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Exploration and measurement of inequities in the occurrence of hospital adverse events in Colombia

Exploración y medición de inequidades en la ocurrencia de eventos adversos hospitalarios en Colombia

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Abstract

What do we know about this topic?

Device-associated infections (DAIs) are preventable adverse events that represent a critical issue for patient safety. These infections, including central line-associated bloodstream infections (CLABSI), catheter-associated urinary tract infections (CAUTI), and ventilator-associated pneumonia (VAP), can be influenced by geographic factors, insurance schemes, sex, and age, leading to differential risks and creating another form of health inequity.

What does this study contribute with?

The study's findings highlight significant inequalities in the distribution of reportable events with undesirable effects such as device-associated infections (DAIs) in Colombia, revealing inequities in patient safety. Significant differences in the incidence rates of events like CLABSI and VAP observed between municipalities and departments reflect the concentration of risks in certain areas, particularly in the Pacific and Eastern regions of the country. This suggests that structural and social factors may be influencing these disparities.

The results emphasize the urgent need to implement strategies that address these inequities, prioritizing the most vulnerable areas and groups, in order to ensure safe and equitable care.

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Introduction: Device-associated infections (DAIs) are preventable adverse events that represent a critical issue for patient safety. These infections, including central line-associated bloodstream infections (CLABSI), catheter-associated urinary tract infections (CAUTI), and ventilator-associated pneumonia (VAP), can be influenced by geographic factors, insurance schemes, sex, and age, leading to differential risks and creating another form of health inequity.

Objective: To explore and measure inequities in patient safety associated with DAIs in Colombia, using data from the SIVIGILA system (2012–2022).

Methods: This observational, analytical study analyzed data on CLABSI, CAUTI, and VAP reported in SIVIGILA. Incidence rates were estimated using random-effects metamodels adjusted for region, year, and device-days. Inequities were formally assessed using coefficients of variation, group deviations, risk differences, and relative risks across comparison groups (region, age group, municipalities).

Results: A total of 750 aggregate reports covering over 49,101 DAI events from 2012 to 2022 were analyzed. CLABSI accounted for 44.4% of events. DAIs were more frequent among men (55.2%), in the contributory insurance scheme (49.3%), followed by the subsidized scheme (42.1%), with only 3% occurring in individuals without affiliation to the general social security system (SGSSS). Mortality associated with these events was 19.9%. Bivariate analyses and metamodels revealed inequities in DAI occurrence, particularly in areas with lower access and resources. DAIs showed disparities across departments, regions, sexes, and age groups. Most municipalities and departments reported rates below 3 cases per 1,000 device-days for CLABSI and VAP, but some departments exhibited risks up to four times higher. CAUTI showed a more homogeneous risk distribution.

Conclusions: The study highlights significant inequities in the occurrence of DAIs in Colombia. These findings underscore the need for regional and targeted strategies to enhance patient safety and reduce disparities in healthcare.

Keywords: Device-associated infections; Patient safety; Equity in health; Adverse events; Inequity.

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Resumen

Introducción: Las infecciones asociadas a dispositivos (IAD) son eventos adversos prevenibles que representan un problema crítico en la seguridad del paciente. Estas infecciones, como la infección del torrente sanguíneo asociada a catéter (ITSAC), la infección sintomática del tracto urinario asociada a catéter (ISTUAC) y la neumonía asociada a ventilador (NV), pueden estar influenciadas por factores geográficos, régimen de aseguramiento, por sexo y por edad, lo que favorece riesgos diferenciales y genera otra forma de inequidad en salud.

Objetivo: Explorar y medir inequidades en la seguridad del paciente asociadas a IAD en Colombia, utilizando datos del sistema SIVIGILA (2012-2022).

Métodos: Estudio observacional, analítico, basado en datos de ITSAC, ISTUAC y NV reportadas en SIVIGILA. Se estimaron tasas de incidencia mediante metamodelos de efectos aleatorios, ajustando por región, año y días-dispositivo. Las inequidades fueron analizadas formalmente con coeficientes de variación, desviaciones entre grupos, diferencias de riesgos y riesgos relativos entre grupos de comparación (región, grupo etario, municipios).

Resultados: Se revisaron 750 reportes de datos agregados para los eventos de IAD entre 2012 y 2022, con más de 49.101 eventos en todo el país, y son en su mayoría ITSAC (44,4 %). Las IAD fueron más frecuentes en hombres (55,2 %), el régimen contributivo (49,3 %), seguido del régimen subsidiado (42,1 %) y solo el 3 % ocurrió en personas sin afiliación al Sistema General de Seguridad Social en Salud (SGSSS). La mortalidad asociada a estos eventos fue del 19,9 %. El análisis bivariado y el uso de metamodelos evidenciaron inequidades en la ocurrencia de IAD, especialmente en áreas con menor acceso y recursos. Las IAD presentan inequidades entre departamentos, entre regiones, por sexo y por edad. La mayoría de municipios y departamentos concentraron tasas menores a 3 casos por 1.000 días-dispositivo para ITSAC y NV, pero algunos departamentos están en extremo alejados de este valor con riesgos hasta cuatro veces más altos. ISTUAC tuvo una distribución más homogénea en el riesgo.

