Health and Climate Change in South America

Economic impacts associated with the health effects of climate change in South America: a scoping review

Juliana Helo Sarmiento,[a,*] Oscar Melo,[b] Laura Ortiz-Alvarado,[a] Chrissie Pantoja Vallejos,[c,d] and Ivonne Fanny Reyes-Mandujano[e,f]

[a]Facultad de Economía, Universidad de los Andes, Bogotá, Colombia
[b]Centro Interdisciplinario de Cambio Global, Pontificia Universidad Católica de Chile, Santiago, Chile
[c]Duke University, Durham, North Carolina, USA
[d]Departamento Académico de Economía, Universidad del Pacífico, Lima, Peru
[e]Faculty of Pharmacy and Biochemistry, Universidad Científica del Sur, Lima, Peru
[f]National Center of Intercultural Health, National Institute of Health, Lima, Peru

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Summary

This scoping review assesses the current evidence on the health impacts of climate change and associated economic costs in South America. In total, 3281 studies were identified using a systematic search strategy, but only 23 articles met the inclusion criteria and were analysed. The results from these articles indicate that the health effects of climate change will likely be costly for South America; however, evidence is limited to a handful of countries or regional analyses that ignore heterogeneity across and within countries. Most of the analysed studies looking at extreme weather events related to climate change focus on the effects and costs of droughts and fire events. A broader understanding of the topic could be achieved by estimating other extreme weather events' health effects and costs, using appropriate research methods to identify causal impacts, and including a more comprehensive and representative regional population sample. Beyond identifying effects, it is important to investigate demand responses for healthcare services, associated costs, availability and expansion of infrastructure, and cost-effectiveness of policies aimed at coping with and adapting to the health dimension of climate change.

Keywords: Climate change; Health; Economic impacts; Economic costs; Adaptation costs; South America

Introduction

Climate change is expected to affect the precipitation and temperature of the atmosphere and oceans.[1] These effects have intermediate impacts on natural and anthropic systems mediated by adaptive capacities and exposure, leading to vulnerabilities and health impacts. These health impacts, in turn, have economic implications due to welfare losses, income changes, and additional private and public expenses. In addition, climate change mitigation may involve co-benefits, for example, from the effects of pollution reduction linked to fossil fuel substitution. The economic implications of climate change health effects can be classified as the costs due to investments and operation of adaptation measures and the economic losses due to the impacts on economic activity and human welfare.

Despite some clear implications of climate change on health and its economic impacts, and evidence that developing countries will disproportionately bear much of these costs, the magnitude and heterogeneity of responses within South America remain to be determined.[2,3] South American countries are particularly vulnerable to the increased frequency of extreme weather events related to climate change that can potentially affect human health, given the importance of the agricultural sector, rising urbanization rates, water demands, their climatic conditions, and the increase of deforestation that are conducive to water and vector-borne disease proliferation.[2–10] For instance, Argentina, Brazil, Paraguay, and Uruguay are net exporters of agricultural and agro-industrial products, and these sectors represent between 6% and 12% of the Gross Domestic Product (GDP) for these countries.[4–6] The region has also experienced one of the most significant urban growth in the world, with almost 84% of the total population now living in cities, compared to the average of 82% in North America and 73% in Europe.[7]

This number of people living in urban areas challenges the provision of public goods such as clean water and sanitation.[11] According to the Inter-American Development Bank, water security in South America faces critical challenges, which is vital in protecting and helping populations to adapt to climate change. These include unequal

*Corresponding author. Calle 19A No. 1-37 Este. Bloque W, Bogotá, Colombia.
E-mail address: j.helo@uniandes.edu.co (J. Helo Sarmiento).

water resource distribution, climate change impacts like increased floods, water quality issues, and developmental obstacles like poverty and infrastructure gaps that threaten quality and access.[11] Beyond demands for water in cities, which account for 21%, water consumption is also essential in agricultural activity (68%).[8] This vital resource for human health can be severely affected by the increase of deforestation and climate variability, which contribute to the incidence of water-borne diseases.[9,10] Most South American countries are also located in tropical latitudes, which are prone to the proliferation of vector-borne diseases such as malaria or dengue that have also been shown to react to climatic changes.[9,10] The 2022 South America report of The Lancet Countdown on health and climate change underscores a pressing concern in South America. Indicator 1.3 reveals a troubling 35.3% increase in climate suitability for dengue transmission over the past decade. Highly urbanized countries in the Southern Cone, such as Argentina and Uruguay, are also experiencing heightened vulnerability to severe dengue outcomes. These developments have dire consequences, particularly for children, leading to increased mortality and morbidity rates and placing overwhelming strain on local health systems.[12]

All these factors contribute to South America's vulnerability to climate change and its impacts on health in these populations. However, a comprehensive analysis on the current available evidence on climate change's health effects and economic impacts is still missing. Understanding how climate change will impact health outcomes in South American countries and the related economic costs is important to guide the design of cost-effective policies to protect human health from climatic threats. This scoping review assesses the current state of the literature in South America, identifies knowledge gaps, and suggests potential areas for future research.

Methods

Search strategy

The research team prepared the search protocol using the PRISMA extension for Scoping Reviews (PRISMA–ScR) guidelines,[13,14] and following Lancet Countdown South America recommendations. A search strategy was developed based on this protocol, and key search terms were refined with online databases before the article search. The keywords and synonyms for each term (cost, climate change, human health, and countries in South America) and datasets are presented in Supplementary Material S1. The literature search was conducted in September 2021 and repeated in August 2023 to update results up to July 2023. The following databases were included: JSTOR, EconPapers, EBSCO, SCOPUS, PubMed, Web of Science (WOS), Microsoft Research, Google Scholar, and SciELO, combining three blocks of search terms related to climate change, health, and economic costs (see Table 1 and Supplementary Material S1 for details on keywords and hits by all databases included in this scoping review). Microsoft Research was used for exploratory searches rather than Google Scholar since the former allows selecting papers in BibTeX (*.bib) format. Using this format allowed us to export references to the Rayyan software. The latter was used to screen articles based on their titles and abstracts for relevance to the research question.

Inclusion criteria, article selection, data management, and characterisation

Only articles from peer-reviewed academic journals in English, Spanish, and Portuguese were considered. Articles were selected if they addressed questions on the health impacts of climate change and quantified their respective economic losses (either direct or indirect) for South America or some of its countries. Since South American countries are included in the Latin America region (LAC) and account for approximately 70% of the population, articles that displayed aggregate analyses for LAC were also considered. No time frame for the analysis was specified. Ineligible documents included those considered grey literature, those for which no full texts were available, or did not link the health impacts of climate change to associated economic outcomes in any South American country. Eligibility favoured quantitative, or mixed methods analyses over qualitative research because the scoping review aimed to determine evidence of the causal and/or association relationships between the variables of interest.

A two-step screening process was followed to identify the relevant articles to be included in the scoping review. Each member of the research team screened the literature by reviewing titles and abstracts organized in Rayyan. Each researcher independently classified the articles as either accepted, maybe, or declined. If all team members classified a document as accepted (declined) according to the inclusion criteria, it was considered (discarded) for a full review. Articles without initial consensus and those classified as "maybe" were openly reviewed by the team until a decision to accept or decline was reached.

