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The impact of the COVID-19 pandemic on HIV testing in Peru: an interrupted time series analysis from 2014 to 2022

Robinson A. Yrene-Cubas[1], Jesus Perez-Castilla[2], Daniel E. Reynaga-Cottle[3], Maria José Bringas[3], David R. Soriano-Moreno[4], Daniel Fernandez-Guzman[1*] and Jose A. Gonzales-Zamora[5]

Abstract

Objectives Our objective was to evaluate the impact of COVID-19 on the proportion of past-year HIV testing in Peru.

Methods Utilizing data from the National Demographic and Health Survey of Peru from 2014 to 2022, we conducted an interrupted time series analysis. The proportion of past-year HIV testing per quarter of each year was considered our unit of analysis. Statistical analysis involved segmented regression with Newey-West standard errors, dividing each year of evaluation into four quarters. Additionally, we applied an Autoregressive Integrated Moving Average (ARIMA) model.

Results We included 211,359 participants aged 15 to 49 years. The proportion of past-year HIV testing in Peru showed a mean decrease of 8.33% (95%CI: -10.73% to -5.93%) after the COVID-19 lockdown (from August-2020) compared to the previous period (before March-2020). Prior to lockdown, there was a mean quarterly increase of 0.30% (95%CI: 0.21–0.40%) in testing proportion, while after the lockdown, there was a mean quarterly decrease of -0.24% (95%CI: -0.56–0.09%). HIV testing declined in 23 of the 25 regions, ranging from −23.7% to -3.0%, except in Amazonas and Cajamarca, where increases of 5.3% and 6.8% were observed. Predictions of counterfactual values without the pandemic using the ARIMA model revealed a percentage drop of -9.20% (95%CI: -13.70 to -4.80) in observed compared to predicted values.

Conclusions This study highlights the decrease in proportion of past-year HIV testing in Peru following the COVID-19 lockdown, emphasizing the urgent need for targeted interventions to address disparities and ensure equitable access to testing services.

Keywords HIV testing, COVID-19 impact, Interrupted time series analysis, Sociodemographic disparities, Peru

*Correspondence:
Daniel Fernandez-Guzman
danferguz@gmail.com
[1]Carrera de Medicina Humana, Universidad Científica del Sur, Carretera Panamericana Sur Km19, Distrito de Villa El Salvador, Lima 15067, Peru
[2]Escuela Profesional de Medicina Humana, Universidad Nacional de San Antonio Abad del Cusco, Cusco, Peru
[3]Carrera de Medicina Humana, Universidad San Martín de Porres, Lima, Peru
[4]Unidad de Investigación Clínica y Epidemiológica, Escuela de Medicina, Universidad Peruana Unión, Lima, Peru
[5]Division of Infectious Diseases, Department of Medicine, Miller School of Medicine, University of Miami, Miami, FL 33136, USA

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Background

Despite substantial progress in preventing and treating infectious diseases, human immunodeficiency virus (HIV) infection remains a significant public health challenge [1]. According to data from 2023, approximately 110, 000 adults are living with HIV in Peru, with a prevalence of 0.5% among individuals aged 15–49 years Haga clic o pulse aquí para escribir texto. In the same year, over 6,000 adults acquired HIV, and the estimated number of deaths due to HIV-related illnesses is under 1,000 [2] Haga clic o pulse aquí para escribir texto. From 2010 to 2021, HIV infections in Latin America increased by 4.7%, while deaths associated with the virus decreased by 27.5% [3].

Detecting HIV infection in a timely manner is critical for initiating early treatment and preventing disease progression and fatal outcomes [4]. However, in 2020, as countries implemented COVID-19 containment measures and social restrictions, there was a decrease in the number of HIV screening tests conducted [5]. This decline may have been influenced by governments prioritizing resources for COVID-19 detection campaigns, vaccination efforts, and changes to sexual behavior. For instance, in Peru, the national lockdown-imposed border closures, restricted domestic flights, and prohibited non-essential business operations [6]. Residents were also mandated to stay at home for five months, from March to July 2020 [7], with a gradual reopening of activities extending over several more months [8].

During the lockdown in Peru, healthcare strategies, including those for HIV prevention and control, were suspended. While the healthcare system aims for universal health coverage and includes both public and private options, access remains variable, with many individuals uninsured, leading to unequal access to care. Numerous services were disrupted, and clinics operated with limited hours, primarily focusing on emergency care. Elective procedures were postponed, and the transition to telehealth services varied across regions. Furthermore, community organizations encountered significant challenges in their outreach efforts, which exacerbated vulnerabilities for marginalized populations [9].

Consequently, a decrease in testing during this period was expected in Peru. However, the extent to which testing was reduced and whether a trend of low testing rates persists has not been quantified. In other countries with similar scenarios of social measures in response to the COVID-19 pandemic, it has been reported that the decline in testing persisted even after the first year following lockdown [10], posing a risk to the population, as it is estimated that 18% of individuals in Latin America and the Caribbean are unaware of their HIV status, with one-third receiving delayed diagnoses [3]. Therefore, there is an urgent need for strategies to enhance HIV testing in the post-COVID-19 era [11].

In accordance with guidelines from Peru's Ministry of Health, all healthcare facilities must provide rapid HIV tests for individuals who need them. Voluntary HIV screening is recommended with informed consent, particularly for individuals diagnosed with pulmonary or extrapulmonary tuberculosis, hepatitis B, hepatitis C, syphilis, or other sexually transmitted infections [12]. According to the study by Rick et al. [11], from January to August 2020, there was a global decrease of 35.4% in the number of HIV diagnostic tests performed across 44 countries spanning four continents, in comparison to the corresponding period in 2019. In the context of Latin America, it has been estimated that the reduction in the number of HIV tests may have experienced a more significant decline post-COVID-19, with reported decreases of up to 44.6% [11].

Understanding the trends in the number of HIV tests performed is increasingly important in the aftermath of the COVID-19 pandemic. As we navigate the post-pandemic landscape, it is essential to assess how healthcare systems adapted to ensure ongoing and robust HIV testing and diagnostic practices, considering the potential long-term impact of the pandemic on public health infrastructure and testing accessibility [13].

