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Climate Risk in Local Health Services in Ecuador

Riesgo Climático en los Servicios de Salud Local en Ecuador

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Abstract

This work analyzes the interaction between climate risk, caused by extreme events resulting from the El Niño-Southern Oscillation (ENSO) and/or Climate Change, and its impact on local health services in Ecuador. The analysis focuses on Ecuador's growing vulnerability to the effects of climate change, which exacerbates challenges in the delivery of health services, particularly in the context of severe climate events. The main objective is to analyze the relationship between the number of hectares affected by climate events and the availability and effectiveness of local health services, considering community resilience and health coverage as moderating variables. The methodology uses a linear regression analysis using data from 221 Ecuadorian municipalities, covering variables such as climate risk, health services, community resilience, health coverage, and demographic and socioeconomic factors. The results indicate a significant influence of climate risk on the effectiveness of health services, moderated by community resilience and health coverage. It is observed that areas with greater preparation and health coverage show a better capacity to respond to extreme weather events. Finally, it is important to integrate climate risk management into health services planning, suggesting that greater community resilience and broad health coverage are essential to mitigate the negative impacts of climate change on public health.

Keywords: Climate Risk; Health services; Resilience, Ecuador.

Resumen

El presente trabajo analiza la interacción entre el riesgo climático, originados por eventos extremos producto del fenómeno El Niño-Oscilación del Sur (ENOS) y/o Cambio Climático, y su impacto en los servicios de salud local en Ecuador. El análisis se centra en la creciente vulnerabilidad de Ecuador a los efectos del cambio climático, que exacerba los desafíos en la prestación de servicios de salud, particularmente en el contexto de fenómenos climáticos severos. El objetivo principal es analizar la relación entre el número de hectáreas afectadas por eventos climáticos y la disponibilidad y eficacia de los servicios de salud locales, considerando la resiliencia comunitaria y la cobertura sanitaria como variables moderadoras. La metodología emplea un análisis de regresión lineal utilizando datos de 221 municipios ecuatorianos, abarcando variables como riesgo climático, servicios de salud, resiliencia comunitaria, cobertura sanitaria, y factores demográficos y socioeconómicos. Los resultados indican una influencia significativa del riesgo climático en la eficacia de los servicios de salud, moderada por la resiliencia comunitaria y la cobertura sanitaria. Se observa que las áreas con mayor preparación y cobertura sanitaria muestran una mejor capacidad de respuesta ante eventos climáticos extremos. Finalmente, es importante integrar la gestión del riesgo climático en la planificación de servicios de salud, sugiriendo que una mayor resiliencia comunitaria y una amplia cobertura sanitaria son esenciales para mitigar los impactos negativos del cambio climático en la salud pública.

Palabras clave: Riesgo Climático; Servicios de Salud; Resiliencia, Ecuador.

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1 Introduction

Climate change constitutes a significant global challenge. Combined with natural climate variability events, such as the El Niño Southern Oscillation -ENSO-, it has dramatic effects on populations, especially in Latin America and Ecuador (García-Parra et al., 2022). ENSO, characterized by the warming of the Central Pacific Ocean, has important repercussions on global weather patterns, causing extreme meteorological events (Alatrista-Salas et al., 2021). In Ecuador, these events manifest through increased rainfall, floods, and droughts, directly impacting agriculture, healthcare services, and infrastructure. Additionally, indirect effects include injuries, diseases, deaths, significant economic losses, and mental health consequences for affected individuals (Toulkeridis et al., 2020).

Thielen et al. (2023) and Hidalgo et al. (2024) detail the impact of ENSO extreme events on Ecuador's precipitation, highlighting the region's increased vulnerability to such climatic anomalies. Furthermore, Rollenbeck et al. (2022) provide a meteorological radar analysis of the 2017 coastal ENSO event, emphasizing the severe challenges faced by Ecuador and Peru.

