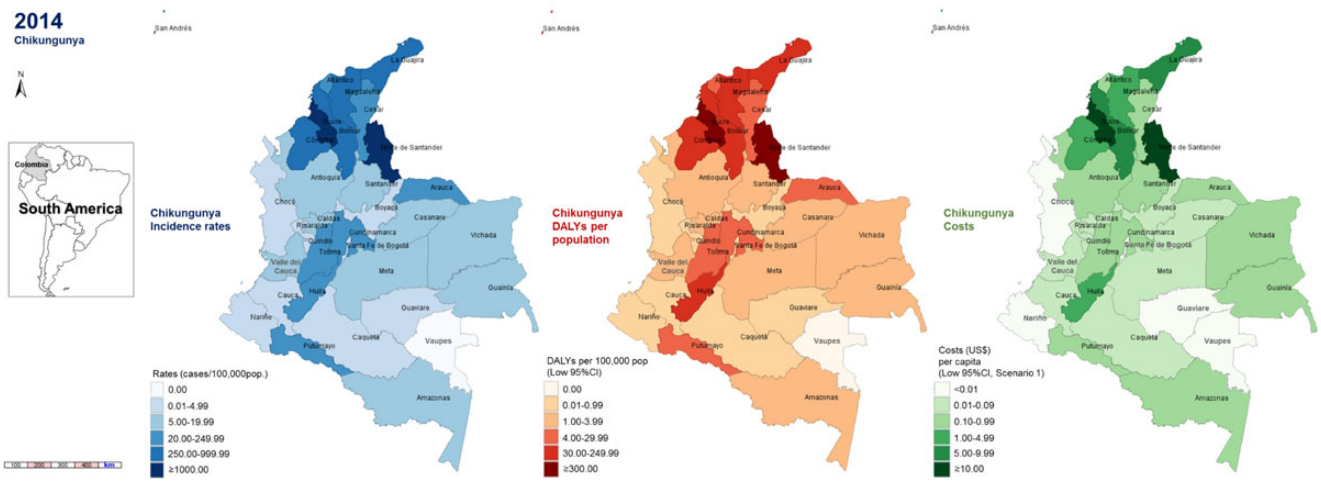

Figure 1. Chikungunya incidence rates, disability adjusted life years (DALYs) per population and costs per capita, by departments in Colombia, 2014. This figure is available in black and white in print and in colour at Transactions online.

forms of the disease, and acute and subacute disease costs were assumed to be the same. The guideline suggests management of post-CHIK arthritis according to national rheumatoid arthritis guidelines, and its recommendations were assumed to have been followed for pCHIK-CIR (Tables 2 and 3). Three scenarios with different needs of non-biological DMARDS and doses were proposed (Table 1), based on national[12] and international[13] recommendations. Each of these scenarios ranged from a low to a high 95% CI estimation (Table 3). The most conservative was for less requirements for care at the lower limit of the 95% CI and the worst case scenario was that at the upper limit of the 95% CI costs would require all the possible therapeutic interventions during two years following the infection without including use of biological DMARDS.

To determine the medical and diagnostic tests cost the SOAT (Obligatory National Insurance Policy) national costs manual from 2013 was used.[24] To determine drug prices the national list of drug prices and regulations of the industry and commerce superintendence were used (Farmaprecios, 2014[25] and Circular 02 de 2014 Superintendencia de Industria y Comercio[26]).

In this study, only sick leave taken during the acute phase of the illness was considered as an indirect cost. We assumed the cost to be that of an absentee day at the level of the Colombian minimum salary in 2014 as officially reported by the Colombian government (Colombian pesos [COP$] 644 350/month). The exchange rate operating on 15 June 2015 was used to express results in US$ (US$1=COP$2675.73).