In the second step, each research team member thoroughly reviewed a similar proportion of the articles selected in step one for further screening. In addition to the inclusion criteria, researchers used a spreadsheet-based standardized data extraction tool created a priori for this study through team discussion to identify relevant information from each document and tabulate the data extracted. The tool gathered data on authors, year of publication, geographical location, sample year, methods, outcomes of interest, primary results, and reasons to discard if it was the case. This tool allowed researchers to determine whether to include or not the document in the final scoping review. Since all information was summarised in the tool, all team members had access to the summary statistics of each article and the reasoning behind including or not an article in the review. Disagreements were solved through discussion in team meetings until consensus was achieved.

Database	Strategy	Hits
PubMed	See Appendix 1 for details on search words.	987
WOS	See Appendix 1 for details on search words.	86
Scielo	((cost*) OR (econom*) OR (value*) OR (consumption) OR (gross domestic product) OR (wage*) OR (cost of infection) OR (public finance) OR (tax*) OR ("Cost of Inaction")) AND ((changing climate) OR (climat* change*) OR (climat* crisis) OR (climat* catastroph*) OR (climat* disrupt*) OR (extreme heat) OR (forest fire) OR (frost) OR (global climate) OR (global warming)) AND ((disease*) OR (illness*) OR (indigenous health) OR (ill) OR (life expectancy) OR (morbidity) OR (mortality) OR (prevalence) OR (public health) OR (sickness*)) AND ((argentin*) OR (bolivia*) OR (brazil*) OR (chile*) OR (colombia*) OR (ecuador*) OR (paraguay*) OR (peru*) OR (uruguay*) OR (south america))	138
EBSCO	TI "climate change" AND TI econom* AND TI health	55
JSTOR	((ti:(cost*) AND ti:(climate change)) AND ti:(health)) ((ti:(cost*) AND ti:(climate change)) AND ti:(health))	9
Scopus	(TITLE-ABS-KEY (Cost*) OR TITLE-ABS-KEY (Econom*) OR TITLE-ABS-KEY (cost-benefit) OR TITLE-ABS-KEY (Gross Domestic Product) OR TITLE-ABS-KEY ("cost inaction")) AND (TITLE-ABS-KEY ("climate change") OR TITLE-ABS-KEY ("Changing climate") OR TITLE-ABS-KEY (Climat* crisis) OR TITLE-ABS-KEY (Climat* emergenc*) OR TITLE-ABS-KEY (Climat* disrupt*) OR TITLE-ABS-KEY (Climat* extreme*) OR (Climat* catastroph*)) AND (TITLE-ABS-KEY (health) OR TITLE-ABS-KEY (Disease*) OR TITLE-ABS-KEY (emerging disease) OR TITLE-ABS-KEY (Ill*)) AND (TITLE-ABS-KEY ("South America") OR TITLE-ABS-KEY (Amazon*) OR TITLE-ABS-KEY ("Latin America") OR TITLE-ABS-KEY ("Global South") OR TITLE-ABS-KEY (Argentin*) OR TITLE-ABS-KEY (Bolivia*) OR TITLE-ABS-KEY (Brazil*) OR TITLE-ABS-KEY (Brasil*) OR TITLE-ABS-KEY (Chile*) OR TITLE-ABS-KEY (Colombia*) OR TITLE-ABS-KEY (Ecuador*) OR TITLE-ABS-KEY (Guyan*) OR TITLE-ABS-KEY (Paraguay*) OR TITLE-ABS-KEY (Peru*) OR TITLE-ABS-KEY (Suriname*) OR TITLE-ABS-KEY (Uruguay*) OR TITLE-ABS-KEY (Venezuela*) OR TITLE-ABS-KEY (Altiplano) OR TITLE-ABS-KEY (Andes) OR TITLE-ABS-KEY ("South American tropic") OR TITLE-ABS-KEY ("South American subtropic") OR TITLE-ABS-KEY (Patagonia*))	147
EconPapers	Free terms: Argentin* Bolivia* Brazil* Chile* Colombia* Ecuador Ecuator* Guyan* Paraguay* Peru* Surinam* Uruguay* Venezuel* Altiplano Amazon* Andes "South America" Patagonia* "Global South" Keywords and Title: AND (econom* cost* financ* employment) AND ("climate change" "changing climate" "global change") AND "health"	111
Microsoft Research	"climate change" OR "cambio climático" OR "mudança climática") AND ("health" OR "salud" OR "saúde") AND ("cost" OR "costo" OR "custo") AND (Argentina OR Bolivia OR Brazil OR Chile OR Colombia OR Ecuador OR Guyana OR Paraguay OR Peru OR Suriname OR Uruguay OR Venezuela	55
Google Scholar	See Appendix 1 for details on search words.	1040

Table 1: **Selected Keywords (with synonyms) and syntax used for the literature search in each database.**

Selected documents are listed and summarized in Table 2 and analysed in the results section below.

Results

The following section presents the results of the research strategy. It also analyses the methods used in the selected articles and their main results concerning the effects and costs of climate change on health outcomes.

Literature profile and characterization

The initial search in September 2021 yielded 1164 documents, of which 1037 were duplicates or unrelated to the search topic, leaving 127 for further consideration. Of these, 41 were excluded because they did not meet the inclusion criteria, leaving 86 articles included for a full-text review. From this total, 66 were discarded because full texts were unavailable, or did not address any of the outcomes of interest, leaving 20 articles that met the inclusion criteria. A second search in August 2023 to update available literature up to July 2023 yielded 347 additional documents, of which 307 were disregarded after the first screening, leaving 40 articles for further consideration. An additional two articles met the inclusion criteria for the scooping review. Most articles were discarded because they did not link the health impacts of climate change to their respective economic costs, estimated economic costs did not relate to health impacts, or did not include any analysis for a South American country or region.

A separate search using the same strategy but with terms in Spanish was performed in August 2023 to complement the results. Out of the 1770 identified, 46 were further considered, and only one additional article was included in the review. Approximately half of the documents in Spanish were grey literature and, thus, discarded. The rest did not address climate change, related health outcomes, associated costs, or countries in South America. Though no separate search was done with terms in Portuguese, our search strategy with English terms is likely to identify articles in Portuguese because these usually list keywords in English for them to be searchable. In fact, 3 of the 23 articles in the scoping review were in Portuguese. Fig. 1 summarizes the selection process for the 23 articles included out of the 3281 hits in the different datasets and search strategies. It reports the aggregate numbers for the three searches.