According to data from the Ministry of Health, in Peru a total of 2,904 new cases of HIV were diagnosed in the first six-months of 2022. This marks a decrease of 24.33% compared to the previous year [14]. However, it is estimated that approximately 70,000 people are still living with HIV in the country, and 21% are unaware of their serological status [15].

Based on the information mentioned above, this study aimed to assess the impact of COVID-19 on the proportion of past-year HIV testing in the period following the lockdown. To achieve this, we utilized the pre-pandemic period from January 2014 to February 2020 as a baseline and evaluated the effects two years after the lockdown (August 2020 to December 2022). This study sought to illuminate the extent of the impact the COVID-19 pandemic has had on HIV detection practices in Peru. Moreover, knowledge of the trend in the number of tests in the years post-pandemic will offer valuable insights into the resilience and adaptability of HIV screening programs over time.

Methods

Study design

This study employed an interrupted time series analysis using cross-sectional time series data spanning from 2014 to 2022 obtained from the National Demographic and Health Survey of Peru (ENDES). ENDES is a comprehensive nationwide household survey designed to assess various public health indicators, including the prevalence of chronic diseases, such as hypertension and obesity, as well as access to healthcare services for disease prevention, including screening for breast cancer, prostate cancer, vaccination, and HIV testing [16]. Furthermore, ENDES has expanded its scope to include a general health assessment applied to a representative sample of individuals aged 15 and older, which has been utilized in previous studies [17].

Population, sample, and sampling

ENDES employs a complex sampling design comprising three stages. In the first stage, a systematic sample of clusters with proportional probability was selected, defined as a group of households based on a sampling framework constructed from the National Population and Housing Census of Peru in 2007 and 2017. In the second stage, a random sample of households, balanced by variables of interest, was chosen in each selected cluster. In the third stage, for the health survey, a person aged 15 or older was randomly selected from each household. In 2020, due to the COVID-19 pandemic, adjustments were made to adhere to the sample generated. Telephone interviews were implemented (from March to July 2020), gradually transitioning back to in-person interviews (since August 2020) with field personnel following biosecurity measures.

It is worth noting that questions regarding HIV testing were posed exclusively to individuals aged between 15 and 49. Additionally, for the purposes of this study, those lacking complete data on the outcome variable (undergoing any HIV test) or on sociodemographic variables of interest (sex, age, area, economic level, region, and assessment year) were excluded.

Variable of interest: HIV testing

The main variable was whether individuals had HIV screening in the past year. To construct this variable, ENDES used the following question: "In the last 12 months, that is, from [month] of last year to [month] of this year, have you been tested to know if you have the virus that causes AIDS (HIV)?". It is important to note that the blank spaces were adjusted according to the survey application date to coincide with the temporality of the last year. The question had possible responses "Yes," "No," and "Don't know / don't remember." In our analysis, responses of "don't know / don't remember" were treated as missing values, leaving only the "Yes" and "No" responses. Thus, for the analysis, we assessed the percentage of respondents who had been screened for HIV in the last year for each year of ENDES. In this way, for the time series analysis, these percentages (ranging from 0 to 100%) were considered as the units of analysis.

Other variables

The study encompassed several variables to characterize the population, including sex (females and males), age groups (15 to 17 years, 18 to 29 years, 30 to 39 years, and 40 to 49 years), marital status (currently with a partner [married or cohabiting] and currently without a partner [single, widowed, separated, or divorced]), educational level (university education, higher education [non-university], secondary, primary, or lower), and wealth index (richest [quintile 5], rich [quintile 4], middle [quintile 3], poor [quintile 2], poorest [quintile 1]). Additionally, the factors of rurality (urban and rural) and natural region (Lima metropolitan [capital of Peru], coast excluding Lima, highlands, and jungle) were also assessed.

Statistical analysis

The ENDES databases were downloaded and imported into the statistical software R (version 4.0.3), where they were merged. Subsequently, all analyses were conducted considering the complex sampling design of the survey. The "Survey" package (version 4.0) was utilized to specify the intricate design through weighting factors, clusters, and strata.

No records were eliminated due to missing data. All available data were analyzed according to standard procedures for surveys with complex sample designs, including the use of weights, strata and clusters. In cases of missing values on key variables, domain estimation techniques were applied, ensuring that the representativeness of the subgroups of interest was maintained without distorting variances or affecting the precision of confidence intervals.

Descriptive analysis of categorical variables involved calculating absolute frequencies, weighted proportions, and their 95% confidence intervals (95% CI). Thus, for the time series analysis, the unit of analysis was the proportion of respondents who reported having taken an HIV test in the past year (ecological level analysis).

The interrupted time series approach, a quasi-experimental method, was employed to estimate the impact of the COVID-19 pandemic on the proportion of past-year HIV testing. The intervention period was defined as the time after the lockdown in Peru (March to July, 2020). Time units were analyzed quarterly, with the proportion of past-year HIV testing averaged across the months within each quarter. Due to the censored period, only data from January and February were considered for the first quarter of 2020, and only August and September for the third quarter of 2020.

To assess whether the proportion of individuals undergoing an HIV test in lats year had changed in the population after the onset of the pandemic, a segmented regression analysis with Newey-West standard errors was employed. This model spanned data measurements before the pandemic (from the first quarter of 2014 to the first quarter of 2020 [censored in March 2020]) and after the lockdown (from the third quarter of 2020 [censored in July 2020] to the fourth quarter of 2022), considering autocorrelation and heteroscedasticity between quarters.

Finally, our models included a time variable, a dummy variable indicating before and after the lockdown (censoring the months of March through July corresponding to the lockdown), and an interaction term between time and the dummy variable. This approach considered trends before the lockdown, allowing the estimation of its effect at different time points by centering time [18]. Thus, the estimated impact of COVID-19 was assessed in terms of changes in prevalence (intercept for the dummy), changes in the prevalence slope over time before (intercept for time), and after the intervention (interaction intercept). The change in the intercept represents only the immediate change in the prevalence level, while the change in the slope reflects sustained changes in the trend between quarters.