Geographical information system (GIS)-based mapping of incidence, DALYs and costs for CHIK in Colombia

Microsoft Access was used to design a spatial database on which was recorded incidence rates of CHIK, DALYs using the low 95% CI adjusted per 100 000 population and estimated costs per capita, by departments to the GIS software. The Client GIS software Open source used was Kosmo Desktop 3.0 RC1 (Sistemas Abiertos de Información Geográfica [SAIG]; http://www.saig.es). Geographic data and shared results with institutional support was provided from the spatial data infrastructure for Colombia in the SIGOT database (GIS for planning and territorial order) of the National Geographic Institute Agustin Codazzi (http://sigotn.igac.gov.co/sigotn/). The shapefiles of departments (.shp) were linked to the database through a spatial join operation, which made it possible to produce digital maps of incidence, DALYs and costs (Figure 1).

Results

During the 2014 CHIK outbreak in Colombia a total of 106 592 cases were reported (104 141 clinically confirmed, 3890 laboratory confirmed and 1439 cases both clinically and laboratory confirmed), with incidences ranging from 0 to 1837.3 cases/100 000 population in different departments, with a median of 19.1 cases/100 000 population (IQR 4.5 to 283.1) (Table 2). CHIK incidence rates at municipalities however ranged from 0 to 13 683.8 cases/100 000 population with a median of 30.1 cases/100 000 population (IQR 9.4 to 147.4) (Supplementary Table 1).

The highest incidence and disease burden were concentrated in northern and central areas of the country, particularly in the Norte de Santander department and in the coastal areas of the Caribbean, while the lowest were near to the Orinoquia region, Amazonas and Chocó departments. Seventeen of the 32 departments had incidence rates greater than 20 cases/100 000 population (Table 2) (Figure 1). Only one department, Vaupés, did not report any CHIK cases in 2014. The number of estimated cases of pCHIK-CIR in the country ranged from 48 052 to 53 435 (Table 2).

In the acute phase of the disease 1.52 to 1.86 DALYs were estimated as lost per 100 000 population and the chronic phase accounted for the 96% of the DALYs lost at a national level with about 39 to 43 DALYs lost per 100 000 population, giving a total DALYs last of 40.44 to 45.14 per 100 000 population (Table 2). Analysis by departments (first administrative level) showed a variation from 0 to 376.04 DALYs per 100 000 population lost across the country (Table 2), while analysis by municipality (second administrative level) showed a wider variation, ranging from 0 to 2800.65 per 100 000 population (Table 2). As expected, municipalities from the Caribbean region had the greatest burden of disease: San Juan Nepomuceno, San Jacinto and Turbaco, all of them from Bolivar department (Supplementary Table 1) (Figure 1). The municipalities with the lowest disease burden were those located at the Southern, Pacific and Eastern regions of the country (Figure 1), with the exception of the municipalities from the department of Putumayo where between 4 and 29.99 DALYs were lost per 100 000 population (Supplementary Table 1) (Figure 1).

According with our estimates management of CHIK for each patient in 2014 cost between US$1438.74 to 3396.57 (COP$2 256 582 to 4 875 889, at the exchange rate effective on 15 June 2015, US$1=COP$ 2675.73) in the first year of the disease (Table 1). The chronic phase represented at least 95% of the total estimated costs and this was attributed mostly to drug costs drugs, especially DMARDS (Table 1). The estimated cost for the 2014 outbreak ranged between US$73.6 million (the most conservative scenario) to US$185.5 million (the worst scenario). Total costs in the departments of Guaviare, Nariño, Chocó and Bogotá DC, were estimated as less than US$0.01 per capita (Figure 1), but in the departments of Norte de Santander and Sucre the outbreak cost more than US$10.0 per capita, between US$17 million to 42.9 million and US$10.1 to 25.6 million, respectively (Table 3) (Figure 1). It was notable that three departments (Norte de Santander, Bolivar and Sucre) accounted for more than 54% of the total DALYs lost and costs of the country; 10 out of 32 departments, accounted for >91% of the DALYs and costs of the country (Table 3).