As described in Table 3, the largest proportion of single and multi-country studies focus on upper-middle-income countries in South America, such as Brazil, Ecuador, and Peru (i.e., 21 out of 23), and only two studies in a high-income country in the region, Chile. The income classification is assigned to countries by the World Bank based on the countries' Gross National Income.[38] Approximately half of the studies included analyses of South America as a region or included in the

Authors and publication year	Method	Location	Main results (summary)
Aragão and Carvalho (2018)	*Quantitative: Regression analysis* A regression analysis is used to determine the association between climate and dengue fever incidence using a database containing spatial-temporal information on human health, climate modelling outputs, sea level rise data, population density and topography.	Brazil	The authors estimate 36,134 hospitalizations due to dengue fever in Sao Paulo State between 2008 and 2015, with 40.5% of these registered in 2015. They document a correlation between El Niño/ increased temperatures and dengue hospitalizations. Using back-of-the-envelope calculations, they estimate the cost of hospitalizations due to dengue outbreaks. With 300 cases per 100,000 inhabitants in 2010 and assuming a population of 400,000 and a cost of BRL 600 per patient (USD 341), the cost of dengue treatment in 2010 was BRL 720,000 (USD 410,000). These costs are likely much higher because they do not consider other diseases associated with the same vector, such as Zikka and Chicungunha, or emergency actions to mitigate the outbreaks.
Bell et al. (2006)	*Quantitative: Economic valuation methods of environmental interventions* Economic valuation of avoided health effects using willingness to pay (WTP) and Cost-of-illness (COI) approaches.	Mexico, Chile, and Brazil	The authors estimate ozone and particulate matter concentrations for Santiago, Sao Paulo, and Mexico City under two different scenarios: business as usual and air pollution control policies. They find that air pollution control would have vast health benefits for the three cities, averting numerous adverse health outcomes, including over 156,000 deaths, 4 million asthma attacks, 300,000 children's medical visits, and almost 48,000 cases of chronic bronchitis. The economic value of avoided health impacts is roughly USD 21–165 billion.
Campanharo et al. (2019)	*Quantitative: Linear regression and uncertainty propagation methods* The total burnt area is estimated using the 2008 biomass map. The loss is directly associated with infrastructure damages, production losses, and costs related to crop reestablishment and future production. The authors find an association between the total burnt area and the total hospitalization cases by municipality and year. They quantify the indirect costs of CO_2 emissions from the biomass loss maps and respiratory morbidities.	Brazil	Droughts increase the probability of fire events, which raises the annual estimated cost related to infrastructure damages, agricultural production losses, CO_2 emissions, and respiratory morbidities around fifteen-fold in Brazil's Acre state compared to an average climatological year. Estimates represent approximately 7% ± 2.45% of Acre's GDP. Quantifying social fire impacts related to respiratory morbidity is complex. The difficulty to establish a robust diagnostic of cause and effect, with relation to fires and respiratory illness, introduces large uncertainties for defining the proportional contribution of these costs to the total economic loss estimates.
Carreras et al. (2015)	*Mixed method: Time series analysis and field research* The data were analyzed using Generalized Additive Models (GAM) with a quasi-Poisson distribution link function. Heterogeneous analysis by season, age groups, and socioeconomic status.	Argentina	The paper assesses the impact of the daily temperature range on population morbidity in Cordoba-Argentina. Higher temperatures increase upper and lower respiratory morbidities, especially among the elderly, less-educated individuals, and poor living conditions.
Cromar et al. (2021)	*Quantitative: FUND model* Using the FUND model the authors evaluate the health-based portion of the existing social cost of carbon. They did a separate analysis for low, middle, and high-income countries. In addition to the base model, three additional experiments assessed the sensitivity of these estimates to changes in the socioeconomic assumptions in the model.	Middle-income countries/ South America	Economic impacts from adverse health outcomes represent 4.4% of the current social cost of carbon in middle-income countries, including South American countries. 7.2% of these health impacts are attributable to diarrhoea mortality and morbidity. The results of the socioeconomic experiments show that the health-based portion of the social cost of carbon estimates is very sensitive to assumptions regarding income elasticity of health effects, income growth, and use of equity weights.
Desbureaux and Aude-Sophie (2019)	*Quantitative: Linear probability model* The paper estimates the effect of droughts on the probability of labour market outcomes using a linear probability model. It exploits random variations in weather to define rainfall and drought shocks and controls for temperature, precipitation, economic activities, and fixed effects for unobserved characteristics and time variations.	78 Latin American cities	Large sustained dry events decrease the probability of being employed, hourly wages, hours worked, and labour income of urban workers, especially for informal workers. The impacts of droughts are higher than the effects of wet events. Workers' health (e.g., increased cases of diarrhoea) and power outages could explain the link.
Dessus and O'Connor (2003)	*Quantitative: CGE* Uses a CGE model to link policy changes (e.g., a pollution tax) to emissions reductions. Develop several links in a causal chain from climate policy to welfare changes. Dispersion model specified by WHO 1989 to link emissions reductions to changes in ambient. Thus, they can identify exposure and health effects, building epidemiological evidence for some air pollutants in Santiago. These effects are valued in monetary units to welfare gains such as willingness to pay (WTP) for reduced mortality risk and other health improvements (morbidity).	Chile	Results suggest that, even with the most conservative assumptions (low WTP, low elasticities), Chile could reduce CO_2 emissions by almost 20% from the 2010 baseline with no net welfare losses. However, a 10% reduction is closer to "optimal". If, instead, Chile was to target a 20% reduction in particulate matter concentrations, a particulate tax would incur slightly lower costs than an equivalent carbon tax to achieve the same health benefits. While the latter is a second-best solution for addressing local pollution, carbon credit sales could fully compensate for the welfare loss of choosing this instrument at a world market price of USD 20/tC.
Ebi (2008)	*Quantitative: DALYs and HadCM2 model* This study estimates Disability Adjusted Life Years Lost (DALYs) related to the annual number of cases of diarrheal diseases. It uses HadCM2 general circulation climate model to simulate the relative climate change risks.	Latin America	The paper estimates the worldwide costs of treating additional cases of malnutrition, diarrheal disease, and malaria attributed to climate change by 2030 to range between USD 4 and USD 12 billion. They use current treatment costs, assume no population or economic growth, and no adaptation measures undertaken. The authors separately estimate costs for different WHO regions, including Latin America. The three diseases pose significant risks for future populations, particularly in low-income countries in tropical and subtropical regions.

(Table 2 continues on next page)