For the purposes of this study, climate risk is defined as the likelihood of extreme weather events, such as floods and droughts, negatively impacting natural and human systems, exacerbating existing vulnerabilities (Field and Barros, 2014). These risks are assessed in terms of their frequency, magnitude, and the extent of damage caused.

In this context, healthcare services primarily refer to the healthcare infrastructure, including the availability of health facilities, their operational capacity, and population accessibility (Hahn, 2019). This encompasses hospitals, clinics, and other care centers integral to the local health system and its ability to provide preventive, care, and emergency services (Phillips, 2005). The focus is not on the quality of individual care or specific public health programs but on the overall availability and responsiveness of the healthcare infrastructure (Moyo et al., 2023).

In Ecuador, health facilities are classified into four levels of care and complexity. The first level includes basic health centers. The second level covers basic hospitals with limited specialized services. The third level consists of general hospitals with a wide range of specialties. The fourth level comprises specialty hospitals and high-complexity centers, offering advanced and specialized care (Ron et al., 2018).

Ecuador's healthcare services face significant challenges due to extreme weather events, exacerbated by the ENSO (Barberán et al., 2019). These events have direct and indirect impacts on public health in Ecuador. For example, increased rainfall and flooding can lead to outbreaks of waterborne diseases, while droughts can affect food security and nutrition (Thielen et al., 2023). Ecuador's healthcare services, already strained by limited resources, struggle to respond to these climate-induced health crises.

Rollenbeck et al. (2022) highlight the profound impact of extreme ENSO events on Ecuador's precipitation patterns, emphasizing the urgency for healthcare services to adapt to these changing climatic conditions. Therefore, it is important to study climate risk in local healthcare services in Ecuador to improve understanding of the implications for health economics and climate risk management (Fernandez et al., 2015).

The intersection between climate risk and healthcare delivery in Ecuador represents a critical yet underexplored research area (Subía-Cabrera and Subía-Cabrera, 2022). Despite acknowledging the broad impacts of climate change on public health, few specific studies examine how these changes affect healthcare delivery in the country (Vaccaro Witt et al., 2023). This gap is significant, given Ecuador's vulnerability to climatic events like ENSO, which can drastically alter disease patterns, healthcare needs, and the overall demand for health services (de Guenni et al., 2017).

This study would not only contribute to the academic knowledge but also provide practical insights for policymakers and health service planners in Ecuador. Therefore, the following research questions arise: How does ENSO specifically alter the demand for health services in different regions of Ecuador? How are the capacity and distribution of health services in Ecuador affected by extreme weather events associated with ENSO?

The conceptual foundations exploring the nexus between health services and climate risk are based on a multidisciplinary approach, combining insights from environmental health, health economics, and disaster risk management. Environmental health theories elucidate the direct and indirect pathways through which climate change affects health outcomes, emphasizing the role of environmental determinants in shaping health vulnerabilities (McMichael et al., 2003). Health economics models, such as the supply and demand framework, are fundamental for analyzing how climate-induced health risks alter the demand for health services and the corresponding adjustments needed in service delivery (Phillips, 2005). Additionally, disaster risk management theories offer frameworks for understanding the resilience and adaptive capacities of health systems in the face of climate risks, highlighting the importance of preparedness, response, and recovery phases to mitigate the impact of climate-related health emergencies (Paton and Johnston, 2017).

The relationship between health services and climate risk in Ecuador, particularly under the ENSO, has provided valuable insights but also presents several limitations (Arjona et al., 2016). Methodologically, many studies rely on retrospective analyses of health outcomes and climate patterns, which may not adequately capture the complex, bidirectional interactions between climatic events and health service responses (Gutierrez et al., 2020; Sorensen et al., 2017; Thielen et al., 2023). The objective of this study is to evaluate the climate risk on health services in Ecuador, focusing on how the effects of ENSO influence the demand for services in different cities.