To account for seasonal changes in clinical activity, a sensitivity analysis was conducted with two pairs of sine and cosine terms (Fourier terms) [18]. Additionally, both a crude model and one adjusted for age and sex were presented. Subgroup analyses were also conducted based on age, sex, education, wealth quintiles, residence area, and region.

Additionally, an Autoregressive Integrated Moving Average (ARIMA) model was implemented to support the initial findings and generate a counterfactual scenario. Unlike segmented regression, ARIMA can eliminate trends and seasonality through differencing without the need to include temporal or seasonal variables [19]. The auto.arima() algorithm from the "forecast" package in R was employed to automatically identify the best ARIMA model by iterating through possible options and selecting the one with the lowest Akaike information criterion/Bayesian information criterion values [20].

Thus, the Arima() function of the forecast package in R was used to fit the selected model, specifying a ARIMA(2,1,1)(0,1,1) model, where the parameters (2,1,1) correspond to the non-seasonal component of the model: an autoregressive process of order 2 (AR), a first order difference (I), and a moving average term of order 1 (MA). The seasonal component (0,1,1) indicates a first-order seasonal difference and a seasonal moving average term of order 1, with a quarterly seasonal periodicity (period = 4). The Ljung-Box test did not reject the null hypothesis of no autocorrelation, demonstrating a good fit.

Subsequently, the pre-lockdown period was utilized to predict the counterfactual proportion of past-year HIV testing for 2020 to 2022 in the absence of COVID-19, estimating the 95% CI. Finally, absolute and relative differences between counterfactual and observed cases were calculated, along with their corresponding CI.

Ethical issues

This study did not require approval from an ethics committee since we analyzed a secondary database. The database gathered data without identifiers, safeguarding the confidentiality of survey participants. Furthermore, respondents had previously given informed consent before participating in the survey. The survey database was freely accessed from the National Institute of Statistics and Informatics website (https://proyectos.inei.gob.pe/microdatos/index.htm).

Results

Out of a total of 309,198 participants surveyed by ENDES during the period 2014 to 2022, we included 217,300 (100%) participants aged 15 to 49, as questions regarding HIV testing were limited to this demographic group. Among these, we excluded 3,224 (1.4%) respondents for lacking information on HIV testing in the last year and 2,717 (1.3%) for having missing values in other variables. Thus, the final sample comprised 211,359 participants, representing 97.3% of the target population (Figure S1).

During the entire study period (before and after the lockdown declaration), we observed a higher proportion of individuals aged 18 to 29 (37.6% and 36.5%), females (50.4% and 51.0%), those with a partner (63.3% and 62.2%), with secondary education as the highest educational attainment (49.7% and 52.6%), belonging to an economically disadvantaged situation (22.6% and 22.5%), and residing in urban areas (76.2% and 82.2%) in the study population. Furthermore, during the period prior to the lockdown, 20.7% of the participants underwent at least one HIV screening test in the year before the survey, while this figure decreased to 17.1% in the post-lockdown period (Table 1). The difference in the proportion of tests conducted during the two study periods was statistically significant ($p < 0.001$). Similarly, a lower proportion of tests was observed post-lockdown across all subgroups (age groups, by sex, marital status, educational levels, wealth index, residential area, and natural region of residence) compared to the period before the lockdown ($p \leq 0.001$) (Table S2).

In 23 out of the 25 departments in Peru, we observed a decrease in HIV tests taken after the COVID-19 lockdown, with a percentage difference ranging from −23.7% to -3.0%. Conversely, Amazonas and Cajamarca were the only departments that recorded an increase in the number of tests performed post-lockdown, with 5.3% and 6.8%, respectively (Fig. 1). Additionally, the annual temporal trend of past-year HIV testing in each department is presented, showing a marked decline in early 2021, with a slight increase during 2022, except in Arequipa,

Table 1 Sociodemographic characteristics of the respondents by period of study ($n=211,359$)

Characteristics	Before COVID-19 lockdown (January 2014 to February 2020)			After COVID-19 lockdown (August 2020 to December 2022)		
	n	%*	95% CI*	*n*	%*	95% CI*
Age						
15 to 17 years	10,885	10.2	10.0–10.5	5659	10.0	9.7–10.4
18 to 29 years	50,855	37.6	37.2–38.0	25,059	36.5	36.0–37.1
30 to 39 years	48,635	28.5	28.1–28.8	26,201	29.1	28.6–29.6
40 to 49 years	29,304	23.8	23.4–24.1	14,761	24.3	23.8–24.8
Sex						
Female	78,139	50.4	50.0–50.8	40,672	51.0	50.4–51.5
Male	61,540	49.6	49.2–50.0	31,008	49.0	48.5–49.6
Marital status						
Currently with partner	96,994	63.3	62.9–63.7	48,808	62.2	61.5–62.8
Currently without partner	42,685	36.7	36.3–37.1	22,872	37.8	37.2–38.5
Education level						
University education	19,545	15.8	15.3–16.3	10,894	18.4	17.8–19.0
Higher education (non-university)	22,063	16.4	16.0–16.7	12,061	17.5	17.0–18.0
Secondary	67,967	49.7	49.1–50.2	37,203	52.6	51.9–53.2
Primary or lower	30,104	18.2	17.7–18.7	11,522	11.6	11.2–12.0
Wealth index						
Richest	14,844	17.1	16.4–17.8	6678	17.7	16.9–18.5
Rich	21,117	19.3	18.8–19.8	9933	20.2	19.6–20.9
Middle	28,491	21.5	21.0–22.0	13,951	22.0	21.5–22.6
Poor	38,028	22.6	22.0–23.2	19,394	22.5	21.8–23.1
Poorest	37,199	19.5	18.8–20.1	21,724	17.6	17.0–18.2
Area of residence						
Urban	95,508	76.1	75.2–76.9	47,905	82.2	81.5–82.8
Rural	44,171	23.9	23.1–24.8	23,775	17.8	17.2–18.5
Natural region						
Lima Metropolitan	16,386	32.7	31.3–34.1	8368	36.8	35.6–38.1
Coast without Lima	41,167	25.5	24.4–26.7	20,367	26.1	25.1–27.1
Highlands	47,796	27.5	26.4–28.7	24,992	23.7	22.8–24.6
Jungle	34,330	14.3	13.5–15.1	17,953	13.3	12.7–14.0
HIV testing in the last year						
No	107,222	79.3	78.9–79.6	58,137	82.9	82.5–83.4
Yes	32,457	20.7	20.4–21.1	13,543	17.1	16.6–17.5

95%CI: 95% confidence intervals

* Weight percentages are according to sampling specifications and the weight of ENDES by year

Ica, La Libertad, Loreto, Pasco, and Tacna, where the pattern differed (Figure S2).