Authors and publication year	Method	Location	Main results (summary)
(Continued from previous page)			
Fishman et al. (2019)	*Quantitative: Regression analysis for causal inference* The empirical specification exploits weather shocks to investigate the effect of temperature around the time of birth on adult earnings. The model incorporates location-fixed effects to capture the long-term, month-specific expected weather.	Ecuador	Elevated in-utero exposure to high temperatures harms formal sector earnings in Ecuador. Individuals who experience in-utero temperatures that are 1 °C above average are less educated and earn 0.7% less as adults. Extrapolation of estimates suggests that future warming may have additional economic impacts that have not been sufficiently appreciated to date.
Hasegawa et al. (2016)	*Quantitative: CGE and DALY* The study measures changes in morbidity and mortality due to nine diseases caused by being underweight with changes in the labour force, population, and healthcare demands. It conducts a simulation and assesses the value of lives lost and the willingness to pay to reduce the risk.	Latin America	The paper quantifies the impact of climate change on human health through undernourishment, which impacts nine diseases (diarrheal diseases, pertussis, measles, tetanus, meningitis, malaria, lower respiratory infections, birth asphyxia and birth trauma, and protein-energy malnutrition). They find that the economic value of healthy lives lost to undernourishment as a result of climate change ranged from 0.4% to 0.0% of the world's gross domestic product (GDP) and varied regionally, from 4.0% to 0.0% of regional GDP in 2100. Contrarily, the actual economic losses caused by increased healthcare costs and the decline in the labour force brought on by undernourishment as a result of climate change, respectively, corresponded to changes of 0.1%–0.0% in GDP and 0.2%–0.0% in household consumption at the global level. These changes are close to 0% for Brazil and the rest of Latin America
Markandya and Chiabai (2009)	*Mixed method: CE and CB analysis and systematic review* The study integrates cost valuation methodologies (i.e., CE and CB) with epidemiological estimates about the proportion of people exposed to malaria (using climatic modelling and clinical evidence of incidence) and projections of population growth rates (unit costs have been calculated in each country for the baseline year).	Latin America	The cost per death avoided through disease control programs focusing on combined health interventions is USD 300–600. The costs per life saved in the case of diarrhoea are considerably lower than those of malaria.
Nakano (2018)	*Quantitative: LCA* The study uses the life cycle assessment framework for adaptive planning to climate change to evaluate the potential climatic effects on industries throughout the supply chain. To quantify the involvement of workers throughout the supply chain, they use multi-regional input-output tables	Brazil	In a multi-country study, only Brazil from South America, the authors identify the industries more vulnerable to the effects of dengue fever. They find that more than 70% of workers in major industries in Brazil would be at risk in 2030, directly impacting the construction, textile, and hotel/restaurant sectors.
Pattanayak et al. (2009)	*Quantitative: CGE model* The paper analyses a Brazilian policy to expand National Forests (FLONAS) by 50 million hectares. It measures health impacts in a CGE model (baseline scenario vs FLONAS) via the labour market, including labour-leisure trade-offs and productivity declines in the workplace. The econometric estimates, OLS, and propensity score matching of health effects are translated into reductions in labour endowments by converting additional cases of morbidity and mortality into "healthy" years lost because of disability, represented as a percentage change in labour endowment.	Brazil	The baseline scenario starts with a 0.3 per cent (urban) to 0.6 per cent (rural) reduction in labour stock because of increased climate-related diseases and 3 million hectares of forest cleared annually. FLONAS conservation scenario mediates the health effects while reducing the land available for agriculture and pasture. FLONAS conservation scenario, compared to the "no action baseline" of climate change and deforestation, suggests a relatively small but negative impact on GDP (−0.1 per cent) by reducing agricultural output and other key macro indicators (investment, exports, imports, and earnings). FLONAS scenario improves health but lowers incomes in frontier regions of the Brazilian Amazon.
Rocha and Soares (2014)	*Quantitative: Regression analysis for causal inference* The paper analyses the health impacts of rainfall fluctuations during the gestational period using a municipality-by-month of birth panel. Heterogeneous effects on infant mortality by GDP, water, and sanitation coverage. Cost-effectiveness analysis focused on mortality before age 1 of expanding water and sanitation services coverage.	Brazil	Adverse rainfall shocks/droughts increase infant mortality, lower birth weight, and shorten gestation periods. An increased incidence of intestinal infections and malnutrition explains mortality effects. They are minimized when the local public health infrastructure is sufficiently developed (municipality coverage of piped water and sanitation). Higher effects are documented during the foetal period (2nd trimester of gestation). Estimates suggest that expansions in public health infrastructure would be a cost-effective way of reducing the response of infant mortality to rainfall scarcity.
Takakura (2017)	*Quantitative: AIM/CGE model* The paper uses the Asia-Pacific Integrated Model/Computable General Equilibrium (AIM/CGE) model as a core tool to estimate the future macroeconomic cost of workplace heat-related illness prevention.	Latin America	The paper estimates the economic costs for workplace heat-related illness prevention through worker breaks under various climate scenarios and socioeconomic conditions. This action reduces work time and labour productivity, which is economically costly. Under a high-emissions scenario (RPC 8.5), GDP loss is expected to range between 2.6% and 4.0% of global GDP in 2100. In Brazil and the rest of Latin America, these costs range from 0.31 to 3.4% and 0.86 to 1.76% of GDP, respectively. The construction and primary sectors are the most affected. Socioeconomic development and climate mitigation can reduce these costs. Even if temperature increases are limited and socioeconomic development is achieved, costs are non-negligible due to outdoor work. Adaptation measures that can be applied to outdoor work should be quantitatively investigated.

(Table 2 continues on next page)

Authors and publication year	Method	Location	Main results (summary)
(Continued from previous page)			
Tol (2005)	*Quantitative: FUND model* The study makes simulations for nine groups of countries using the Climate Framework for Uncertainty, Negotiation and Distribution model with climate projections from the IPCC.	Latin America	The paper tests if development aid is more effective in reducing the impacts of climate change than greenhouse gas emission reductions. Using a multi-region simulation based on the FUND model, the authors find that investing in development, particularly aid, which targets vector-borne infectious diseases in poorer countries, is a better strategy for reducing the impacts of climate change than greenhouse gas emission reduction. These investments reduce vulnerabilities in some sectors, such as infectious diseases, water resources, and agriculture. Latin America and Africa enter the group of countries in which this is the case.
Zamand and Hyder (2016)	*Quantitative: Probit* Outcomes of interest: enrolment, three cognition and psychometric development indicators, two anthropometric measures of health and nutritional status (BFA z-score and HFA z-score). Probit estimation using Young Lives Project.	Peru	The paper analyses the impact of self-reported exposure to droughts and floods on human capital, measured by educational and health outcomes, for children aged 14–16 years in Peru. Only a negative association is found between droughts and Peabody Picture Vocabulary Test scores, while negative but non-significant results for other educational outcomes such as school enrolment, mathematics test scores, and health measures such as body mass index or height-for-age z-scores were documented.
Bakhtsiyarava et al. (2022)	*Quantitative: Multi-level distributed lag non-linear model* Using live birth data from SALURBAR for cities in Brazil, Chile, and Mexico and monthly average ambient temperature from ERA5, the authors use a non-linear distributed lag model controlling for sex, season of conception, and calendar year of child's birth; controlled for maternal age, education, partnership status, presence of previous births, and climate zone; and included a random term for the sub-city of mother's residence. They use other findings in the literature to infer losses in birthweight and future earnings, but they do not report specific numbers for cities in the sample.	Brazil, Chile, Mexico	Higher temperatures (relative to the 19 °C reference) during gestation are associated with lower birth weight, particularly in Mexico and Brazil. The cumulative effect appears to be driven by stronger associations during the last months of gestation. Studies have shown that a 10% increase in birth weight is associated with a 0.9% increase in earnings and a 1.2% increase in high school graduation (Black et al. 2007).
Madeira (2022) In Spanish	Literature *Review* Review estimates from the literature to compare Chile's economic impacts of climate change to other South American and OECD countries.	Chile	The literature shows that climate change will not significantly affect Chile's GDP and labour productivity compared to other Latin American and OECD countries under different RCP scenarios. In contrast, Brazil could lose approximately 10% of its labour productivity. Climate change, particularly droughts, increases mortality risks, especially in Chile's central zone. Estimates for Chile indicate that mortality costs of climate change could be equivalent to 3.2% of GDP and 0.9% of health-related costs. Chile is highly vulnerable to air pollution mortality.
Freitas et al. (2020) In Portuguese	*Accounting Exercise* Analysis of the economic impact of natural disasters on healthcare facilities in Brazil from 2000 to 2015. They use data from 15,950 disaster register forms, categorizing them according to the Brazilian Classification and Coding of Disasters (COBRADE). The study primarily focused on costs (in Brazilian Reais, R$) associated with damages to healthcare infrastructure. Forms lacking healthcare damage data and those with missing values were excluded. The study adopted COBRADE's disaster classification, and the results provide insights into the financial implications of different disaster types on healthcare facilities in Brazil, considering their location and extent of damage.	Brazil	The authors calculate that the total cost of disasters in healthcare facilities between 2000 and 2015 was almost 4 million R$ (Brazilian Reais). Regarding the type of disaster that affected healthcare facilities, climatological disasters (droughts, forest fires, cold spells) were the most common, accounting for 56.2% of occurrences, followed by hydrological (floods, landslides) (34.9%), meteorological (thunderstorms, hailstorms, windstorms) (8%), and geological (landslides) (0.9%) disasters. Despite frequent climatological disasters, they represented only 0.3% of total costs. In contrast, though less frequent, hydrological disasters accounted for 88.5% of the total costs. Hydrological disasters are 3.2 and 3.6 times costlier than other disasters. Notably, while making up 49.3% of events with cost data, meteorological disasters contributed only 9.9% to the total costs. The study also examined costs by region, revealing variations in disaster impact and financial burden across different parts of Brazil.
Da Cruz et al. (2016) In Portuguese	*Quantitative: Correlation exercise* Ecological time-series study to examine the relationship between healthcare parameters and meteorological factors in São Carlos, São Paulo, Brazil, from 2008 to 2012. Monthly and annual data on all hospital admission authorization numbers (AIH), mortality rates, hospital mortality rates, and spending categorized by disease group (according to ICD-10) from the Unified Health System's Hospital Information System. Meteorological data on temperature and humidity from the National Institute of Meteorology (INMET). Spearman's correlation coefficient was used to evaluate correlations between meteorological factors and healthcare outcomes, classified based on the correlation strength.	Brazil	Between 2008 and 2012 in São Carlos, 7144 hospital admissions were recorded under different disease categories (DR). Correlation analysis showed a moderate negative correlation between hospital admissions and average compensated temperatures and a weak negative correlation with minimum temperatures. Mortality rates showed a weak positive correlation with average compensated and maximum temperatures, while costs had a weak negative correlation with average compensated, maximum, and minimum temperatures.

