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Original article

An empirical analysis of the effects of schistosomiasis and lymphatic filariasis on macroeconomic output in Ghana

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ABSTRACT

Background: Schistosomiasis and Lymphatic Filariasis (LF) are endemic in Ghana. These diseases cause significant morbidity and disability which can adversely affect the participation of affected persons and their caregivers in economic activities, resulting in reduced economic output at the macrolevel. This study, therefore aims to provide the first empirical evidence of the effects of these diseases on economic output at the macrolevel in Ghana.

Methods: The study uses annual time series data on Ghana collected from secondary sources over the period, 1990–2019. Gross Domestic Product (GDP) is used as the proxy for macroeconomic output (i.e., dependent variable) and the main independent variables are the point prevalence of schistosomiasis and LF (including their sex disaggregation). The Ordinary Least Square (OLS) and the Instrumental Variable Two-Stage Least Square (IV2SLS) regressions are employed as estimation techniques.

Results: Using the OLS (IV2SLS) regressions, a percentage increase in the overall prevalence of schistosomiasis as well as the prevalence of schistosomiasis among males and females is found to be associated with a 1.37% (1.36%), 1.29% (1.30%) and 1.41% (1.39%) fall in macroeconomic output respectively, at the 1% level of significance. Similarly, a percentage increase in the overall prevalence of LF as well as the prevalence of LF among males and females is found to be associated with a 0.34% (0.37%), 0.34% (0.37%) and 0.34% (0.38%) fall in macroeconomic output respectively, at the 1% level of significance.

Conclusion: There is the need to strengthen efforts towards fighting schistosomiasis and LF in Ghana in order to reduce their associated economic losses.

1. Introduction

Schistosomiasis and Lymphatic Filariasis (LF) are among the common Neglected Tropical Diseases (NTDs) in Ghana. These diseases normally affect the poor, especially those without access to adequate sanitation facilities and safe drinking water.[1] Schistosomiasis is contracted through contact with water contaminated by parasitic worms[2] while LF is transmitted by various species of mosquitoes including *Aedes*, *Culex*, *and Anopheles*[3].

The signs, symptoms and other effects of these diseases could lead to absenteeism and presenteeism among affected persons, resulting into reduced economic output at both the individual(micro) and macro

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(overall) levels. For instance, LF has been noted to be associated with severe pain and disability due to unusual enlargement of body parts[4] while schistosomiasis can be associated with lower abdominal pain and tiredness.[2] In Ghana, schistosomiasis and LF were respectively responsible for Disability-Adjusted Life Years (DALYs) of 46442 years and 14388 years in 2019. In the same year, the Years Lived with Disability (YLDs) from schistosomiasis and LF stood at 37304 years and 14388 years, respectively.[5]

Given the above, studies have been conducted to examine the economic burden of schistosomiasis and LF in other parts of the world[6–11] and Ghana.[12] However, the study on Ghana[12] focused on LF and not schistosomiasis. Moreover, the study investigated the economic burden of LF at the individual level in Northern Ghana (using cross-sectional data) and not all endemic settings in the country.[12] This therefore does not give insight on the effect of LF on macroeconomic output. Conducting a macrolevel analysis helps in unearthing the effects of these diseases on economic output in the whole country, which is more important in highlighting the overall output losses associated with these diseases, which would help in drawing more attention on the need to deepen efforts towards fighting these diseases. In addition, while cross-sectional analysis can provide evidence at a single point in time, it is unable to provide evidence spanning several time intervals.

This study therefore proposes to fill the above lacunae in the literature by examining the effects of schistosomiasis and LF on economic output at the macrolevel in Ghana using annual time series data from 1990 to 2019. The study also investigates the sex dimensions of the effects of these diseases on macroeconomic output. Thus, to the best of our knowledge, the study is the foremost macrolevel empirical analysis of the effects of schistosomiasis and LF on economic output in Ghana, employing data over several periods (years). By doing so, the study provides insights on the overall effects of schistosomiasis and LF as well as the sex specific effects of these conditions on macroeconomic output in Ghana. These findings are expected to increase the attention given to the fight against these diseases which would help to significantly decrease the huge economic losses associated with them.