In the interrupted time series analysis, we observed that after the COVID-19 lockdown, there was an average decrease of 8.33% (95% CI: -10.73% to -5.93%) in the proportion of past-year HIV testing conducted in the Peruvian population. During the pre-lockdown period, we noted an average quarterly increase of 0.30% (95% CI: 0.21–0.40%) in the proportion of past-year HIV testing carried out. In contrast, the post-lockdown period showed a declining trend of -0.24% (95% CI: -0.56–0.09%) in past-year HIV testing compared to the pre-lockdown trend; however, this change was not statistically significant (Fig. 2 and Table 2).

When stratifying the interrupted time series analysis by sociodemographic variables in the post-lockdown period, we observed a significant decreasing trend in the average proportion of past-year HIV testing (%) in various subgroups. This decline was notably observed in the age group of 15 to 17 years (change in slope: -0.23; 95% CI: -0.42 to -0.04), individuals aged between 40 and 49 years (change in slope: -0.39; 95% CI: -0.70 to -0.09), those with a primary education or lower (change in slope: -0.37; 95% CI: -0.50 to -0.25), individuals belonging to the poorest socioeconomic level (change in slope: -0.30; 95% CI: -0.49 to -0.11), those in the middle socioeconomic level (change in slope: -0.51; 95% CI: -0.99 to -0.04), those living in rural areas (change in slope: -0.46; 95% CI: -0.76 to -0.17), and those residing in the coastal region excluding

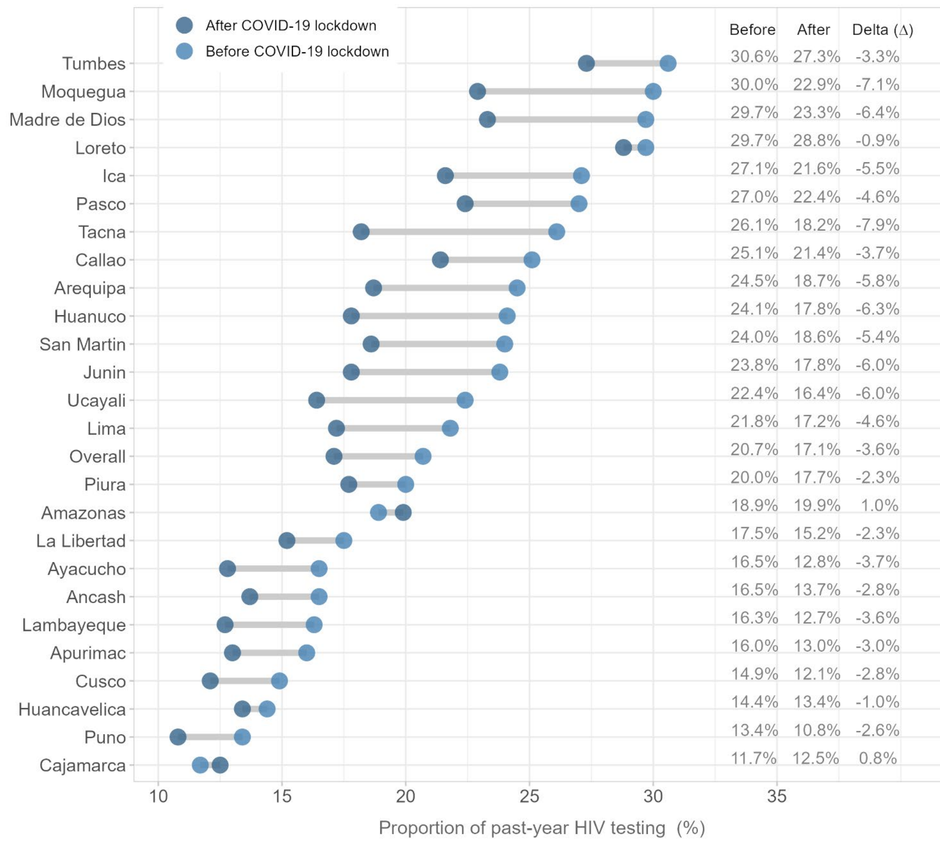

Fig. 1 Comparison of the departmental prevalence of HIV testing after the COVID-19 lockdown (August 2020 to December 2022) vs. before the COVID-19 lockdown (January 2014 to February 2020)

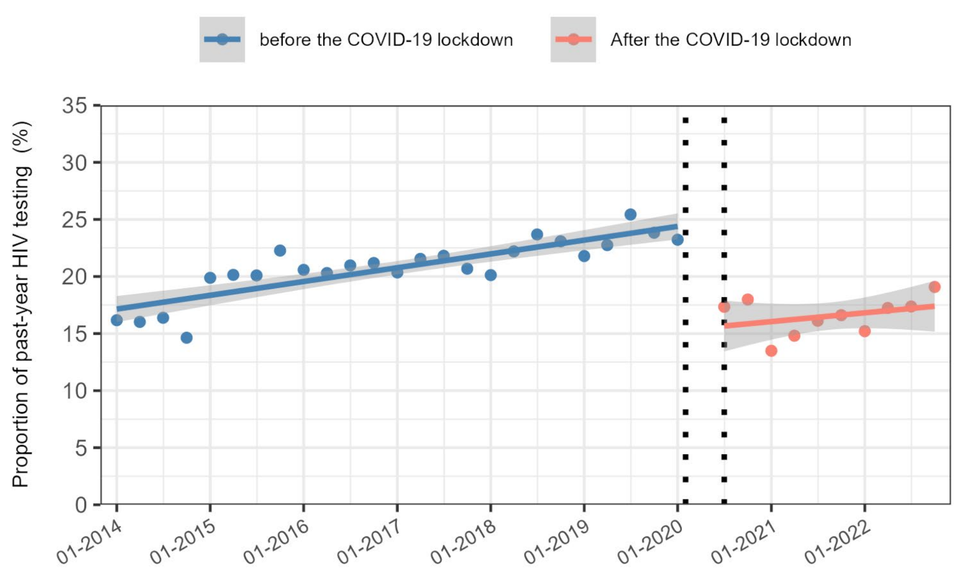

Fig. 2 Interrupted time series analysis for the proportion of past-year HIV testing per quarter