(Table 2 continues on next page)

Authors and publication year	Method	Location	Main results (summary)
(Continued from previous page)			
Pereira et al. (2014) In Portuguese	*Quantitative: Cost of illness* Partial economic evaluation using a relative cost-of-illness methodology for dengue cases attributed to the disaster in Nova Friburgo on January 11–12, 2011. Dengue and leptospirosis were the most intensified diseases post-disaster and the focus of specific epidemiological control measures. Data sources include restricted-access secondary data from the Municipal Health Foundation of Nova Friburgo, covering epidemiological reports, financial reports, and dengue notification records. The study assesses costs to the health system (hospital and outpatient procedures) and societal costs (loss of productivity).	Brazil	A total of 937 confirmed dengue cases and 419 discarded cases were reported in Novo Friburgo attributed to the natural disaster favoring vector maintenance and circulation. Treatment costs through the healthcare system were estimated at R$58,341.97 (Brazilian Reais) for treating suspected cases, excluding diagnostic tests, of which R$45,791.97 corresponded to hospitalized cases and R$12,550.00 for out-of-patient care. The authors estimate that hospitalization cases translated into 175 days of absenteeism for economically active individuals, resulting in estimated productivity losses ranging from R$5652.60 to R$9673.74, depending on income references. Among confirmed out-of-patient care, productivity losses varied from R$20,820.00 to R$312,300.00, depending on income references. The total cost of the illness, including healthcare and societal costs, ranged from R$48,865.18 to R$580,021.54.
Wen et al. (2023)	*Quantitative: Association between ambient temperature and productivity loss* Analyzing data on age, sex, date of death, and the primary cause of death for the working-age population in Brazil. All-cause mortality data was classified according to the Tenth Revision of the International Classification of Diseases (ICD-10). Meteorological data, including temperature and relative humidity, were obtained from the European Centre for Medium-Range Weather Forecasts Reanalysis dataset. PM 2.5 data was estimated using machine learning models that combined information from chemical transport models, meteorological records, and air quality stations. The association between ambient temperature and productivity loss was assessed using a two-stage time-series analysis, with a distributed lag nonlinear model (DLNM) applied to evaluate the relationship. Sensitivity analyses were conducted to test the robustness of the results.	Brazil	The study assesses productivity losses due to non-optimal temperatures in Brazil. They use working-age population (15–64 years), all-cause mortality, meteorological data, and PM 2.5 data. The study estimates Productivity-Adjusted Life-Years (PALYs) lost per 100,000 residents from 2000 to 2019. Results show a significant productivity burden associated with non-optimal temperatures, with variations observed across different geographical areas, age groups, and sexes. The findings highlight the need for tailored policies and adaptation strategies to mitigate the impacts of climate change on labour capacity and social development in Brazil.

Table 2: **Summary of selected publications.**

LAC region instead of single countries/case studies. Given the limited amount of evidence found in the literature search, articles that analysed Latin America were included in the scoping review because South American countries are included in this classification. Restricting search to the South American region only would have reduced the number of selected articles to 16. Only a few articles analysed differential responses by characteristics within a country: four separate the analysis by urban and rural areas and two by gender. Most studies (i.e., 20 out of 23) used quantitative analysis, and only two studies used mixed methods (quantitative and qualitative).

Type of methods used in economic research

The methods used in the economic analyses, the studies' location, and the main findings of the selected articles are presented in Table 2. More than half of the studies use simulation methods such as Computable General Equilibrium (CGE), Integrated Assessment Models of Climate Change (e.g., FUND model), Life-Cycle Assessment (LCA), uncertainty propagation methods, Disability Life Years Lost (DALYs), among others.[15–37,39] These models estimate baseline scenarios (or business-as-usual) and compare them to simulated policy scenarios, changes in technology, or other counterfactual scenarios to examine how climate change, deforestation rates, or carbon dioxide (CO_2) emissions impact economic outcomes through changes in health, land use patterns or other channels. For example, the Climate Framework for Uncertainty, Negotiation, and Distribution (FUND) model explicitly assesses the health cost contribution to estimates of the social cost of carbon dioxide (SC-CO_2).[18,19] Furthermore, these models forecast relevant variables' trajectories for up to 100 years using baseline estimations and the embedded dynamics in the structure of the model.