2 Materials and Methods

ENSO significantly impacts public health in Ecuador, increasing the prevalence of waterborne diseases, respiratory infections, and vector-borne diseases such as dengue, malaria, and cholera (Sorensen et al., 2017). Vulnerable rural populations face barriers to accessing healthcare due to displacement and economic hardships (Díaz-Vélez et al., 2020). Additionally, there are disparities in the accessibility and quality of health services between urban and rural areas, exacerbated by socioeconomic factors (Gutierrez et al., 2020; Liu et al., 2023). Therefore, it is necessary to improve emergency preparedness, enhance disease surveillance and response mechanisms, and integrate climate risk assessments into the planning and delivery of healthcare services (Schwartz et al., 2023). In this context, the following hypothesis is proposed: *H1*: Climate risk significantly affects local health services in Ecuador.

2.1 Community Resilience

Community resilience to natural disasters and climate change encompasses a wide range of concepts and measures, focusing on the capacity of communities to anticipate, prepare for, respond to, and recover from adverse situations. This resilience is built on several pillars, including robust infrastructure, effective local governance, social cohesion, and economic diversification (Aldrich and Meyer, 2015). Community resilience measures often involve assessments of these pillars, along with the capacity for adaptive learning and the implementation of sustainable environmental management practices (Patel et al., 2017; Pacheco-Peña et al., 2023).

Examples of municipal strategies to increase resilience to ENSO include the development of early warning systems, the construction of flood-resistant infrastructure, and the establishment of community emergency response teams (Vilema and Mendoza, 2014). In Ecuador, municipalities have engaged in reforestation projects to reduce landslide risks and have implemented water management strategies to address the challenges posed by both excess water during heavy rains and water scarcity during droughts (Vilema and Roman, 2018).

Additionally, the implementation of local public policies on resilience and the effectiveness of health service responses have considered integrating a health approach into broader municipal planning for disaster risk reduction and climate adaptation (Arjona et al., 2016). Studies have shown that municipalities prioritizing the resilience of health services in their planning processes experience fewer disruptions in healthcare delivery and can provide more effective responses to public health emergencies induced by the ENSO (Gutierrez et al., 2020; Sorensen et al., 2017; Vilema et al., 2017; Vilema and Mendoza, 2014). Therefore, the following hypothesis is proposed: *H2*: Community resilience moderates the effect between climate risk and local health services in Ecuador.

2.2 Health Coverage

Comprehensive health coverage plays a fundamental role in enhancing the resilience of vulnerable populations to the impacts of climate change. Effective health coverage can reduce these populations' exposure to climate-related health risks by improving access to preventive care, emergency services, and disease management programs (Moyo et al., 2023). Additionally, integrating climate change considerations into health coverage policies can guide the development of specific interventions aimed at reducing health disparities and improving public health preparedness for the effects of climate change (Ansah et al., 2021).

Comprehensive health coverage ensures timely access to health services, thereby reducing morbidity and mortality associated with climate-induced health problems (Gutierrez et al., 2020). For instance, during the 1997-1998 ENSO episode, areas with extensive health coverage in Ecuador were able to provide more effective disease surveillance, early warnings, and timely interventions, significantly reducing adverse health outcomes associated with the episode (Thielen et al., 2023).

This coverage included the establishment of mobile health units, the stockpiling of essential medications, and the training of healthcare workers on climate-related health risks (Patel et al., 2017; Rollenbeck et al., 2022). Therefore, the following hypothesis is proposed: *H3*: Health coverage moderates the effect between climate risk and local health services in Ecuador.

2.3 Geographic Diversity

The importance of geography in the planning and delivery of health services in the face of climate risks cannot be underestimated. Geographic considerations are crucial for developing tailored health service delivery models that address the specific vulnerabilities of each region (Fernandez et al., 2015; Vilema and Mendoza, 2014). For example, coastal areas may require robust infrastructure to withstand flooding, while mountainous regions might benefit from enhanced food security programs to prevent malnutrition during ENSO events (Gutierrez et al., 2020; Thielen et al., 2023). Thus, incorporating geographic diversity into health service planning allows for the development of adaptive strategies that are sensitive to the distinct needs and vulnerabilities of different regions (Schwartz et al., 2023).