Lima (change in slope: -0.30; 95% CI: -0.58 to -0.01), in the highlands (change in slope: -0.41; 95% CI: -0.68 to -0.13), and in the jungle (change in slope: -0.67; 95% CI: -0.96 to -0.37). All the findings remained consistent after considering seasonality (Fourier terms) in the models (Table 2).

Finally, when predicting the counterfactual values in the absence of the COVID-19 pandemic and comparing

Table 2 Interrupted time series regression analysis to evaluate the impact of COVID-19 lockdown on the proportion of past-year HIV testing in Peru

Frequency of HIV testing in the last year	Model 1			Model 2		
	Estimated Impact: β	95% CI	*p*-value	Estimated Impact: β	95% CI	*p*-value
All (see Fig. 3)						
Pre-intervention slope (trend, per quarter)	0.30	0.21 to 0.40	**< 0.001**	0.30	0.21 to 0.40	**< 0.001**
Change in intercept (immediate effect)	-8.33	-10.73 to -5.93	**< 0.001**	-8.40	-10.32 to -6.34	**< 0.001**
Change in slope (interaction, gradual effect, per quarter)	-0.24	-0.56 to 0.09	0.125	-0.24	-0.52 to 0.04	0.112
Females						
Pre-intervention slope (trend, per quarter)	0.23	0.06 to 0.39	**< 0.001**	0.23	0.06 to 0.40	**0.002**
Change in intercept (immediate effect)	-7.60	-10.01 to -5.18	**< 0.001**	-7.75	-9.94 to -5.26	**< 0.001**
Change in slope (interaction, gradual effect, per quarter)	-0.17	-0.54 to 0.20	0.468	-0.16	-0.51 to 0.17	0.511
Males						
Pre-intervention slope (trend, per quarter)	0.37	0.30 to 0.45	**< 0.001**	0.37	0.31 to 0.43	**< 0.001**
Change in intercept (immediate effect)	-9.01	-11.96 to -6.06	**< 0.001**	-8.99	-11.39 to -6.63	**< 0.001**
Change in slope (interaction, gradual effect, per quarter)	-0.31	-0.63 to 0.01	0.057	-0.33	-0.56 to -0.05	**0.024**
15 to 17 years						
Pre-intervention slope (trend, per quarter)	0.21	0.01 to 0.41	**0.006**	0.21	0.02 to 0.4	**0.008**
Change in intercept (immediate effect)	-5.24	-8.86 to -1.62	**0.006**	-5.24	-8.52 to -1.96	**0.009**
Change in slope (interaction, gradual effect, per quarter)	-0.23	-0.42 to -0.04	**0.038**	-0.22	-0.43 to -0.02	**0.042**
18 to 29 years						
Pre-intervention slope (trend, per quarter)	0.26	0.10 to 0.43	**< 0.001**	0.25	0.12 to 0.41	**< 0.001**
Change in intercept (immediate effect)	-10.49	-13.66 to -7.33	**< 0.001**	-10.28	-12.99 to -8.00	**< 0.001**
Change in slope (interaction, gradual effect, per quarter)	-0.18	-0.52 to 0.15	0.458	-0.24	-0.46 to 0.09	0.257
30 to 39 years						
Pre-intervention slope (trend, per quarter)	0.30	0.20 to 0.39	**< 0.001**	0.30	0.19 to 0.40	**< 0.001**
Change in intercept (immediate effect)	-8.03	-11.48 to -4.58	**< 0.001**	-8.32	-11.03 to -5.04	**< 0.001**
Change in slope (interaction, gradual effect, per quarter)	-0.10	-0.66 to 0.47	0.649	-0.07	-0.62 to 0.42	0.733
40 to 49 years						
Pre-intervention slope (trend, per quarter)	0.26	0.14 to 0.38	**< 0.001**	0.26	0.14 to 0.38	**< 0.001**
Change in intercept (immediate effect)	-4.91	-8.13 to -1.69	**0.006**	-4.99	-7.73 to -2.09	**0.007**
Change in slope (interaction, gradual effect, per quarter)	-0.39	-0.70 to -0.09	**0.011**	-0.4	-0.67 to -0.12	**0.012**
Primary or lower						
Pre-intervention slope (trend, per quarter)	0.17	0.06 to 0.28	**0.004**	0.16	0.06 to 0.27	**0.002**
Change in intercept (immediate effect)	-4.67	-6.25 to -3.08	**0.002**	-4.34	-5.99 to -3.35	**0.001**
Change in slope (interaction, gradual effect, per quarter)	-0.37	-0.50 to -0.25	**0.049**	-0.43	-0.50 to -0.25	**0.016**
Secondary						
Pre-intervention slope (trend, per quarter)	0.22	0.11 to 0.33	**< 0.001**	0.21	0.12 to 0.32	**< 0.001**
Change in intercept (immediate effect)	-7.56	-9.22 to -5.91	**< 0.001**	-7.54	-8.8 to -6.33	**< 0.001**
Change in slope (interaction, gradual effect, per quarter)	-0.28	-0.52 to -0.04	0.047	-0.3	-0.48 to -0.08	0.041
Higher education (non-university)						
Pre-intervention slope (trend, per quarter)	0.28	0.14 to 0.42	**0.016**	0.29	0.12 to 0.43	**0.015**
Change in intercept (immediate effect)	-10.16	-13.72 to -6.60	**< 0.001**	-10.60	-13.70 to -6.62	**< 0.001**
Change in slope (interaction, gradual effect, per quarter)	0.17	-0.66 to 1.00	0.666	0.21	-0.62 to 0.96	0.602
University education						
Pre-intervention slope (trend, per quarter)	0.14	0.01 to 0.27	**0.014**	0.14	0.01 to 0.26	**0.015**
Change in intercept (immediate effect)	-7.98	-12.62 to -3.33	**0.001**	-8.13	-11.79 to -4.16	**0.002**
Change in slope (interaction, gradual effect, per quarter)	-0.01	-0.45 to 0.44	0.991	-0.01	-0.41 to 0.40	0.978
Poorest						
Pre-intervention slope (trend, per quarter)	0.30	0.11 to 0.49	**< 0.001**	0.30	0.13 to 0.48	**< 0.001**
Change in intercept (immediate effect)	-5.52	-8.67 to -2.36	**< 0.001**	-5.44	-8.13 to -2.9	**< 0.001**
Change in slope (interaction, gradual effect, per quarter)	-0.30	-0.49 to -0.11	**0.018**	-0.33	-0.49 to -0.11	**0.011**
Poor						
Pre-intervention slope (trend, per quarter)	0.26	0.16 to 0.35	**< 0.001**	0.25	0.17 to 0.34	**< 0.001**
Change in intercept (immediate effect)	-8.13	-10.42 to -5.83	**< 0.001**	-7.99	-9.92 to -6.34	**< 0.001**