Discussion

Although the mortality of dengue is significantly higher[7] than of CHIK, chronic sequelae have considerable implications for CHIK patients. Our results showed that the CHIK epidemic in 2014 in Colombia, based on the most conservative scenario, cost approximately US$73.5 million. This represents nearly 0.8% of the total national budget for health, and accounted for an estimated 40.4 DALYs lost per 100 000 population, which is greater than the reported burden in 2005 for traffic accidents, cerebrovascular disease and lower tract respiratory infections in Colombia. These injuries and diseases provide the most recent DALY data available in the country.[27] As another comparison in 2008, a total of 63 463

Table 2. Estimated DALYs related to acute phase and pCHIK-CIR incidence by departments, Colombia, 2014

Territory	Cases[a]	Population	Incidence (cases/100 000 pop)	pCHIK-CIR[b]		DALYs						DALYs per 100 000		
						Acute phase		Chronic phase[c]		Total				
				Low	Upper	Low	Upper	Low	Upper	Low	Upper	Low	Median	Upper
Colombia	106 592	48 321 405	220.6	48 052	53 435	733	900	18 809	20 916	19 543	21 816	40.44	42.80	45.15
Departments														
Norte de Santander	24 694	1 344 038	1 837.3	11 132	12 379	169.9	208.4	4357.5	4845.7	4527.4	5054.1	336.85	356.45	376.04
Sucre	14 741	843 202	1 748.2	6 645	7 390	101.4	124.4	2601.2	2892.6	2702.6	3017.0	320.52	339.16	357.81
Cartagena[d]	12 279	990 179	1 240.1	5 535	6 155	84.5	103.6	2166.8	2409.5	2251.2	2513.1	227.36	240.58	253.81
Santa Marta[d]	4 318	476 385	906.4	1 947	2 165	29.7	36.4	762.0	847.3	791.7	883.8	166.18	175.85	185.51
Bolívar	18 190	2 073 004	877.5	8 200	9 119	125.1	153.5	3209.8	3569.4	3335.0	3722.9	160.88	170.23	179.59
La Guajira	6 850	930 143	736.4	3 088	3 434	47.1	57.8	1208.8	1344.2	1255.9	1402.0	135.02	142.87	150.73
Barranquilla[d]	4 341	1 212 943	357.9	1 957	2 176	29.9	36.6	766.0	851.8	795.9	888.5	65.62	69.43	73.25
Magdalena	4 090	1 247 514	327.9	1 844	2 050	28.1	34.5	721.7	802.6	749.9	837.1	60.11	63.60	67.10
Córdoba	5 476	1 683 782	325.2	2 469	2 745	37.7	46.2	966.3	1074.5	1004.0	1120.8	59.63	63.09	66.56
San Andrés	204	75 801	269.1	92	102	1.4	1.7	36.0	40.0	37.4	41.8	49.34	52.21	55.08
Huila	2 131	1 140 539	186.8	961	1 068	14.7	18.0	376.0	418.2	390.7	436.1	34.26	36.25	38.24
Tolima	1 772	1 404 262	126.2	799	888	12.2	15.0	312.7	347.7	324.9	362.7	23.14	24.48	25.83
Arauca	264	259 447	101.8	119	132	1.8	2.2	46.6	51.8	48.4	54.0	18.66	19.74	20.83
Atlántico	2 122	2 432 003	87.3	957	1 064	14.6	17.9	374.5	416.4	389.0	434.3	16.00	16.93	17.86
Cesar	797	1 016 533	78.4	359	400	5.5	6.7	140.6	156.4	146.1	163.1	14.37	15.21	16.05
Cundinamarca	1 816	2 639 059	68.8	819	910	12.5	15.3	320.5	356.4	332.9	371.7	12.62	13.35	14.08
Putumayo	93	341 034	27.3	42	47	0.6	0.8	16.4	18.2	17.1	19.0	5.00	5.29	5.58
Santander	403	2 051 022	19.6	182	202	2.8	3.4	71.1	79.1	73.9	82.5	3.60	3.81	4.02
Vichada	13	70 260	18.5	6	7	0.1	0.1	2.3	2.6	2.4	2.7	3.39	3.59	3.79
Antioquia	1 115	6 378 132	17.5	503	559	7.7	9.4	196.8	218.8	204.4	228.2	3.21	3.39	3.58
Guainía	7	40 839	17.1	3	4	0.0	0.1	1.2	1.4	1.3	1.4	3.14	3.33	3.51
Amazonas	12	75 388	15.9	5	6	0.1	0.1	2.1	2.4	2.2	2.5	2.92	3.09	3.26
Casanare	39	350 239	11.1	18	20	0.3	0.3	6.9	7.7	7.2	8.0	2.04	2.16	2.28
Meta	105	943 072	11.1	47	53	0.7	0.9	18.5	20.6	19.3	21.5	2.04	2.16	2.28
Caldas	82	986 042	8.3	37	41	0.6	0.7	14.5	16.1	15.0	16.8	1.52	1.61	1.70
Valle del Cauca	375	4 566 875	8.2	169	188	2.6	3.2	66.2	73.6	68.8	76.8	1.51	1.59	1.68
Cauca	66	1 366 984	4.8	30	33	0.5	0.6	11.6	13.0	12.1	13.5	0.89	0.94	0.99
Quindío	19	562 114	3.4	9	10	0.1	0.2	3.4	3.7	3.5	3.9	0.62	0.66	0.69
Boyacá	30	1 274 615	2.4	14	15	0.2	0.3	5.3	5.9	5.5	6.1	0.43	0.46	0.48
Caquetá	9	471 541	1.9	4	5	0.1	0.1	1.6	1.8	1.7	1.8	0.35	0.37	0.39
Risaralda	17	946 632	1.8	8	9	0.1	0.1	3.0	3.3	3.1	3.5	0.33	0.35	0.37
Nariño	23	1 722 945	1.3	10	12	0.2	0.2	4.1	4.5	4.2	4.7	0.24	0.26	0.27
Bogotá D.C.[d]	93	7 776 845	1.2	42	47	0.6	0.8	16.4	18.2	17.1	19.0	0.22	0.23	0.24
Chocó	5	495 151	1.0	2	3	0.0	0.0	0.9	1.0	0.9	1.0	0.19	0.20	0.21