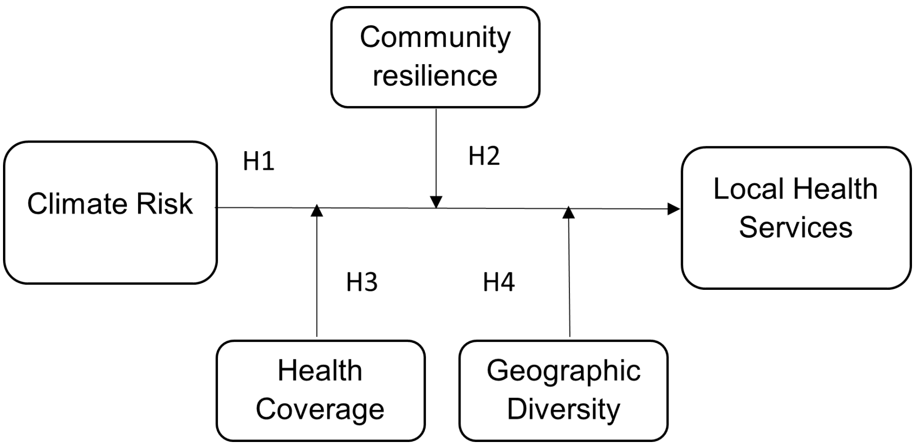

Figure 1. Research model.

Geographic factors in Ecuador significantly influence the relationship between health services and climate risk, highlighting the importance of spatial analysis to understand vulnerability and response capacity (Vilema et al., 2024). Gutierrez et al. (2020) mention that higher altitude areas face different challenges compared to coastal regions, including variability in temperature and precipitation patterns that affect disease vectors differently.

Díaz-Vélez et al. (2020) note the spatial correlation between ENSO-induced climate anomalies and outbreaks of climate-sensitive diseases such as malaria and dengue. Therefore, the following hypothesis is proposed *H4*: Geographic diversity drives the effect between climate risk and local health services in Ecuador.

To analyze the influence of climate risk on local health services in Ecuador, data from the country's 221 municipalities are used, considering various information sources and years. Table 1 presents the study variables used to test the hypotheses, and the following linear regression equation is proposed.

$$\text{services}_i = \beta_0 + \beta_1 \text{risk}_i + \beta_j \sum_{n}^{j=2} \chi_i + \beta_k \sum_{n}^{j=2} Z_k + \varepsilon \quad (1)$$

In Equation 1, the proposed statistical model is shown, where, services_i is the dependent variable local health services in canton i. risk_i is the independent variable climate risk of city i. $\sum_n^{j=2} \chi_i$ is a set of moderating variables for city i is (community resilience and health coverage). $\sum_n^{j=2} Z_k$ is a set of control variables for city i (population, per capita income, coastal, highlands, Amazon). $\beta_0, \beta_1, \beta_j, \beta_k$ are the regression coefficients representing the relationship between the variables. And ε the error term, capturing the variation not explained by the independent variables.

The participation of local health services in the city is an indicator that highlights the health sector's contribution to the overall economy, providing information on the importance of resource allocation, efficiency, and the sector's capacity to respond to health crises, including those exacerbated by climate risks (Phillips, 2005). Analyzing investments in the health sector correlates with improvements in accessibility, quality, and distribution of health services, crucial factors for mitigating the impacts of climate change on public health (Moyo et al., 2023).

On the other hand, the indicator of hectares affected by hazardous events due to increased precipitation and temperature serves as a critical measure for assessing climate risk. This metric quantitatively captures the extent of environmental and agricultural damage, directly reflecting the increased vulnerability and exposure of ecosystems and human settlements to climate-induced hazards (Field and Barros, 2014).