Table 2 (continued)

Frequency of HIV testing in the last year	Model 1			Model 2		
	Estimated Impact: β	95% CI	*p*-value	Estimated Impact: β	95% CI	*p*-value
Change in slope (interaction, gradual effect, per quarter)	-0.24	-0.65 to 0.16	0.231	-0.28	-0.58 to 0.09	0.136
Middle						
Pre-intervention slope (trend, per quarter)	0.31	0.18 to 0.44	**< 0.001**	0.30	0.18 to 0.43	**< 0.001**
Change in intercept (immediate effect)	-8.50	-11.47 to -5.53	**< 0.001**	-8.44	-11.26 to -5.73	**< 0.001**
Change in slope (interaction, gradual effect, per quarter)	-0.51	-0.99 to -0.04	**0.012**	-0.53	-0.97 to -0.06	**0.014**
Rich						
Pre-intervention slope (trend, per quarter)	0.24	0.11 to 0.37	**< 0.001**	0.23	0.12 to 0.36	**< 0.001**
Change in intercept (immediate effect)	-8.81	-12.83 to -4.8	**< 0.001**	-8.94	-11.92 to -5.7	**< 0.001**
Change in slope (interaction, gradual effect, per quarter)	0.12	-0.47 to 0.72	0.641	0.11	-0.35 to 0.6	0.658
Richest						
Pre-intervention slope (trend, per quarter)	0.15	-0.01 to 0.31	**0.065**	0.15	-0.01 to 0.32	**0.08**
Change in intercept (immediate effect)	-10.1	-13.12 to -7.07	**< 0.001**	-10.09	-12.89 to -7.31	**< 0.001**
Change in slope (interaction, gradual effect, per quarter)	0.45	-0.04 to 0.93	0.124	0.44	0.01 to 0.88	0.147
Urban						
Pre-intervention slope (trend, per quarter)	0.26	0.13 to 0.39	**< 0.001**	0.26	0.13 to 0.39	**< 0.001**
Change in intercept (immediate effect)	-8.52	-11.35 to -5.69	**< 0.001**	-8.59	-10.91 to -6.13	**< 0.001**
Change in slope (interaction, gradual effect, per quarter)	-0.15	-0.57 to 0.27	0.463	-0.15	-0.51 to 0.21	0.446
Rural						
Pre-intervention slope (trend, per quarter)	0.29	0.14 to 0.43	**< 0.001**	0.28	0.16 to 0.42	**< 0.001**
Change in intercept (immediate effect)	-6.53	-8.66 to -4.40	**< 0.001**	-6.6	-8.27 to -4.78	**< 0.001**
Change in slope (interaction, gradual effect, per quarter)	-0.46	-0.76 to -0.17	**0.018**	-0.47	-0.78 to -0.14	**0.014**
Lima Metropolitan						
Pre-intervention slope (trend, per quarter)	0.17	0.00 to 0.34	0.061	0.16	0.00 to 0.34	0.058
Change in intercept (immediate effect)	-8.45	-12.41 to -4.49	**< 0.001**	-8.33	-11.61 to -5.30	**< 0.001**
Change in slope (interaction, gradual effect, per quarter)	0.18	-0.43 to 0.80	0.555	0.14	-0.28 to 0.65	0.632
Coast without Lima						
Pre-intervention slope (trend, per quarter)	0.33	0.22 to 0.44	**< 0.001**	0.32	0.22 to 0.43	**< 0.001**
Change in intercept (immediate effect)	-9.15	-11.19 to -7.10	**< 0.001**	-9.03	-10.88 to -7.41	**< 0.001**
Change in slope (interaction, gradual effect, per quarter)	-0.30	-0.58 to -0.01	**0.047**	-0.32	-0.57 to -0.03	**0.045**
Highlands						
Pre-intervention slope (trend, per quarter)	0.25	0.19 to 0.32	**< 0.001**	0.26	0.19 to 0.32	**< 0.001**
Change in intercept (immediate effect)	-6.17	-8.25 to -4.10	**< 0.001**	-6.37	-7.88 to -4.47	**< 0.001**
Change in slope (interaction, gradual effect, per quarter)	-0.41	-0.68 to -0.13	**0.005**	-0.39	-0.65 to -0.16	**0.006**
Jungle						
Pre-intervention slope (trend, per quarter)	0.43	0.34 to 0.51	**< 0.001**	0.43	0.34 to 0.51	**< 0.001**
Change in intercept (immediate effect)	-9.07	-10.77 to -7.37	**< 0.001**	-9.11	-10.83 to -7.31	**< 0.001**
Change in slope (interaction, gradual effect, per quarter)	-0.67	-0.96 to -0.37	**< 0.001**	-0.66	-0.97 to -0.36	**0.001**