The rest of the selected articles identify correlations or associations between the variables of interest by estimating regression models. Most use Ordinary Linear Squares (OLS) and time series analyses.[21,23–25,31,33] Others use Linear Probability Models (LPM) or Probit Models to predict the probabilities of the occurrence of specific outcomes.[24,26] Only two articles properly identify a causal relationship between climate risks (e.g., droughts, extreme rainfall and temperature) and human health, labour productivity, or welfare outcomes.[27,28] Two studies use valuation techniques such as cost of illness and willingness to pay (WTP) to analyse the relationship between climate and dengue fever incidence,[29,34] and another study reviews the literature to construct a cost-effectiveness index for different intervention programs in developing countries, including some South American countries.[30] To estimate related economic costs, two follow an accounting approach to identify illnesses and resulting hospitalizations associated with climate events

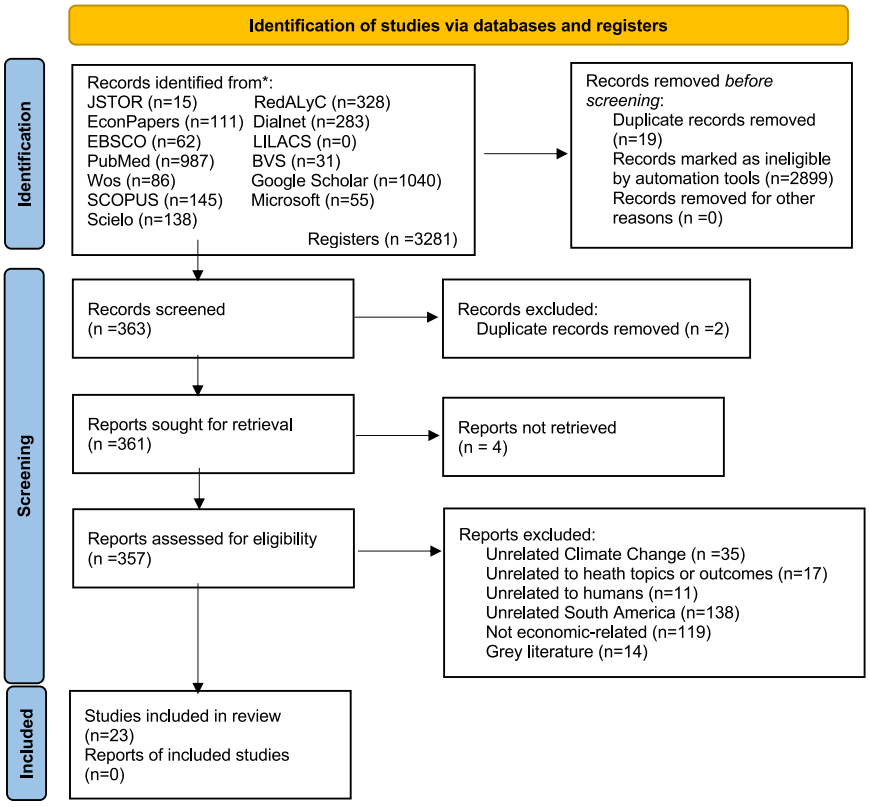

Fig. 1: Flowchart of scoping review selection process.

or health infrastructure damages due to extreme weather events.[32,34]

The effects of climate change on health outcomes and related costs

Climate change is directly and indirectly associated with rising temperatures and increased risks of extreme weather events such as heat waves, droughts, wildfires, floods, pollution, and ecosystem disruptions. Many of these hazards have been related to health impacts and their implied economic costs, and there is a thin but growing literature documenting them in South American countries. These weather events threaten, among others, agricultural yields, production losses, access to drinking water, and the capacity to generate electricity since most countries in the region rely on hydroelectric power.[26] In turn, these threats, directly and indirectly, affect health through food security and undernourishment, mortality and morbidity from cardiovascular stress, respiratory illness or increased proliferation of vector and water-borne diseases.

Health impacts have associated economic costs at the individual and macroeconomic levels. These impacts are monetized into economic costs through measures such as years of life lost, the value of statistical life, quality-adjusted life years (QALYs) or disability-adjusted life years (DALYs), welfare losses, lost income, reduced labour productivity, lower educational attainment, and at the macro level, economic growth, or gross domestic product (GDP), and consumption. Beyond the economic costs of health impacts, coping with these adverse effects of climate change requires additional private and public spending on adaptation policies that could be adaptive or reactive. Fig. 2 summarizes this conceptual framework and links the health impacts of climate change to the associated economic and adaptation costs.

Economic impacts from adverse health outcomes represent 4.4% of the current SC-CO_2 in middle-income countries, including South American countries. 7.2% of these health impacts are attributable to diarrhoea mortality and morbidity.[18] Aggregate estimates for Chile indicate that mortality costs of climate change could be equivalent to 3.2% of GDP and 0.9% of health-related costs.[37] These estimates provide a broad sense of climate change's health costs but ignore that the effects are heterogeneous within the region. Though the literature has identified some of the associated health effects in South American countries, evidence of the related economic costs is thin. Scientific evidence in South America is limited to a few case studies, mainly in Brazil and Chile. Impacts and associated economic and

Study characteristics	Number (n=); included articles, n (%)	Article number in references
Income status		
Upper-middle income	21 (91.3)	15–35
High income	2 (8.7)	36,37
Geographical area		
Latin America	7 (30.4)	15,17,19,22,26,28,29
South America	3 (13.0)	18,20,30
Brazil	8 (34.8)	16,21,23,31–35
Argentina	1 (4.3)	25
Chile	2 (8.7)	36,37
Ecuador	1 (4.3)	27
Peru	1 (4.3)	24
Study setting		
Urban	7 (30.4)	19,23,25,29–31,33
Rural	2 (8.7)	21,28
Both	4 (17.4)	16,22,26,27
Not given	10 (43.5)	15,17,18,20,24,32,34–37
Study method type		
Quantitative	20 (87.0)	16–24,26–31,32–36
Mixed methods	2 (8.7)	15,25
Systematic or literature review	1 (4.3)	37
Results disaggregated by sex		
Yes	4 (17.4)	24,27,31,35
No	19 (82.6)	15–23,25,26,28–30,32–34,36,37
Language		
English	19 (82.6)	15–31,35,36
Spanish	1 (4.3)	37
Portuguese	3 (13.1)	32–34

Table 3: **Characteristics of the original articles included.**

adaptation costs are summarized below by type of weather event.

Droughts and fires

Most of the available literature on South America focuses on the health and related economic impacts of droughts. Droughts affect agricultural yields and drinking water access, increasing infant mortality, lowering birth weight, and shortening gestational periods.[21,28] Rocha and Soares find that in Northeast Brazil, mortality effects are explained by malnutrition and intestinal infections, which are minimized when local health infrastructure, such as piped water and sanitation, is sufficiently developed. Considering infant mortality's impacts, the authors find that universalizing piped water and sanitation is cost-effective as a preventive strategy to adapt to climate change.[28]

Droughts also increase the probability of fire events which translates into direct and indirect effects on health and subsequent economic costs. Using data from the Acre State in the Brazilian Amazon, Campanharo et al. show that following the 2010 ENSO-El Niño related droughts, the total area affected by forest fires was approximately 16 times that of a typical year.[21] Direct costs of these fires include infrastructure damages and agricultural losses due to crop reestablishment and affections on future production. Indirect costs are related to increased carbon dioxide (CO_2) emissions and respiratory morbidities likely explained by increased exposure to particulate matter. These losses account for approximately 7% of Acre's gross domestic product (GDP).[21]

Significant sustained dry events harm labour market outcomes such as the probability of being employed, hourly wages, hours worked, and income in Latin American cities.[26] Desbureaux et al. find that small dry shocks decrease employment by 0.4% and more significant shocks, sustained over two months, by 1.5% compared to "normal" precipitation periods.[26] Informal workers are impacted the most. Two mechanisms mainly explain these effects: (*i*) droughts impact health outcomes and, in turn, workers' productivity, and (*ii*) power outages affect companies and production since most countries rely on hydroelectric power.