In evaluating the study's hypotheses, the variability in data quality across different municipalities is considered, as it could influence the study's results. This disparity in data quality could be due to differences in monitoring and reporting capacity for climate and health events among municipalities. Municipalities with better recording and monitoring systems may provide more accurate and comprehensive data, while those with limited resources may have less reliable data. This difference in data quality is accounted for in the analyses and mitigated by using multiple data sources and applying robust statistical techniques to control for potential biases and variations.

3 Results and Discussion

Table 2 presents descriptive statistics crucial for understanding the impact of climate risk on the delivery of local health services in the Ecuadorian context. The data reveal that, on average, the gross value added (GVA) of local health services, expressed in thousands of dollars, is 5.078, with a standard deviation of 6.362, indicating significant variability among cities in terms of the economic contribution of health services to the total GVA of the city.

Regarding climate risk, measured by the number of hectares affected by hazardous events related to increased precipitation and temperature between 2010 and 2020, the mean is alarmingly high, with 4 225.756 hectares affected and a standard deviation of 27 179.89, highlighting the extreme variability and significant impact of these events in the country. Community resilience, assessed through the municipal operational capacity index, shows an average of 17.279 with a standard deviation of 3.835, reflecting differences in emergency response capacity. Health coverage, measured by the number of health establishments, has a mean of 14.185 and a standard deviation of 2.034, evidencing discrepancies in the availability of health services.

Table 1. Study variables.

CODE	DESCRIPTION	MEASUREMENT	SOURCE
Services	Local health services. - measured by the share of the Gross Value Added (GVA) of the health economic branch in the Total Gross Value Added of the city in 2020.	Thousands of dollars	Regional Accounts - (Banco Central del Ecuador, 2022)
Risk	Climate risk. - measured by the number of hectares affected by reported hazardous events due to increased precipitation and temperature during 2010 to 2020.	Hectares	Threat and Hazardous Event Monitoring Report - Secretaría Nacional de Gestión de Riesgos (2022)
Resilience	Community resilience. - Measured by the municipal operational capacity index (2016-2020).	Scores	GAD monitoring and evaluation report - Consejo Nacional de Competencias (2022)
Cover	Health coverage. - measured by the number of health facilities (2020).	Establishment	Health in figures - Ministerio de Salud Pública (2022)
Pop20	Share of the city's population in the total population, projection to the year 2020.	Inhabitants	Population projections 2010- 2020 - Instituto Nacional de Estadística y Censos (2022)
Ingpc	Per capita income in the city. - GVA / Population (2020)	Thousands of dollars per capita	Regional Accounts - Banco Central del Ecuador (2022)
Coastline	Coastal region	1 = yes ; 0 =no	Population and Housing Census - INEC (2022)
Highland	Highlands region	1 = yes ; 0 =no	
Amazon	Amazon region	1 = yes; 0 =no	

Table 3 presents a linear regression analysis to evaluate the impact of climate risk, measured by the number of hectares affected by hazardous events, on local health services, represented by the share of the Gross Value Added (GVA) of health in the local economy. The results demonstrate a statistically significant negative relationship between climate risk and local health services, both in the model without control variables (coefficient = $-1{,}57 * 10^{-5}, p < 0{,}01$) and in the model with control variables (coefficient = $-1{,}36 * 10^{-5}$, $p < 0{,}01$).

This finding suggests that an increase in hectares affected by hazardous climate events is associated with a decrease in the economic contribution of the health sector at the local level. These results provide empirical evidence in support of Hypothesis *H1*, which postulated that climate risk significantly affects local health services in Ecuador. The statistical significance of the climate risk coefficient in both models underscores the relevance of climate change and its adverse effects as a critical determinant of the capacity and efficiency of local health services.

Table 2. Descriptive Statistics.