HIV; Human immunodeficiency virus; β: Crude beta coefficient; CI: confidence interval

Model 1: Poisson segmented regression models with autocorrelation addressed using Newey-West standard errors to calculate confidence intervals, with a lag of up to 3; *p*-values < 0.05 are shown in bold

Model 2: Sensitivity analyses that take into account seasonality using two Fourier pairs in Poisson segmented regression models with autocorrelation addressed using Newey-West standard errors to calculate confidence intervals, with a lag of up to 3; *p*-values < 0.05 are shown in bold

these with the values observed by means of the ARIMA model, we noted that the percentage change between the observed and the counterfactual values was −9.20% evidence (95%CI: -13.70 to -4.80), while the ratio between the observed and the counterfactual values was 0.65 (95%CI: 0.78 to 0.56) (Fig. 3, and Table 3).

Discussion

This study reports a significant decrease in the proportion of HIV screening tests following the lockdown in Peru. Prior to the lockdown, 20.7% of participants underwent HIV screening tests, whereas this figure decreased to 17.1% in the post-lockdown period, with an increase to 19.1% in the fourth period of 2022. This decline aligns with trends observed in other countries, such as the United States [21], South Africa [18], and Malawi [22],

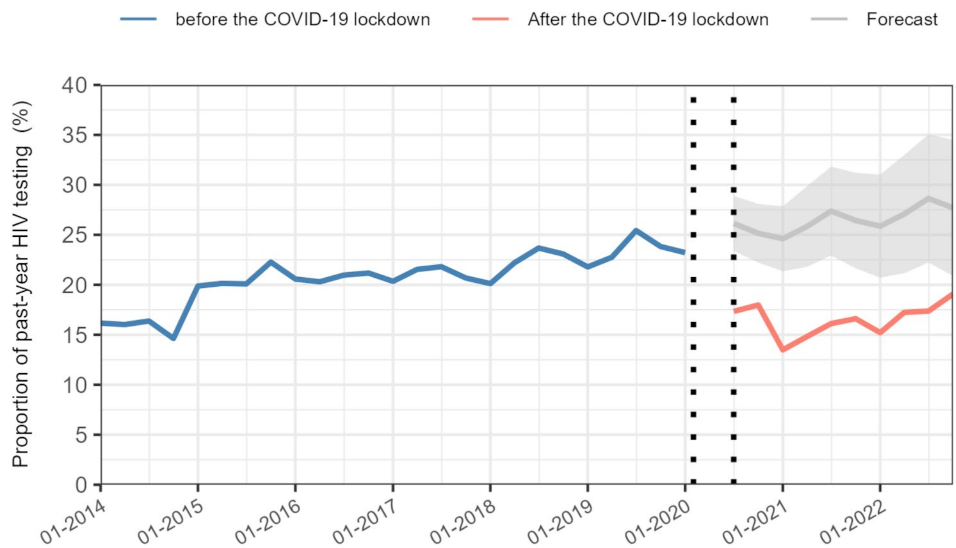

Fig. 3 Interrupted time series analysis for proportion of past-year HIV testing, The blue points and line represent the period before the COVID-19 lockdown (January 2014 to February 2020). The red points and line represent the period after the COVID-19 lockdown (August 2020 to December 2022), The grey line corresponds to the predicted counterfactual proportion in the scenario in which the COVID-19 lockdown did not occur, and includes a 95% confidence interval

Table 3 Effect of COVID-19 pandemic on proportion of past-year HIV testing in Peru from 2020 to 2022

Period	Observed proportion of past-year HIV testing (%)	Counterfactual (forecast) proportion of past-year HIV testing (%) [95% CI]	Difference	
			Absolute [95%CI]	Ratio [95%CI]
Q4–2020	18.0	25.2 [22.2–28.1]	-7.17 [-10.11 to -4.24]	0.71 [0.64 to 0.81]
Q1–2021	13.5	24.6 [21.4–27.9]	-11.12 [-14.36 to -7.87]	0.55 [0.48 to 0.63]
Q2–2021	14.8	25.8 [21.8–29.8]	-11.01 [-15.04 to -6.98]	0.57 [0.50 to 0.68]
Q3–2021	16.1	27.4 [22.9–31.8]	-11.26 [-15.70 to -6.81]	0.59 [0.51 to 0.70]
Q4–2021	16.6	26.4 [21.7–31.2]	-9.82 [-14.60 to -5.04]	0.63 [0.53 to 0.77]
Q1–2022	15.2	25.9 [20.7–31.0]	-10.66 [-15.81 to -5.51]	0.59 [0.49 to 0.73]
Q2–2022	17.2	27.1 [21.2–33.0]	-9.84 [-15.75 to -3.92]	0.64 [0.52 to 0.81]
Q3–2022	17.4	28.6 [22.2–35.0]	-11.27 [-17.68 to -4.87]	0.61 [0.50 to 0.78]
Q4–2022	19.1	27.7 [20.9–34.5]	-8.62 [-15.43 to -1.80]	0.69 [0.55 to 0.91]
Overall	17.1	26.3 (21.9–30.8)	-9.20 [-13.70 to -4.80]	0.65 [0.78 to 0.56]

HIV; Human immunodeficiency virus; Q: Quarter; CI: Confidence interval

where reductions ranging from 31.9 to 54.5% have been described.

Several factors likely contributed to this decrease in HIV screening rates. The closure or limited capacity of laboratories due to reallocation of resources towards COVID-19 testing may have impacted the availability of HIV testing services. Additionally, fear of COVID-19 exposure among patients could have deterred individuals from seeking routine healthcare services, including HIV screening. Furthermore, transportation difficulties and economic constraints resulting from pandemic-related restrictions may have further hindered access to healthcare facilities offering HIV testing services [23, 24]. Another important factor is that COVID-19 pandemic led to changes in sexual behavior, which may have influenced individual motivations for HIV testing. Studies in both South America and other countries report a mixed impact on sexual behavior during the pandemic, with some individuals reducing sexual activity due to social distancing measures and others engaging in higher-risk behaviors driven by isolation, anxiety, and limited access to preventive services [25]. These changes in sexual behavior could explain some of the variation in HIV testing observed in Peru, as risk perception and testing behaviors are often closely linked.