Conclusiones: El estudio revela desigualdades importantes en la ocurrencia de IAD en Colombia. Estos hallazgos destacan la necesidad de crear estrategias regionales y focalizadas para mejorar la seguridad del paciente y reducir las inequidades en la atención.

Palabras clave: Infección asociada a dispositivos; Seguridad del paciente; Equidad en salud; Evento adverso; Inequidad.

INTRODUCTION

Patient safety is a leading challenge for public health and a fundamental component of healthcare quality. (1,2) Failures in care processes, along with deficiencies in patient safety, significantly increase the risk of morbidity, mortality, disability, prolonged hospitalization, and consequently, healthcare costs. These deficiencies also do not affect the population uniformly, as they are influenced by social determinants outside the strictly healthcare domain. This leads to avoidable and unjust inequalities, considered inequities in patient safety, which represent an additional form of health inequity. (3) Therefore, adverse events, often preventable, not only generate negative outcomes for patients but also reflect structural disparities.

In recent years, the literature has pointed to a close relationship between negative patient safety outcomes and

adverse events and gender, racial, ethnic, educational, and socioeconomic inequities. (4-6) Additionally, factors such as the characteristics of the healthcare system, the public or private nature of services, and institutional particularities also influence the incidence of reportable events with unwanted effects (REUE), especially those considered preventable. (7,8) However, patient safety policies in various contexts, including those generated by States, often do not explicitly incorporate these factors, limiting their ability to address equity gaps in risk management and safety outcomes.

In Colombia, one of the countries with the highest inequity levels, there are no studies exploring how social determinants affect patient safety. The patient safety policy, adopted in 2008, (9) does not include equity as one of its guiding principles, and some of its objectives could even perpetuate or widen existing gaps. Historically, health inequities have

been measured mainly through variables related to access, timeliness, and quality of care, leaving aside health outcomes, as they are challenging to measure. (10,11) However, in the last decade, several authors have made inroads into the evaluation of health inequities, including measurements related to REUE and their complications, especially as they have considered social determinants that influence health outcomes. (12,13)

There are different methodologies that can be used to assess health inequities that exist between subjects of different social categories or forms of grouping. Variables or determinants can be measured using methodologies designed to identify absolute or relative differences or distances between groups where unjust and avoidable differences (i.e., inequities) are suspected. Additionally, differences in the distribution of the variable in the population can be explored through proportions (disproportionality indices), or

new indices can be constructed to provide a graphical and quantitative representation of the problem (bidimensional or multidimensional indices). (10,11)

Absolute differences are the differences or distances in the occurrence of a specific variable between populations or the relative mean deviation, the disparity index, and the variance between groups. (11) The dissimilarity index is another absolute inequality index designed to determine the distance between different population groups in relation to the global population, and the sum of the absolute values of these differences is divided by two. It does not seem to work well in the context of health and socioeconomic groups. (14) Other measures that typically allow the evaluation of inequities are: the population attributable fraction, the population attributable risk, and absolute and weighted risk differences. (15)

The objective of this work was to explore and measure inequities in patient safety at the time of receiving care in health institutions in Colombia. For this, DAIs, including CLABSI, CAUTI, and VAP, available since 2012 in the SIVIGILA public health surveillance system in Colombia, were analyzed.

METHODS

Study design

An observational study was conducted in a population cohort exposed to health care in intensive care units in Colombia, based on the analysis of administrative databases (SIVIGILA).

Study population

The study population consisted of adult, pediatric, and neonatal populations who received healthcare in intensive and

intermediate care units in Colombia and were exposed to central catheter, urinary catheter, or mechanical ventilation devices, and were reported in the SIVIGILA database between 2012 and 2022.

For all analyses in this phase, the source of information was the SIVIGILA database of the National Institute of Health (INS) in Colombia. The information on the events of interest in this study is public and is available in aggregate form in the reports of healthcare-associated infections on the INS website.

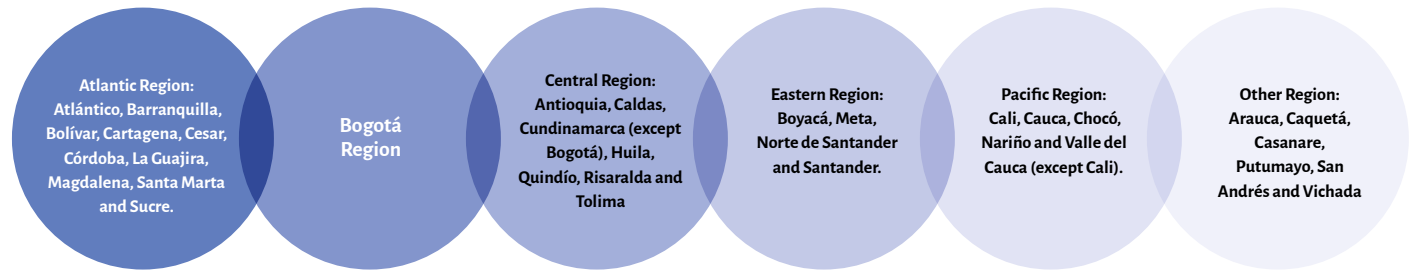
The information reported under a specific notification protocol contains individual or case data. The variables analyzed correspond to sociodemographic and clinical characteristics, institutional-level variables such as the location of the Primary Data Generating Unit (UPGD) (department and municipalities or special districts), general characterization variables of the event such as the source of the report, date of occurrence, place of the report, type of event, time of occurrence during the course of care, number of occurrences per epidemiological week, number of events, and device-days as an aggregate measure of exposed cases. This information was used to calculate risk measures stratified by place of occurrence, type of event, age groups, and setting (neonatal, pediatric, and adult ICU).