Variable	Mean	Std. Dev.	Units
Services	5.078	6.362	Miles US $
Risk	4225.756	27179.89	Hectares
Resilience	17.279	3.835	Points
Coverture	14.185	2.034	Establishments
Pop20	0.452	1.534	Inhabitants
Ingpc	3.388	5.094	Miles of US $
Coastline	0.402	0.4915	%
Highland	0.375	0.485	%
Amazon	0.144	0.352	%

Table 4 presents a detailed analysis investigating the moderating effect of community resilience on the relationship between climate risk and local health services. The results indicate that, both with and without controls, climate risk has a significantly negative impact on local health services (coefficients of $-1{,}55 * 10^{-5}$ and $-1{,}35 * 10^{-5}$, respectively, $p < 0{,}001$), highlighting the vulnerability of health services to extreme climate events. However, community resilience, measured by the municipal operational capacity index, did not show a statistically significant moderating effect on this relationship (coefficients of -0.0191 without controls and -0.00539 with controls, $p > 0{,}05$).

These findings provide partial evidence for Hypothesis *H2*, which postulated that community resilience moderates the effect of climate risk on local health services in Ecuador. While climate risk demonstrates a negative effect on health services, the lack of statistical significance in the moderating role of community resilience suggests that other factors may be influencing the capacity of communities to mitigate the impacts of climate risk on health services. Table 5 examines the moderating effect of health coverage on the relationship between climate risk and local health services, contributing to the understanding of how extensive health coverage can mitigate the adverse effects of climate change on healthcare delivery.

The results reveal that, without controls, climate risk has a significant negative effect on local health services with a coefficient of $-1{,}57 * 10^{-5}$ ($p < 0{,}01$), while, with controls, this effect intensifies to $-2{,}14 * 10^{-5}$ ($p < 0{,}01$).

Notably, health coverage emerges as a significant moderator in this context, with a positive coefficient of 0.119 ($p < 0{,}05$) in the controlled model. This finding indicates that greater health coverage helps mitigate the negative impacts of climate risk on health services. Consequently, these results support Hypothesis *H3*, suggesting that effective health coverage plays a crucial role in moderating the adverse effect of climate risk on local health services in Ecuador.

Table 3. Linear regression between local health services and climate risk.

Variables	No controls (1)	With controls (2)
Risk	$-1.57*10^{-5}$***	$-1.36*10^{-5}$***
	($4.64*10^{-6}$)	($4.55*10^{-6}$)
Constant	5.145***	5.055***
	(0.434)	(1.718)
Observations	221	221
R-squared	0.004	0.040

Robust standard errors in parentheses:
*** $p < 0{,}01$, ** $p < 0{,}05$, * $p < 0{,}1$

Table 4. Linear regression of the moderating effect of community resilience between local health services and climate risk.

Variables	No controls (1)	With controls (2)
Risk	$-1.55{*}10^{-5}$***	$-1.35{*}10^{-5}$***
	$(4.77{*}10^{-6})$	$(4.71{*}10^{-6})$
Resilience	-0.0191	-0.00539
	(0.0938)	(0.0972)
Constant	5.475***	5.148***
	(1.661)	(2.194)
Observations	221	221
R-squared	0.005	0.040

Robust standard errors in parentheses:
*** $p < 0{,}01$, ** $p < 0{,}05$, * $p < 0{,}1$

Table 6 presents a pioneering analysis exploring how geographic diversity modulates the impact of climate risk, associated with ENSO, on local health services. The regression model used reveals that climate risk, measured in terms of hectares affected by extreme climatic events, has a significant relationship with the capacity of local health services, adjusted for the geographic influence of the coastal, highlands, and Amazon regions. Specifically, it was found that climate risk increases local health services by 0.0734 units for each unit increase in risk in the coastal region ($p < 0{,}05$), while a similar decrease is observed in the highlands and Amazon regions, indicating a negative relationship between climate risk and health services in these areas.

This finding supports Hypothesis *H4*, which postulated that geographic diversity drives the effect between climate risk and local health services in Ecuador. It indicates that the geographic regions of the country not only differ in terms of their exposure and vulnerability to climate risk but also in how this risk affects the availability and demand for health services.