In response to these challenges, the Ministry of Health of Peru has implemented various strategies aimed at bolstering HIV testing and treatment services, particularly at the primary healthcare level. These initiatives include decentralizing molecular testing, contact tracing notification, and decentralizing antiretroviral treatment [26]. However, despite these efforts, the results of our study indicate that by December 2022, HIV testing rates had not yet returned to pre-pandemic levels. This slow recovery contrasts with experiences in other countries (such as Myanmar, Rwanda, etc.) where a more rapid rebound in testing rates was observed [22, 27].

In addition, the persistent low testing rates in Peru may be attributed to several factors. Firstly, the overwhelming focus on COVID-19 response within hospital settings may have diverted attention and resources away from routine healthcare services, including HIV testing. Secondly, the suspension of services at the primary care level for HIV screening during the lockdown period likely disrupted the continuity of care for individuals at risk of HIV infection. Additionally, inadequate budget al.location for health may have limited the capacity of healthcare systems to scale up HIV testing services in the aftermath of the pandemic [27].

Furthermore, our study identified a downward trend in the number of tests among individuals with lower socioeconomic status, lower education levels, residing in rural areas, living outside the capital, and belonging to extreme age groups (15 to 17 years and 40 to 49 years) during the post-lockdown period. This trend is consistent with findings from previous research, in which similar factors were associated with reduced HIV testing rates [28, 29]. Plausible explanations for these disparities include the potential correlation between higher education and increased awareness of HIV-related issues [30]. Additionally, urban areas, typically better resourced, may offer greater accessibility to testing services [31], In Peru, the concentration of these services in the capital (Lima) may exacerbate the disparities observed, especially given the deficiencies in primary care services [9]. Concerning age, research indicates that individuals younger than 19 years face higher levels of stigma associated with HIV testing [32]. However, there is a lack of clarity regarding why those over 40 years exhibit lower rates of testing despite evidence suggesting that stigma is less prevalent in this age group [33] g. Thus, addressing these multifaceted dynamics is crucial for devising targeted interventions to mitigate the impact of the COVID-19 pandemic on HIV testing utilization, particularly among the vulnerable populations identified in our study.

Implications for public health

Our study reveals a decrease in HIV testing without recovery to pre-pandemic levels by December 2022, particularly among the vulnerable populations identified in this analysis. For public health the implications of this reduction are substantial, as the UNAIDS targets of 95-95-95, aimed at diagnosing, treating, and achieving viral suppression in 95% of people living with HIV, have already been challenging to meet in Peru in recent years, despite an upward trend in these indicators [34, 35].

The COVID-19 pandemic has intensified this challenge, particularly affecting the vulnerable populations identified. In response, potential strategies to enhance early HIV diagnosis include the adoption of self-administered tests recommended by the WHO, leveraging telehealth, and reinforcing primary care with the decentralization of HIV testing and treatment [13, 36]. Diagnosis as early as possible is critical for public health, as a substantial proportion of HIV transmissions occur among people who are unaware of their infection, especially considering the observed increase in cases at advanced stages during the pandemic [37, 38]. However, it is important to be aware of the limitations of HIV antibody tests, which can only reliably detect antibodies approximately 90 days after infection [39].

Innovative approaches, such as combining HIV and COVID-19 testing in emergency departments, have been proposed, recognizing that acute HIV infection symptoms may mimic those of COVID-19 [40]. Moreover, it is essential to acknowledge the likely shortages of both HIV tests and treatments during the pandemic, particularly in rural areas [9]. Addressing these challenges requires a multifaceted approach that prioritizes vulnerable populations, integrates innovative testing methods, and ensures the sustained availability of resources for HIV prevention and treatment.

Limitations and strengths

Regarding limitations, we acknowledge the potential for recall bias or inadequate understanding of questions in certain subgroups. However, the interviewers received proper training for fieldwork to minimize these issues. Secondly, being derived from a secondary database, we lack information on the test results, limiting our ability to comprehend the impact of COVID-19 on HIV positivity. Thirdly, it is essential to recognize that the prediction error of the ARIMA model might increase when applied to longer prediction times, potentially affecting the accuracy of our results. This led to an expansion of the 95% CI with a greater number of prediction points in this study. Fourthly, these results are confined to the population aged 15 to 49 years, and this demographic limitation should be considered. Lastly, our data relied on self-reporting, introducing the possibility of social desirability bias, particularly given the sensitive nature of questions related to a stigmatized infection.

Despite these limitations, we analyzed information gathered from a national survey spanning from 2014 to 2022. Moreover, this study marks the first in Peru to utilize nationally representative data to assess the impact of COVID-19 on HIV testing, employing a time series approach. Additionally, the survey was conducted by adequately trained personnel, aiming to minimize errors in data collection and enhance the overall quality and accuracy of the information. Therefore, we believe that the findings of this study help to provide comprehensive understanding of the impact of COVID-19 on HIV testing in Peru.

Conclusions

In conclusion, the findings of this interrupted time-series study suggest that the COVID-19 lockdown policies in Peru led to a significant reduction on HIV testing without restoration to pre-pandemic levels, particularly among specific population groups, such as those with lower socioeconomic status, lower educational attainment, residing in rural areas, living outside the capital, and belonging to extreme age groups (15 to 17 years and 40 to 49 years). We believe that adequate public health interventions are needed in Peru to mitigate the impact of the COVID-19 pandemic on HIV testing, especially among vulnerable populations.

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s12879-024-10407-y.

Supplementary Material 1

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Data availability
The datasets are available in the "Instituto Nacional de Estadistica e Informatica" repository, (https://proyectos.inei.gob.pe/microdatos/index.htm). In addition, the datasets and materials are available upon reasonable request to the corresponding author.

Declarations

Ethics approval and consent to participate
Not applicable.

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

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