Continued

Table 2. *Continued*

Territory	Cases[a]	Population	Incidence (cases/100 000 pop)	pCHIK-CIR[b]		DALYs						DALYs per 100 000		
						Acute phase		Chronic phase[c]		Total				
				Low	Upper	Low	Upper	Low	Upper	Low	Upper	Low	Median	Upper
Guaviare	1	109 490	0.9	0	1	0.0	0.0	0.2	0.2	0.2	0.2	0.17	0.18	0.19
Vaupés	0	43 240	0.0	0	0	0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.00	0.00

DALYs: disability adjusted life years; pCHIK-CIR: post-chikungunya chronic inflammatory rheumatism.
[a] Suspected, confirmed and imported.
[b] Based on previous estimates.
[c] Only assuming pCHIK-CIR.
[d] Special country districts.

DALYs were lost due to pneumococcal infection in Colombians aged 15 or over (2.03 DALYs per 1000 Colombians).[28] In the case of dengue, the WHO Global Burden of Disease Study (GBD) of 2010 found that all age DALYs increased from 1990 with 712 000 (226 000 to 513 000) up to 825 000 (344 000 to 1 412 000) in 2010,[29] reaching 1 142 700 (727 600 to 1978 200) in the 2013 GBD study[30] None of these GBD studies have included yet data for CHIK.

Previous studies conducted in the 2006 outbreak in India showed comparable results for the district of Andra Pradesh (first administrative level) with an estimated cost of about US$12.4 million,[4] similar to that seen in the departments of Norte de Santander, Bolívar and Sucre, which sustained the greatest disease burden), where the cost in the lower limit of scenario one ranged from US$10–17 million. These departments have a lower economic status than other departments in Colombia. The Gross domestic product (GDP) of Norte de Santander represented only 1.6% of Colombia's GDP, and 4.3% for Bolivar and 0.8% for Sucre.