This climatic risk also affects human capital accumulation and potential economic costs. However, the regional evidence is limited to a case study in Peru, which identifies a correlation between education

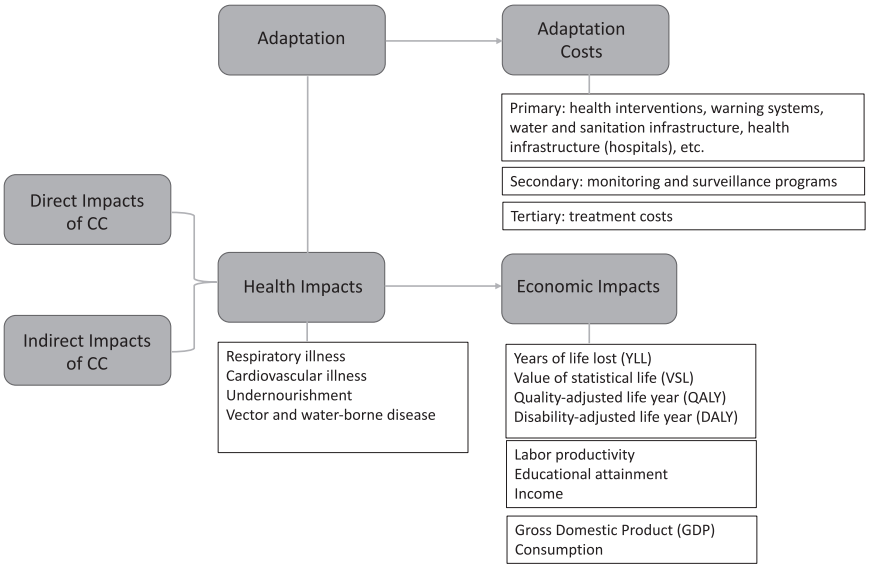

Fig. 2: Conceptual framework of the pathway of the health-related costs of climate change from the literature reviewed.

outcomes and droughts. Zamand and Hyder suggest that exposure to droughts negatively affects educational attainment, cognitive development, and health outcomes in Peru's children aged 14–16.[24] For instance, performance in the Peabody Picture Vocabulary Test (PPVT) is significantly lower for those who report experiencing a dry event.

Temperature

Increasing temperatures and heat waves are associated with worse health, human capital accumulation, and labour market outcomes.[16,17,27,31,33] For instance, Fishman et al. find that in Ecuador, higher temperatures in-utero lead to lower educational attainment and adult earnings. An increase of 1 °C in average monthly temperature while in-utero translates into a 0.7% decline in adult earnings, with somewhat more significant effects for women.[27] Bakhtsiyarava et al. find that higher temperatures decrease birthweight in cities in Brazil, which could potentially be related to lower earnings and high school graduation rates.[31,39]

Losses in labour productivity and working hours have also been associated with rising temperatures.[17,35] Using Brazilian data, Wen et al. find that non-optimal temperatures reduce productivity measured as Productivity-Adjusted Life-Years (PALYs) lost per 100,000, especially in working men.[35]

Takakura et al. estimate the cost of prevention of heat-related illness using worker breaks in a simulation exercise for the world and Latin America, including South American countries. They calculate the decline in working hours using the recommended work/rest ratio and index of heat stress under four different climate change scenarios—the implied GDP losses by 2100 in Brazil and the rest of Latin America range from –0.02% to –3.04% and –0.09% to –1.76%, respectively.[17]

Increasing temperatures have also been linked to the proliferation of infectious diseases by increasing habitat suitability, such as dengue and malaria in Brazil, resulting in worse health outcomes and reduced labour endowments.[16] Pattanayak et al. find that effects are more severe in places with higher levels of deforestation and show that forest conservation can mediate the health impacts of climate change.[16]

Natural disasters

Climate change is expected to affect the precipitation and temperature of the atmosphere and oceans, which can impact the frequency of extreme weather events and natural disasters such as hurricanes, droughts, wildfires, flooding, and high winds.[1,32] Beyond the direct impacts of natural disasters on health, they could have detrimental effects on infrastructure that contributes to and protects human health, such as sanitation, hospitals, and roads. The literature search identified two papers in Brazil, one quantifying the health costs attributed to dengue cases associated with a natural disaster in Nova Friburgo in 2011, and the other on health-related infrastructure losses of different types of natural disasters.[32,34] The first paper estimates that dengue-related hospitalization cases translated into 175 days of absenteeism for economically active individuals, resulting in estimated productivity losses ranging from R$5652.60 to R$9673.74, depending on income references. Among confirmed out-of-patient care, productivity losses varied from R$20,820.00 to R$312,300.00, depending on income references. The total cost of the illness, including

healthcare and societal costs, ranged from R$48,865.18 to R$580,021.54.[34]

Freitas et al. link types of disasters to losses in healthcare facilities in Brazil. Climatological disasters (droughts, forest fires, cold spells) were the most common, accounting for 56.2% of occurrences, followed by hydrological (floods, landslides) (34.9%), meteorological (thunderstorms, hailstorms, windstorms) (8%), and geological (landslides) (0.9%) disasters. Though climatological events were the most common disaster, they represented only 0.3% of total estimated costs. Hydrological disasters accounted for 88.5% of the total costs, particularly 3.2–3.6 times costlier than other disasters. Though it is difficult to compare to other settings because of the lack of estimates, they shed light on possible response and adaptation strategies for the region.[32]

Pollution

High levels of air pollution negatively impact human health, causing respiratory illness and increased morbidity. Bell et al. estimate the economic burden of air pollution in three Latin American cities: Mexico City (Mexico), Santiago (Chile), and São Paulo (Brazil).[29] Using two emissions scenarios, annual ozone levels and historical particulate matter (2000–2020), they find that an air pollution control policy would have extensive health benefits in the three cities. The policy would prevent adverse health outcomes, including over 156,000 deaths, 4 million asthma attacks, 300,000 children's medical visits, and almost 48,000 cases of chronic bronchitis in the period studied. The economic value of averted health impacts is roughly 21–165 billion USD.[29]

Adaptation

To cope with the adverse health effects of climate change, relevant stakeholders can undertake adaptation measures, including policies, practices, and projects aimed at moderating or preventing damages. Actions in the public health sector are classified into three categories[30]: Primary actions include health interventions to prevent damage like warning systems, water, sanitation programs, and infrastructure. Measures such as monitoring and surveillance programs to detect diseases are termed secondary. Tertiary programs aim to reduce the health impacts that have already occurred.[30] However, these strategies are costly, and understanding the economic costs is relevant to inform policy design and decision-making. It is imperative to know what damages could be avoided through adaptation and what is the cost-effectiveness of the proposed programs.[30]

Given the relevance of these costs, there is a need for more evidence of their magnitude in South America. The reviewed articles estimate costs worldwide, with some separating the analysis at the regional level, including Latin America. Moreover, only a few articles relate climate change to health adaptation costs, and most of them instead rely on estimating the costs of health interventions targeted at diseases that can respond to the weather.[22] Markandya and Chiabai summarise the available information and conclude that there is a lack of studies measuring costs.[30] A significant limitation to the development of these studies is the need for more appropriate data, especially in the developing world.