The results reveal significant interactions between climate risk and the capacity of local health services to respond effectively to emerging needs, particularly in the context of the ENSO. Linear regression analyses indicate that climate risk, measured by the number of hectares affected by hazardous events $(\beta = -1{,}57 * 10^{-5} * **, p < 0{,}001)$, has a significantly negative impact on local health services, confirming Hypothesis *H1*. This underscores the vulnerability of the health sector to extreme climatic changes and events, affecting its operational capacity and emergency response.

Table 5. Linear regression of the moderating effect of health coverage between local health services and climate risk.

Variables	No controls (1)	With controls (2)
Risk	$-1.57{*}10^{-5}$***	$-2.14{*}10^{-5}$***
	$(4.74{*}10^{-6})$	$(4.77{*}10^{-6})$
Coverture	0.000699	0.119**
	(0.0166)	(0.0475)
Constant	5.136***	4.223***
	(0.511)	(1.735)
Observations	221	221
R-squared	0.004	0.063

Robust standard errors in parentheses:
*** $p < 0{,}01$, ** $p < 0{,}05$, * $p < 0{,}1$

Table 6. Linear regression of the geographic diversity effect between local health services and climate risk.

Variables	No controls (1)	With controls (2)
Risk	0.0734*	0.0714*
	(0.0375)	(0.0378)
Risk x Coastal	-0.0735*	-0.0714*
	(0.0375)	(0.0378)
Risk x Highlands	-0.0735*	-0.0714*
	(0.0375)	(0.0378)
Risk x Amazon	-0.0741**	-0.0720*
	(0.0375)	(0.0378)
Constant	5.046***	5.648***
	(0.434)	(0.532)
Observations	221	221
R-squared	0.039	0.057

Robust standard errors in parentheses:
*** $p < 0{,}01$, ** $p < 0{,}05$, * $p < 0{,}1$

The moderating influence of community resilience on the relationship between climate risk and local health services, although not statistically significant in all models ($\beta = -0{,}0191, p > 0{,}05$), suggests a trend towards mitigating the negative impact of climate risk, partially supporting Hypothesis *H2*. This finding highlights the importance of strengthening community resilience as a strategy to improve the response capacity of health services to extreme climatic events.

On the other hand, health coverage shows a positive and significant moderation ($\beta = 0{,}119**, p < 0{,}01$) in the relationship between climate risk and local health services, supporting Hypothesis *H3*. This result emphasizes the crucial role of extensive and accessible health coverage in mitigating the adverse effects of climate risk on public health. Finally, the effects of geographic diversity ($\beta = 0{,}0714*, p < 0{,}05$ for specific regions) corroborate Hypothesis *H4*, indicating that geography plays a determining role in how climate risk affects local health services. Specific regions, such as coastal and Amazonian areas, show significant variations in vulnerability and response capacity, highlighting the need for adaptive and customized approaches in health planning.

4 Conclusions

This study evaluated the impact of climate risk, particularly events associated with ENSO, on local health services in Ecuador. Through a comprehensive analysis of data from 221 municipalities, we revealed how climate variability significantly affects the capacity and distribution of health services. Community resilience and health coverage proved to be significant moderators in this relationship, suggesting that strengthening local response capacity and access to health services can mitigate the negative effects of climate risk. However, geographic differences introduce notable variability in this effect, underscoring the importance of adapting mitigation strategies to the specific characteristics of each region.

Despite these significant findings, the study faced limitations, including variability in data quality among municipalities and the difficulty of capturing the full complexity of health systems and their interaction with climate factors. Future research should explore in greater detail how specific adaptation and mitigation interventions can improve the resilience of health systems to climate change, especially in more vulnerable areas. Additionally, better integration of health and climate data is crucial for developing more accurate predictive models to guide public health planning in the context of climate change.

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Author contribution

S.V.E.: Conceptualization, Data processing, Data curation, Methodology, Visualization, Writing- original draft, Writing- review and Editing; M.M.O.: Conceptualization, Conceptualization, Data processing, Data curation, Methodology, Visualization, Writing- original draft, Writing- review and Editing.

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