The actual cost of CHIK may be greater since the disease burden attributable to CHIK in Colombia and the new endemic areas in Latin America, has been reported as consistently higher than in Indian epidemics. This may explain the results of scenarios two and three.[2,5] We also estimated the outbreak to have cost almost twice as much as the outbreak in Réunion (US$48.9 million) although this comparison may be considered unfair, given the small size of the island. Studies in Réunion have been complete and detailed.

Over the course of the significant epidemics of the last 10 years, beginning with the 2005–2006 in Réunion, relatively few studies have assessed the burden and the costs of CHIK.[4,10,31,32] Only four studies, three in India (in 2009, 2010 and 2013) and one in Réunion (in 2011) have thus far been reported and in all the costs of CHIK were lower, for the same administrative levels or after adjusting for population size, than those currently reported for Colombia.

Our estimates have several limitations. Firstly in Colombia the operational definition of clinical CHIK (patient with fever plus severe arthralgia or acute arthritis, with no other medical explanation, i.e. dengue, that lives or comes from an epidemic or endemic area two weeks before the beginning of the symptoms) precludes serological and/or molecular confirmation of all the cases.

Additionally, although the estimated proportion of patients evolving to pCHIK-CIR has been previously reported,[3] there is no specific accurate estimate of the proportion of patients progressing to arthritis alone, and this may mean we have overestimated the need of DMARDS and laboratory tests (the main factors in costs). However, under-reporting of the disease and underestimation of costs are also possible, since departments such as Chocó have showed low incidence rates and low DALYs lost, despite having the socioeconomic and climatic conditions which favor the vector and the virus. Chocó also has significant migratory interchange with areas with a high CHIK burden such as Antioquia or Risaralda.

In addition, we assumed that sub-acute forms of the disease were treated similarly to acute forms, since there is insufficient evidence to establish the proportion of patients that progress to sub-acute forms of the disease and their proper management. It is possible that these patients need specialist care. We also did not consider the other recognized chronic sequelae of the