Regarding health interventions related to disease incidence, Ebi estimated the costs of treating additional cases of malnutrition, diarrheal disease, and malaria attributed to climate change by 2030. They use current treatment costs, assume no population or economic growth, and that no adaptation measures are undertaken. Worldwide, estimates range between 4–12 billion USD in 2000 and 50–518 million USD for diarrhoea and malaria (the two account for most of the costs) in Latin America for that same year. They conclude that these three diseases pose significant risks for future populations, particularly in low-income countries in tropical and subtropical regions that will bear high costs. Mitigating emissions could reduce the costs of treating these diseases by as much as 49% in the most stringent scenario.[22]

Evidence suggests that the costs of climate change without adaptation measures are much higher than costs with adaptation opportunities. Additional analyses are needed to determine which adaptation strategy is the most cost-effective. However, there is some evidence for developing countries that the cost per life saved seems to be smaller for cases of diarrhoea related to climate than for cases of malaria.[22] Investments in water and sanitation, essential to avoid diarrhoea, can result in lower costs per case.[22] This is consistent with the results of Rocha and Soares for Brazil, which find that universalizing piped water and sanitation is cost-effective as a preventive strategy to adapt to climate change.[28]

Tol et al. also tests if development aid is more effective in reducing the impacts of climate change than greenhouse gas emission reductions. Using a multi-region simulation based on the FUND model, the author finds that investing in development, particularly aid that targets vector-borne infectious diseases in poorer countries, is a better strategy for reducing the impacts of climate change than greenhouse gas emission reduction. These investments reduce vulnerabilities in some sectors, such as infectious diseases, water resources, and agriculture. Latin America and Africa are the regions in which this appears to be the case.[19]

Alternatively, Takakura et al. estimate the economic costs for workplace heat-related illness prevention through worker breaks under various climate scenarios and socioeconomic conditions. Even though breaks protect workers' health, they reduce work time, which is economically costly. Under a high-emissions scenario (RPC 8.5), GDP loss is expected to range between 2.6% and 4.0% of global GDP in 2100. In Brazil and the rest

of Latin America, these costs range from 0.31% to 3.4% and 0.86% to 1.76% of GDP, respectively. Construction and primary sectors are the most affected. Socioeconomic development and climate mitigation can reduce these costs. Even if temperature increases are limited and socioeconomic development is achieved, costs are non-negligible due to outdoor work. The authors conclude that adaptation measures that can be applied to outdoor work should be quantitatively investigated.[17]

Discussion

This scoping review assesses the current evidence on the health impacts of climate change and associated economic costs in South American countries. Only 23 articles met the inclusion criteria of the systematized search strategy and were synthesized. Of these articles, ten analysed the region as a whole or included in the LAC region analysis, and the rest were mainly confined to two countries: Brazil and Chile. More than 80% of research in the region is produced in English, followed by papers in Portuguese that focus almost entirely on small case studies in Brazil. Literature in Spanish is mainly grey literature, which was not included in the scoping review. The limited evidence suggests that the health effects of climate change will be costly for South America. However, knowledge gaps were identified on the health impacts of a broad range of extreme weather events, their economic costs, heterogeneous effects within the region, and causal identification.

Most of the reviewed literature estimates impacts and economic costs from droughts and fires, and a handful on the effects of extreme temperature. These events were associated with GDP, agricultural production, and infrastructure losses at the macro level and reduced labour outcomes and educational attainment at the individual level. Evidence on the impacts and costs of excessive rainfall and floods was not identified in this systematic search, even though changes in precipitation patterns are expected in many Andean countries. Health costs of pollution and ecosystem disruptions were also limited but worth exploring in a region with increasing urbanization rates and high levels of deforestation. Also, no studies evaluating the health costs of coastal impacts due to increased storms and sea level rise were identified in a region where large communities live in this area and depend on the sea for their livelihood.

The included studies did not separate analysis by urban and rural divide, estimate impacts at the subnational level, by gender, age groups, or other socioeconomic characteristics, which could be relevant for understanding the cost of health effects that can vary significantly across and within countries. Quantitative methods mainly identified correlations between the variables of interest rather than causal impacts. The lack of appropriate data such as longitudinal or health surveys, vital statistics, morbidity outcomes, pollution measures, and the challenges inherent in causal identification likely explain why such analyses still need to be addressed in this literature.

Coping with the adverse health effects of climate change requires adaptation measures that need financial resources and planning, including policies, practices, and projects to moderate or prevent damages. Data availability limits the number of specific analyses for the region or included in LAC, hindering the identification of cost-effective strategies. However, evidence suggests that investments in water and sanitation infrastructure could be cost-effective as a preventive strategy to adapt to climate change in LAC. Moreover, outdoor workers were identified as being at risk; breaks could ameliorate health effects, but other adaptation opportunities that can be applied to outdoor work should be investigated. Further research, however, was identified as essential to guiding actions in South America, where income inequalities and weak healthcare systems may limit adaptive capacity.

This scoping review identified several gaps the warrant future research. Given the threats related to rising temperatures, the multiple extreme weather events associated with most climate change scenarios (e.g., droughts, floods, fires, heat waves), pollution, and ecosystem disruptions, it is vital to understand and quantify, first and foremost, the health impacts and related economic costs. Though several articles document the effects of temperature on health outcomes such as mortality or the incidence of specific types of disease, most of them do not translate these effects into their corresponding economic costs, which are important in tailoring adaptation policies and cost-benefit analyses. This is partly why so few articles were included in the scoping review.

Further research in this area is important, especially in a region that is particularly vulnerable to climate change and currently faces some challenges that could exacerbate health outcomes and costs, particularly in vulnerable populations.[4–6,9–12] The expected health impacts of climate change are likely to increase demand for health services, and therefore, monitoring healthcare costs, availability, and expansion is needed. It is, therefore, crucial to understand the cost-effectiveness of policies addressing the health effects of climate change, the benefits, costs, adaptation opportunities, and the ability to fund them.

Contributors

All authors contributed to the overall paper structure and concepts. JH, OM, and IR designed the search strategy. IR did the literature search and organized the references. JH, OM, IR, CP, and LO reviewed the literature and did the analysis. JH, IR, and CP wrote the first draft of the manuscript, to which all authors contributed. JH and OM reviewed the draft and produced the final version.

Declaration of interests

The authors declare no competing interests.

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Appendix A. Supplementary data

Supplementary data related to this article can be found at https://doi.org/10.1016/j.lana.2023.100606.

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