Risk measurements were calculated after extracting the information in standardized Excel forms, including cumulative incidence and incidence rates according to data availability. As preparation for modeling and descriptive analysis, the extraction forms were reviewed in order to search for atypical and extreme data, which were then verified. A descriptive analysis of the recovered variables was performed. Results of the univariate and bivariate analyses were presented according to sex, age groups, place of residence (rural versus urban), region of occurrence, ethnicity, insurance scheme, among others, when

the information allowed this description. The analysis of these variables was performed according to their nature using measures of central tendency and dispersion for quantitative variables or relative and absolute frequency measures for qualitative variables. For all quantitative variables, goodness-of-fit was determined using the Shapiro-Wilk and Shapiro-Francia tests, as well as graphical tests such as histograms, stem-and-leaf plots, box-and-whisker plots, and Kernel density.

For DAI incidence rates, 1) direct calculations obtained from the information reported in epidemiological bulletins were used, and 2) random-effects metamodels were developed to calculate combined incidence and combined incidence rate, considering variability between reporting years 2012 to 2022, geographic regions, and institutions where the event occurs (cluster by UPGD and region) and age groups, weighting by the inverse of the variance of each incidence included in the model. (16) The inverse variance method for combined incidence and incidence rate estimation weights individual incidence rates by the inverse of their variance, giving more weight to estimates with greater precision. In all cases, double arcsine correction was used with the Freeman-Tukey method. This correction method is applied to stabilize variance and make the data distribution better approximate a normal distribution, which is necessary as an assumption to apply meta-analysis statistical methods. Freeman-Tukey is indicated when incidence data are very low, or when there are many rare events and even zeros. (17)

The incidence of DAI events was estimated by subgroups, developing metamodels according to the region of occurrence (Figure 1), age, and location of the institution where care was received. All model results were presented with their 95% confidence intervals. The STATA statistical software package version 16® was used.

Figure 1. Departments and municipalities located in the regions selected for analysis.

Source: Authors.

To explore inequities, two types of analysis were performed: an exploratory analysis that considered the results of each type of DAI event by subtypes such as CAUTI, CLABSI, and VAP, allowing the exploration of inequities between regions, age groups, insurance schemes, and origin or place of residence. For this, the same measurement unit was applied to all incidence measures (rates $\times$ 1,000 device-days or exposure) for comparability, and a bivariate analysis was performed. The second analysis was carried out using the Health Equity Assessment Tool Plus (18) and the STATA 16® software to calculate variance and deviation between comparison groups, coefficients of variation, differences between groups, as well as relative risks for REUE within and between regions with the best and worst safety outcomes. (15)

to be more frequent in men (55.2%), in the contributory insurance scheme (49.3%), followed by the subsidized scheme (42.1%), and only 3% occurred in individuals without SGSSS affiliation. Mortality associated with these events was 19.9%.

In the group, in more than 96% of cases, race was "other," and occurrence was mainly in municipal capitals.

CLABSI, CAUTI, and VAP were analyzed in ICUs and some step-down units that reported data for adult, pediatric, and neonatal populations.

Estimation of a combined measure, considering temporal and group variation (ICU, step-down unit, and population subgroups) and using random-effects models, allowed to calculate the incidence rate (IR) of CLABSI for Colombia throughout

the period with a result of 2.9 (95% CI 2.6-3.2) cases $\times$ 1,000 central catheter-days. The same procedure was performed for the measurement by population subgroups, with a result of 2.9 cases $\times$ 1,000 central catheter-days for the adult population (95% CI 2.5-3.4), 3.4 for the pediatric population (95% CI 3.0-3.9), and 2.0 for the neonatal population (95% CI 1.3-2.7).

It was also possible to estimate the incidence rates of this REUE by regions, exploring some differences in their behavior. Significant variations were found in incidence rates by region, the highest occurring in Bogotá and the Pacific (2.7 and 2.5 cases $\times$ 1,000 central catheter-days, respectively) and lowest in the "Other" region (0.5 95% CI 0.0-2.0 cases $\times$ 1,000 central catheter-days).

RESULTS

The analysis of aggregate measures between 2012 and 2022 reported by the INS was conducted according to mandatory reporting. In total, 750 aggregate data reports for DAI events were reviewed, with over 49,101 undesirable events analyzed nationwide, mostly central line-associated bloodstream infections (CLABSI) (44.4%) (Table 1).