Table 3. Medical costs related to the chikungunya epidemic, Colombia, 2014

				Costs (US$) (thousands)														
				Acute/ subacute	Chronic (pCHIK-CIR)						Total							
	Acute	pCHIK-CIR[b]			Scenario 1		Scenario 2		Scenario 3		Scenario 1		Scenario 2		Scenario 3		% Costs	Cum. %
Territory	Cases[a]	Lower	Upper		Lower	Upper	Lower	Upper	Lower	Upper	Lower	Upper	Lower	Upper	Lower	Upper		
Colombia	106 592	48 052	53 435	8 166	65 453	72 785	130 763	145 411	159 527	177 397	73 619	80 951	138 929	153 578	167 693	185 563	100.00	100.00
Departments																		
N. De Santander	24 694	11 132	12 379	1 892	15 163	16 862	30 294	33 687	36 957	41 097	17 055	18 754	32 185	35 579	38 849	42 989	23.17	23.17
Bolívar	18 190	8 200	9 119	1 394	11 170	12 421	22 315	24 815	27 223	30 273	12 563	13 814	23 708	26 208	28 617	31 667	17.07	40.23
Sucre	14 741	6 645	7 390	1 129	9 052	10 066	18 084	20 109	22 062	24 533	10 181	11 195	19 213	21 239	23 191	25 662	13.83	54.06
Cartagena	12 279	5 535	6 155	941	7 540	8 385	15 063	16 751	18 377	20 436	8 481	9 325	16 004	17 692	19 318	21 376	11.52	65.58
La Guajira	6 850	3 088	3 434	525	4 206	4 677	8 403	9 345	10 252	11 400	4 731	5 202	8 928	9 869	10 777	11 925	6.43	72.01
Córdoba	5 476	2 469	2 745	420	3 363	3 739	6 718	7 470	8 195	9 114	3 782	4 159	7 137	7 890	8 615	9 533	5.14	77.14
Barranquilla	4 341	1 957	2 176	333	2 666	2 964	5 325	5 922	6 497	7 225	2 998	3 297	5 658	6 255	6 829	7 557	4.07	81.22
Santa Marta	4 318	1 947	2 165	331	2 651	2 948	5 297	5 891	6 462	7 186	2 982	3 279	5 628	6 221	6 793	7 517	4.05	85.27
Magdalena	4 090	1 844	2 050	313	2 511	2 793	5 017	5 580	6 121	6 807	2 825	3 106	5 331	5 893	6 434	7 120	3.84	89.11
Huila	2 131	961	1 068	163	1 309	1 455	2 614	2 907	3 189	3 547	1 472	1 618	2 777	3 070	3 353	3 710	2.00	91.10
Atlántico	2 122	957	1 064	163	1 303	1 449	2 603	2 895	3 176	3 532	1 466	1 612	2 766	3 057	3 338	3 694	1.99	93.10
Cundinamarca	1 816	819	910	139	1 115	1 240	2 228	2 477	2 718	3 022	1 254	1 379	2 367	2 616	2 857	3 161	1.70	94.80
Tolima	1 772	799	888	136	1 088	1 210	2 174	2 417	2 652	2 949	1 224	1 346	2 310	2 553	2 788	3 085	1.66	96.46
Antioquia	1 115	503	559	85	685	761	1 368	1 521	1 669	1 856	770	847	1 453	1 606	1 754	1 941	1.05	97.51
Cesar	797	359	400	61	489	544	978	1 087	1 193	1 326	550	605	1 039	1 148	1 254	1 387	0.75	98.26
Santander	403	182	202	31	247	275	494	550	603	671	278	306	525	581	634	702	0.38	98.63
Valle del Cauca	375	169	188	29	230	256	460	512	561	624	259	285	489	540	590	653	0.35	98.99
Arauca	264	119	132	20	162	180	324	360	395	439	182	200	344	380	415	460	0.25	99.23
San Andrés	204	92	102	16	125	139	250	278	305	340	141	155	266	294	321	355	0.19	99.42
Meta	105	47	53	8.0	64	72	129	143	157	175	73	80	137	151	165	183	0.10	99.52
Putumayo	93	42	47	7.1	57	64	114	127	139	155	64	71	121	134	146	162	0.09	99.61
Bogotá D.C.	93	42	47	7.1	57	64	114	127	139	155	64	71	121	134	146	162	0.09	99.70
Caldas	82	37	41	6.3	50	56	101	112	123	136	57	62	107	118	129	143	0.08	99.77
Cauca	66	30	33	5.1	41	45	81	90	99	110	46	50	86	95	104	115	0.06	99.84
Casanare	39	18	20	3.0	24	27	48	53	58	65	27	30	51	56	61	68	0.04	99.87
Boyacá	30	14	15	2.3	18	20	37	41	45	50	21	23	39	43	47	52	0.03	99.90
Nariño	23	10	12	1.8	14	16	28	31	34	38	16	17	30	33	36	40	0.02	99.92
Quindío	19	9	10	1.5	12	13	23	26	28	32	13	14	25	27	30	33	0.02	99.94
Risaralda	17	8	9	1.3	10	12	21	23	25	28	12	13	22	24	27	30	0.02	99.96
Vichada	13	6	7	1.0	8.0	8.9	16	18	19	22	9.0	10	17	19	20	23	0.01	99.97
Amazonas	12	5	6	0.9	7.4	8.2	15	16	18	20	8.3	9.1	16	17	19	21	0.01	99.98
Caquetá	9	4	5	0.7	5.5	6.1	11	12	13	15	6.2	6.8	12	13	14	16	0.01	99.99
Guainia	7	3	4	0.5	4.3	4.8	8.6	10	10	12	4.8	5.3	9.1	10	11	12	0.01	99.99
Chocó	5	2	3	0.4	3.1	3.4	6.1	6.8	7.5	8.3	3.5	3.8	6.5	7.2	7.9	8.7	<0.01	99.99
Guaviare	1	0	1	0.1	0.6	0.7	1.2	1.4	1.5	1.7	0.7	0.8	1.3	1.4	1.6	1.7	<0.01	100.00

Continued

Table 3. *Continued*

Territory	Acute			Costs (US$) (thousands)																	
				Acute/ subacute	Chronic (pCHIK-CIR)						Total										
		pCHIK-CIR[b]			Scenario 1		Scenario 2		Scenario 3		Scenario 1		Scenario 2		Scenario 3		% Costs	Cum. %
	Cases[a]	Lower	Upper		Lower	Upper	Lower	Upper	Lower	Upper	Lower	Upper	Lower	Upper	Lower	Upper		
Vaupés	0	0	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.00	100.00

pCHIK-CIR: post-chikungunya chronic inflammatory rheumatism.
[a] Suspected, confirmed and imported.
[b] Based on previous estimates.

disease (e.g., neurological and cardiovascular), and costs were calculated ignoring the prevalence of congenital, severe, atypical and paediatric CHIK. All of these factors may have contributed to an underestimation of the costs to which these complications give rise.

Despite these limitations, our approach allowed us to clarify an approximation of the cost represented by the 2014 CHIK epidemic to the health system of Colombia. By considering different scenarios we wanted to provide the potential cost margins and this is, to the best of our knowledge, the first which has considered the CHIK national burden of disease and also cost estimates for the current Latin American epidemic.

Our results raise concern about potential effects of continued spread, not only in Colombia but in other Latin America countries. The cost burden of CHIK per case is far greater than that of dengue by a factor of almost five.[6] The total cost per dengue case in 2012 was derived by adding the costs incurred by the healthcare system to the costs to the household (including indirect costs) and this was US$202.3 for ambulatory patients, US$497.9 for hospitalized patients, and US$2306.7 for patients with severe dengue.[6] Nevertheless, dengue does not have a chronic phase. The chronic phase in CHIK represents more than 75% of the costs and occurs in around half of the patients according to estimates and recent data published by our group in Colombia.[3,33,34] Also costs would be higher if we consider in the indirect costs that we were able to use the minimum wage salary instead of a median salary, for which a database/estimate is not available for Colombia and which would provide a much more reasonable estimate.

The variable economics of the region, along with high reported out of pocket expenditure, not measured in this work, associated with CHIK in other epidemics,[31] will debilitate both health care systems, but also threaten to overwhelm economies. Although CHIK is unlikely to threaten or destabilize the health system in Colombia, it will certainly have a negative economic impact.

For other countries, such as Venezuela, where there is a complete lack of control of vector borne diseases,[8,35,36] our estimates of the loss associated with DALYs and the economic cost are also of concern.

There are still many aspects of this disease which remain to be assessed and understood. Long-term complications may persist for more than 6 years in pCHIK-CIR[37] and over two years for neurological impairment in children.[38] In Colombia the incidence in the first three months of 2015 have doubled compared to the whole of 2014,[17] and this suggests that there may be three to four times more cases by the close of 2015.

Another limitation of our study was that in 2014 deaths and atypical, pregnant and congenital cases were not included in official data, and currently during 2015, there are many reports of these cases, with associated mortality.[14,39,40]

Conclusions

Finally, the lack of effective disease control measures by National Governments contributes to the importance of CHIK as a cause of acute and chronic disability in the short and longer term. The expected increase both in acute cases and the numbers of those with chronic sequelae should act as a spur to research investment in prevention and effective management. Control of disease spread is a major challenge but surveillance should be enhanced for chronic sequelae.

Supplementary data

Supplementary data are available at Transactions online (http://trstmh.oxfordjournals.org/).

Authors' contributions: JACO and AJRM conceived the research question, designed the study, conducted the initial analysis, and contributed to and provided critical review of manuscript drafts; WVG, CEJC and DMCH collected and cleaned the data and were involved in the revision of the manuscript drafts; AJRM conducted the final analysis; JACO wrote the manuscript and contributed to critical review or the manuscript drafts with the assistance of AJRM; WVG, CEJC and DMCH contributed to and provided critical review of the manuscript drafts towards finalization. All authors read and approved the final manuscript. AJRM is the guarantor of the paper.

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