In terms of sociodemographic characterization, DAIs in general were found

Table 1. Distribution of REUE-type HAIs in Colombia in the 2012-2022 period.

	n: 49,101	
Type of REUE	n	Proportion (%)
Central line-associated bloodstream infection (CLABSI)	21,798	44.4
Catheter-associated urinary tract infection (CAUTI)	11,866	24.2
Ventilator-associated pneumonia (VAP)	15,437	31.4

REUE: Reportable event with undesirable effect. HAI: Healthcare-associated infection.

Source: Authors.

On the other hand, the CAUTI IR for Colombia throughout the period was 2.1 (95% CI 1.9-2.4) cases $\times$ 1,000 urinary catheter-days. By population subgroups, measurements were 2.2 (95% CI 1.9-2.6) and 2.0 (95% CI 1.7-2.3) cases $\times$ 1,000 urinary catheter-days for the adult and the pediatric populations, respectively.

The CAUTI IR was estimated by regions, exploring some differences in their behavior, with findings of significant variations, with IRs, being the highest in the Eastern and Pacific regions (1.8 and 1.5 cases $\times$ 1,000 urinary catheter-days) and the lowest in the region designated as "Other" (< 0.01 cases $\times$ 1,000 urinary catheter-days).

Finally, the estimated combined measurement of the VAP IR for Colombia throughout the period was 2.1 (95% CI 1.7-2.5) cases $\times$ 1,000 ventilator-days. The measure by adult population subgroups was 3.5 (95% CI 3.0-4.1), pediatric 1.6 (95% CI 1.3-1.8), and neonatal 0.8 (95% CI 0.5-1.3) cases $\times$ 1,000 ventilator-days.

For this REUE, exploring some differences in IR behavior by regions, significant variations were shown, with IRs being the highest in the Pacific region (2.3 cases $\times$ 1,000 central catheter-days) and the lowest in the Bogotá region (0.1 cases $\times$ 1,000 central catheter-days).

Intra-region REUE behavior

The six regions constructed for the analysis were: Atlantic, Bogotá, Central, Eastern, Pacific, and Other. This last category included several departments where a different healthcare service provision was anticipated due to their geographical, cultural, and particular contexts. For the analysis, variability in the estimated incidence measurements of healthcare-associated events, specifically those related to device-associated infections in the six regions constructed for the analysis, was explored.

Atlantic region

For the entire Atlantic region, a CLABSI incidence rate of 2 cases $\times$ 1,000 central catheter-days (95% CI 1.7-2.24) was estimated. Intra-region, several differences were found, with incidence rates as high as in the case of Cesar, with an incidence rate of 6.1 (95% CI 4.2-8.2), and values as low as <0.01 for the department of Atlántico (Barranquilla excepted), La Guajira 0.1, and Sucre 0.8.

For CAUTI, significant intra-region differences were also found, explained by values as high as in Magdalena with a combined incidence rate of 3.2 (95% CI 1.2-6.2) cases per 1,000 urinary catheter-days, while the departments of Atlántico (without Barranquilla) and Bolívar (without Cartagena) have incidence rates as low as <0.01 and 0.2, respectively.

For VAP, the combined IR of the region was 1.1 (95% CI 0.8-1.14) cases $\times$ 1,000 ventilator-days; disparities were found, with values as high as the combined incidence rate in Sucre of 2.7 (95% CI 1.7-4), and significantly lower values in other departments like Atlántico and Magdalena at <0.01 , or La Guajira with 0.2 cases $\times$ 1,000 ventilator-days.

Intra-region variations were not only observed between departments and municipalities but also by population or risk groups; for CLABSI, the incidence rate in the pediatric population was found to be the highest as a combined risk measure, at 3.0 (95% CI 2.1-4) cases $\times$ 1,000 catheter-days, followed by the incidence rate in adults at 2.2 (95% CI 1.7-2.8) cases $\times$ 1,000 catheter-days; the incidence rate in the neonatal group was 1.3 (95% CI 0.9-1.7) cases $\times$ 1,000 catheter-days.

For CAUTI, the adult population had the highest risk of events, with an incidence rate of 1.4 (95% CI 1.1-1.7), showing a risk twice as high as that of the pediatric population (0.7 cases $\times$ 1,000 catheter-days). The same risk trend was observed for VAP, it being six times higher in adults than in the pediatric population and 13 times higher than in the neonatal population (2.6 vs. 0.4 and 0.2, respectively).

Bogotá region

For the Bogotá region, the combined incidence rate of CLABSI was 2.7 (95% CI 2.3-3.0) cases $\times$ 1,000 catheter-days, while for CAUTI the combined incidence rate was 0.9 (95% CI 0.6-1.1). A much lower value was found for VAP, with an incidence rate of 0.1 (95% CI 0.0-0.3) it the combined measurement.

The combined risk measurement for each of these events according to population subgroups was also estimated. For CLABSI, very similar values were found in the three subpopulations: adults, pediatric, and neonatal, at 2.7 in each case. For CAUTI, the figure was predominantly higher in adults, with an incidence rate of 1.8 cases $\times$ 1,000 urinary catheter-days versus 0.2 in the pediatric population. For VAP, it remains much higher in the adult population, with a combined incidence rate of 1.7 (95% CI 1.3-2.2), versus only 0.4 (95% CI 0.2-0.5) in the neonatal population.

Central region

As far as the occurrence of CLABSI is concerned, it was found that the department with the highest risk is Caldas, with a combined measurement of 3.2 (95% CI 2.4-4.1) cases $\times$ 1,000 catheter-days, followed by Antioquia with 2.9 (95% CI 2.5-3.4), in contrast with a low-risk incidence rate of 0.1 (95% CI 0.0-0.4) for the department of Tolima.

For CAUTI, Antioquia stands out with combined incidence rate of 2.4 (95% CI 2.0-2.8) cases $\times$ 1,000 catheter-days, twice as high as the reported rates for departments such as Tolima and Caldas. In this REUE, Quindío has the lowest values, with an estimated incidence rate of less than 0.01 cases $\times$ 1,000 catheter-days.

For VAP, Caldas and Antioquia persist with high incidence rates compared to the rest of the departments that make up this region, with values of 3.0 and 3.2, respectively. The lowest risk of this event was observed in Cundinamarca, with an incidence rate of 0.4 (95% CI 0.1-0.8).

Intra-region variation in IRs was also explored in population groups, with findings of particularly high values in the adult population compared to the rest of the population in CAUTI and VAP events; however, the neonatal population had the highest incidence rate of CLABSI, with a value of 2.4 (95% CI 1.9-3.0).

Eastern region

Variability in CLABSI incidence rates was much lower in this region, with the highest found in Santander (2.1), followed by Norte de Santander and Meta, each with a combined incidence rate of 1.9. For the entire region, an incidence rate of 1.8 (95% CI 1.6-2.1) cases $\times$ 1,000 central catheter-days was estimated.

For CAUTI, significant variability was found among the departments that make up the region, with a much higher combined incidence rate of 3.1 (95% CI 2.7-3.5) in Boyacá. The combined rate of this event for the region was 1.8 (95% CI 1.4-2.1) cases $\times$ 1,000 catheter-days.

In the case of VAP, significant variability in IR was also found, and it is higher in Santander, with a combined incidence rate of 2.0 (95% CI 1.5-2.7) compared to Meta, where only a combined incidence rate of 0.1 (95% CI 0.0-0.9) was obtained.

Once again, the analysis was performed according to population subgroups, and it was found that the adult population for the three events had the highest risk with incidence rates of 2.2 for CLABSI, 2.1 in CAUTI, and 3.5 for VAP, the latter almost three times higher than for the neonatal and pediatric populations.

Pacific region

Consistently high values were observed in Cauca, Nariño, and Valle, the latter two with

the highest values for CLABSI compared to Chocó, with a combined incidence rate of 0.3. In Chocó, systematically lower values of incidence rates were found for each of the three events.

For CAUTI, the highest values were found in Valle del Cauca and Nariño, and the lowest values in Chocó. For VAP, Valle and Nariño also showed the highest values in their incidence rate: 2.6 and 2.8, respectively.

Regarding the incidence rate by population, similar risks were found for the analyzed population groups in CLABSI and CAUTI events, while for VAP in the adult population, the incidence rate was a little more than double that for the pediatric and neonatal populations (3.2 vs. 1.4 vs. 1.6, respectively).

"Other" region

Notoriously variable rates were recorded, including extreme values such as in the case of Putumayo, which had an incidence rate of 8.4 for CLABSI compared to values of less than 0.01 cases $\times$ 1,000 catheter-days as in the case for San Andrés and Vichada.

For the CAUTI event, the highest values were found in Putumayo again, with an incidence rate of 1.9, while in most departments this incidence rate was less than 0.2 cases $\times$ 1,000 urinary catheter-days.

In the case of VAP, very dissimilar values were found, and Arauca is the department with the highest incidence rate at 13.8 cases $\times$ 1,000 ventilator-days (95% CI 9.8-18.4). In other departments, this rate was less than 0.01 cases $\times$ 1,000 ventilator-days.

The intra-region analysis for this group of departments, in which the incidence rate was evaluated according to population groups, found that for CLABSI, the pediatric population was the most affected with an incidence rate of 13.1 (95% CI 3.3-27.9), compared to the adult population whose risk rate was 1.9 (95% CI 0.3-4.4). For CAUTI,

the highest risk was found in the adult population with 0.8 cases $\times$ 1,000 urinary catheter-days. For the VAP event, the adult group was again the most affected, with an incidence rate of 3.9 (95% CI 1.4-7.4).

Exploration of Inequities in DAI REUE

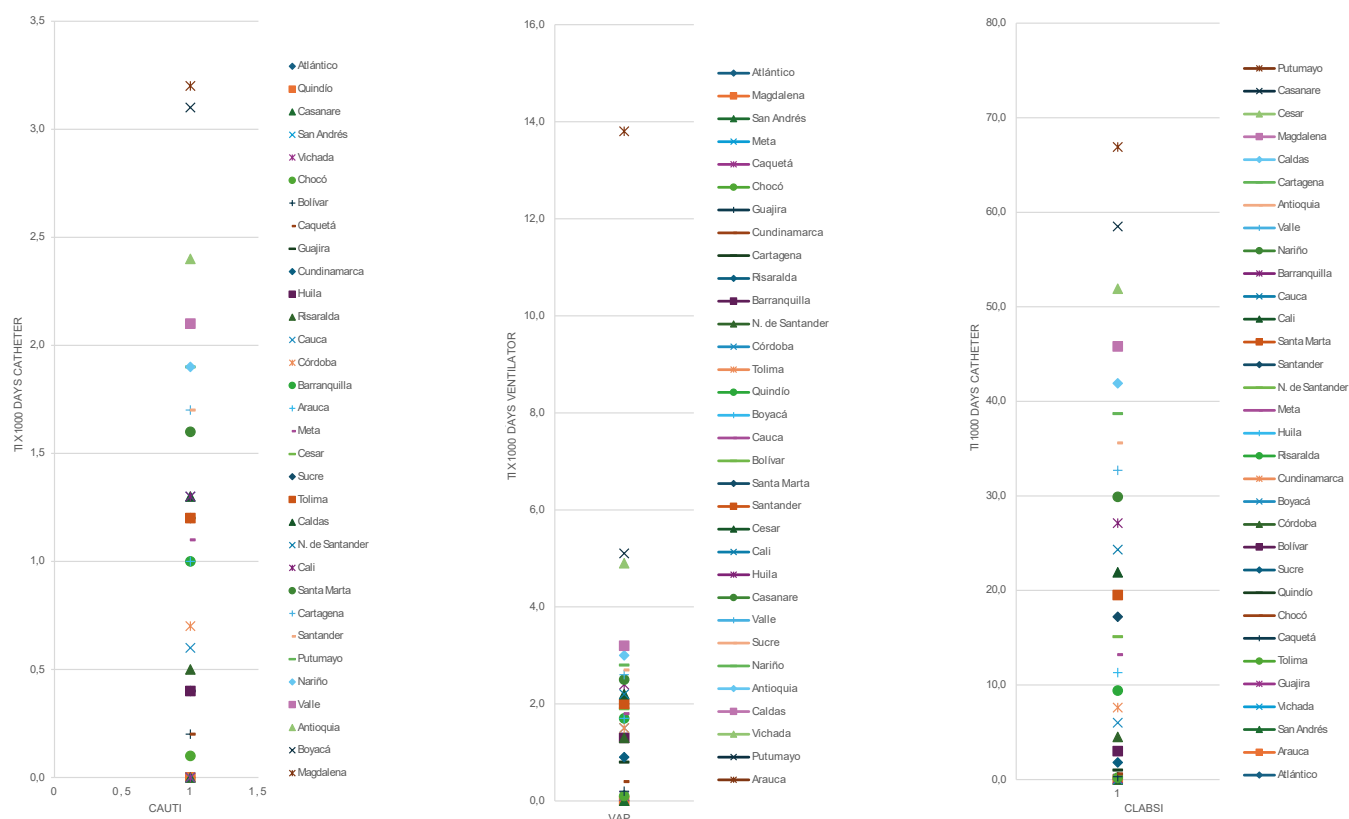
The exploration of differences among departments, municipalities, and regions, as well as by populations, allowed not only to recognize the existing differences in the occurrence of this type of DAI REUE but also to estimate the magnitude of these differences.

Regarding the exploration of inequities in the estimates derived from the random-effects models for DAI-type healthcare-associated infections, an asymmetric distribution for the municipalities and departments in which these incidence rates were calculated was observed in two of these events (CLABSI and VAP).

As shown in [Figure 2](#), regarding CLABSI cases, the concentration of departments and municipalities towards the left end of the graph is notable, corresponding to a lower risk of REUE (less than three cases $\times$ 1,000 catheter-days); however, from this value, a lower frequency of municipalities and departments is found (four of the departments), showing an asymmetric distribution.

This same trend can be observed with the VAP event, in which most municipalities and departments concentrate IR values of less than three cases $\times$ 1,000 catheter-days, while there are few departments and municipalities at the extremes of this concentration, with large differences between the extremes.

This trend was not the rule for CAUTI cases, in which a lower proportion of extreme data was observed, and the risk was homogeneously distributed throughout all the departments and municipalities included in the analysis ([Figure 2](#)).

Figure 2. Graphical distribution of differences in the risk of DAI occurrence in Colombia.

CAUTI: catheter-associated urinary tract infections; **CLABSI:** central line-associated bloodstream infections; **VAP:** ventilator-associated pneumonia.

Source: Authors.

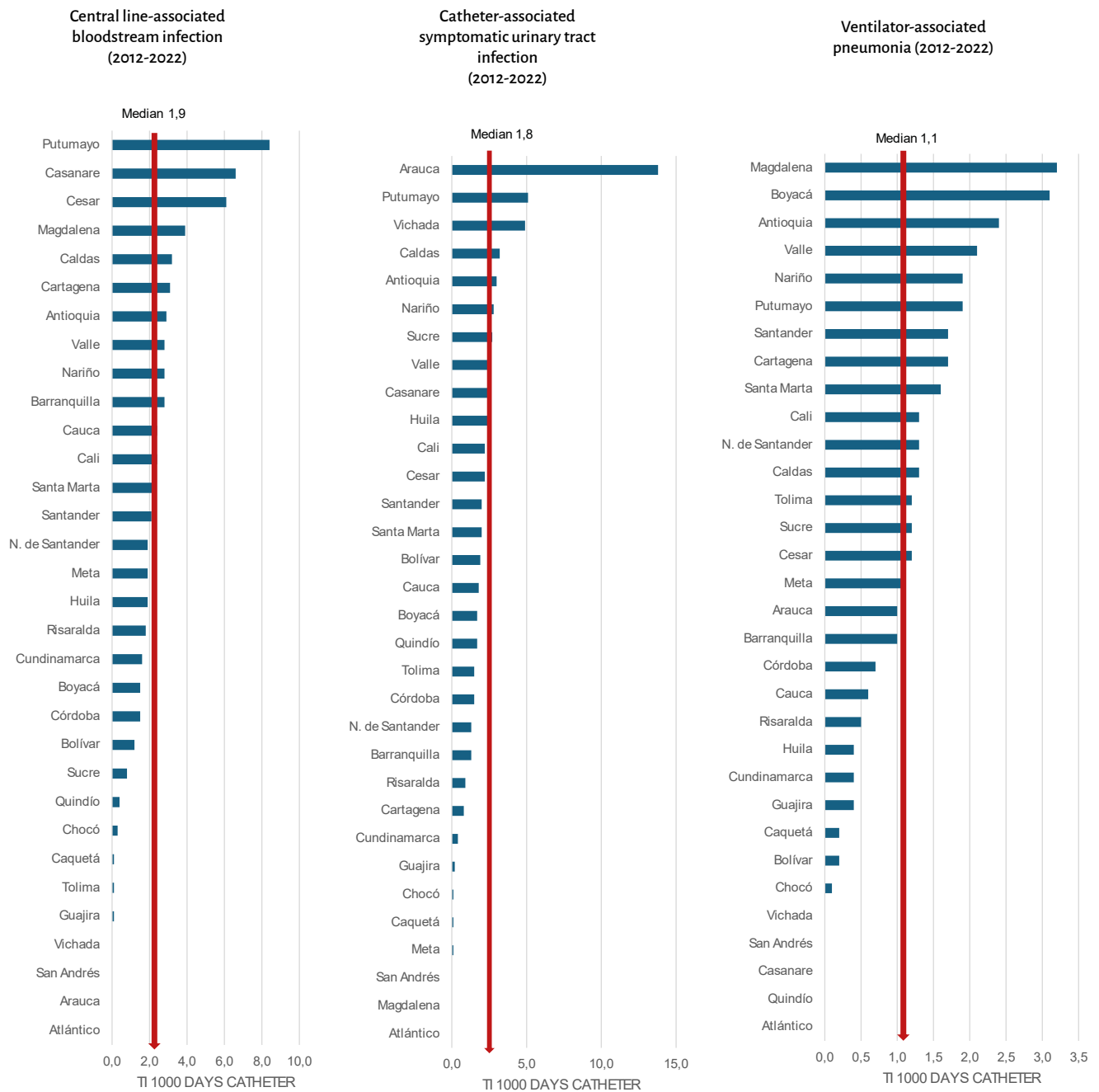
Once the analysis was performed concerning a reference measure (the median of these values) for each type of DAI, as shown in Figure 3, it is notable that there is a large proportion of departments and municipalities that exceed this median risk in the country for both CLABSI and CAUTI; however, this is not the case for VAP, for which there is a lower proportion of departments and municipalities that exceed this value, although excess risk is significant for one of the departments.

Quantification of inequities in HAI REUE in Colombia

After exploring possible inequities, the

analysis proceeded to quantify them and determine significant differences in the occurrence of these events. The quantification of differences within the country began by comparing the risk of prioritized REUE occurring in the different departments and municipalities of Colombia for which information is available in the surveillance systems. In this first level of analysis, risk estimates (incidences and incidence rates) were compared during the 2012-2022 period. Significant differences were found for all types of DAI-related REUE; the most extensive are those generated by VAP with a risk difference of 11.7% ($p < 0.001$) and an RR of 6.6 ($p < 0.001$). CLABSI and CAUTI also showed significant differences.

Differences persist when performing an aggregated analysis by regions of interest for this project. Significant differences were again found for all the studied REUE, and the differences in CAUTI (RR 180), VAP (RR 23), and CLABSI (RR 6.8) ($p < 0.001$ in all measures) are more evident, highlighting regions that begin to present higher risks systematically, such as the Pacific, Other region, Eastern regions. Finally, a comparison of the risk measure according to population groups in Colombia was made for CLABSI, CAUTI, and VAP. It was found that only for VAP were there significant differences in the risk of occurrence between groups with an RR of 4.4. The details of this analysis are presented in Table 2.

Figure 3. Distribution of the risk of DAI occurrence in Colombia compared to the median risk.

The red line represents the national median for the incidence of each of the analyzed events.

HAI: Healthcare-associated infection.

Source: Authors.

Table 2. Magnitude of Inequities in the occurrence of DAI REUE in Colombia (Analysis period 2012-2022).

Context	Domain	Indicator	Risk difference*	Risk ratio (RR)*	p-value
Inequities between departments and municipalities	DAI	CLABSI	5.5**	2.9	< 0.001
Inequities between departments and municipalities	DAI	CAUTI	1.1**	1.5	< 0.001
Inequities between departments and municipalities	DAI	VAP	11.7**	6.6	< 0.001
Inequities among regions	DAI	CLABSI	2.3**	6.8	< 0.001
Inequities among regions	DAI	CAUTI	1.8**	180	< 0.001
Inequities among regions	DAI	VAP	2.2**	23	< 0.001
Inequities among population groups	DAI	CLABSI	1.4**	1.7	> 0.05
Inequities among population groups	DAI	CAUTI	0.2**	1.1	> 0.05
Inequities among population groups	DAI	VAP	2.7**	4.4	< 0.001

*Difference or ratio between the lowest and highest risk in the dataset; ** Cases × 1,000 device-days.

CAUTI: catheter-associated urinary tract infection; CLABSI: central line-associated bloodstream infection; DAI: device-associated infection; VAP: ventilator-associated pneumonia.

Source: Authors.

DISCUSSION

The study's findings highlight significant inequalities in the distribution of reportable events with undesirable effects (REUE) such as device-associated infections (DAIs) in Colombia, revealing inequities in patient safety. Significant differences in the incidence rates of events like CLABSI and VAP observed between municipalities and departments reflect the concentration of risks in certain areas, particularly in the Pacific and Eastern regions. This suggests that structural and social factors may be influencing these disparities.

The asymmetric distribution in CLABSI and VAP, with a higher concentration of municipalities at low incidence levels but some departments with elevated risks, underscores the need for targeted interventions. In contrast, the more homogeneous risk observed in CAUTI could

indicate a more uniform management of this event nationwide, although the proportion of municipalities and departments exceeding the median risk is still a source of concern.

The aggregated analysis by regions reinforces the idea of systematic inequities, with regions like the Pacific standing out for their higher risk. Previous studies in Colombia on health inequities not only demonstrate that there are also differences in health outcomes in the regions, but also that the Amazon and Pacific regions exhibit the lowest health and equity indicators. (19,20) This pattern could be related to limitations in resources, infrastructure, and access to timely and quality care. Differences by population groups, although less consistent, underscore the need to consider specific social determinants in public policy planning.

Increasingly, international studies report inequities in the occurrence of

adverse health events, showing that factors such as race, age, geographic location, and income level are associated with higher risks of experiencing these events; (21,22) for example, Afro-descendant populations and rural communities have higher rates of medical complications due access barriers and healthcare quality. Similarly, older people and those with lower socioeconomic status often face additional difficulties in receiving timely and effective treatments. (4-6)

In the Colombian context, widely documented health inequities suggest that inequalities in the occurrence of adverse events are expected. Since health inequities and patient safety share common social determinants, such as unequal access to services, socioeconomic conditions, and differences in health infrastructure, it is necessary to address these underlying causes. Strengthening surveillance systems and implementing

public policies that reduce regional and population gaps are essential to ensure more equitable and safe care.

Overall, the results emphasize the urgency of implementing strategies that address these inequities, prioritizing the most vulnerable areas and groups to ensure safe and equitable care.

This study stands out for its novel design, the use of robust statistical analyses, and advanced methods to explore the concentration of risks and inequities in REUE. However, an important limitation is the use of secondary data from surveillance systems, which may be subject to underreporting and variability in reporting quality.

CONCLUSIONS

This study provides key evidence on inequities in REUE in Colombia, highlighting vulnerable areas and populations. The findings can guide clinical strategies to reduce risks, strengthen data-driven risk management, and promote patient safety policies that consider social determinants, thereby improving equity and quality in healthcare.

ETHICAL RESPONSIBILITIES

Ethics committee approval

The study was approved by the Committee under Minutes CE-0108-22, dated July 28, 2022, from the School of Medicine of the Universidad Nacional de Colombia.

Protection of human and animal subjects

The authors declare that no experiments were conducted on humans or animals for this research. The authors declare that the procedures followed were in accordance with the ethical standards of the responsible

human experimentation committee and in accordance with the World Medical Association and the Declaration of Helsinki.

Data confidentiality

The authors declare that they have followed their workplace protocols pertaining to the publication of patient data.

Right to privacy and informed consent

The authors declare that no patient data appear in this article. The authors have obtained informed consent from the patients and/or subjects referred to in the article. This document is kept by the corresponding author.

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Authors' contributions

KEO: proposed the research idea, directed the study, and performed data analysis.

HG and JES: participated in the analysis of the data and results obtained. All authors contributed to the interpretation of the results and the writing of the paper.

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Conflicts of interest

The authors declare no conflicts of interest.

Presentations

None declared by the authors.

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