2. Methods

2.1. Data

Annual time series data on Ghana for the period, 1990–2019, are used by this study to examine the effects of schistosomiasis and LF on macroeconomic output. The study period is dictated by the availability of data on all variables. The dependent variable is macroeconomic output (EO) proxied by Gross Domestic Product (GDP). The point prevalence of schistosomiasis and LF (i.e. i. overall prevalence, ii. prevalence among males, and iii. prevalence among females) are the main independent variables. Foreign Direct Investment (FDI), inflation, regulatory quality,[1] domestic investment, consumption and net exports are used as control variables. These control variables are selected based on literature.[13–17] The data on schistosomiasis and LF are obtained from the Global Burden of Diseases Study,[52] data on regulatory quality are obtained from the World Bank's Worldwide Governance Indicators[18] and data on all the rest of the variables are obtained from the World Bank's World Development Indicators.[19]

GDP is measured in constant 2015 United States (US) Dollars ($), and the point prevalence of schistosomiasis and LF are measured in percentages. FDI is measured as net inflows as a percentage of GDP, consumption is measured as final consumption expenditure as a percentage of GDP, and inflation is measured by GDP deflator in percentages. In addition, regulatory quality is measured on a scale of −2.5 to 2.5 (with higher figures indicating better regulatory quality), domestic investment is measured by gross fixed capital formation as a percentage of GDP and net exports is measured by the difference between exports (as a percentage of GDP) and imports (as a percentage of GDP).[3]

We expect the prevalence of schistosomiasis and LF to have negative effects on macroeconomic output because, health is an important component of human capital, and human capital is a major determinant of economic output.[20,21] Thus, as espoused above (in the introduction), schistosomiasis and LF would negatively affect the economic productivity of affected persons and their caregivers through absenteeism and presenteeism. The expected signs of FDI, net exports and inflation can be either positive or negative. The expected signs of domestic investment and regulatory quality are positive. The explanations for the expected signs of the control variables can be found elsewhere.[22]

2.2. Model specification and estimation strategy

To examine the effects of schistosomiasis and LF on macroeconomic output, we specify the equations below:

$$EO_t = f\,(SCH_t, M_t), \tag{1}$$

$$EO_t = f\,(LF_t, M_t), \tag{2}$$

where EO is as defined already in sub-section 2.1, time (years) is represented by t, SCH and LF represent the prevalence of schistosomiasis and LF respectively, and M is a vector of the chosen control variables.

We respecify equations 1 and 2 in more estimable forms as follows:

$$EO_t = \varpi + \varphi SCH_t + \aleph M_t + \varepsilon_t \tag{3}$$

$$EO_t = \varpi + \beta LF_t + \aleph M_t + \varepsilon_t, \tag{4}$$

where ϖ is the intercept of the equations, the coefficients of schistosomiasis, LF and the vector of control variables are indicated by φ, β and $\aleph$ respectively, and the disturbance term is indicated by ε.

Concerning the empirical estimation strategy, we use the Ordinary Least Square (OLS) regression for our baseline analysis since the dependent variable is continuous. However, there is a potential endogeneity between macroeconomic output and the selected NTDs, which if not addressed, could biased the estimates. Thus, higher macroeconomic output would be associated with higher income which would improve the ability of people, especially the poor to afford quality healthcare, improved water and sanitation as well as other health inputs, hence reducing the prevalence of schistosomiasis and LF, and vice versa.

To address this plausible endogeneity problem, the Instrumental Variable Two-Stage Least Square (IV2SLS) regression, given its ability to deal with endogeneity, is used as a robustness check to the OLS estimates. Since the IV2SLS regression requires the use of instruments, we employ the first lags of the selected NTDs and the first lag of gross national expenditure (as a percentage of GDP) as instruments. This is because, current macroeconomic output cannot affect previous levels of the instruments, however, these instruments can affect the current levels of the prevalence of the chosen NTDs. The data on gross national expenditure are gleaned from the World Bank's World Development Indicators.[19]

The appropriateness of our IV2SLS estimates are checked using the Kleibergen-Paap rk LM underidentification test (UI), the Kleibergen-Paap rk Wald F statistic test of weak identification (WI), and the

[1] Gaps in the regulatory quality data are filled using linear interpolation and extrapolation.

[2] It should be noted that, for the Global Burden of Diseases Study, the data on DALYs and YLDs stated in the introduction were accessed on 23 June 2023 while data on overall prevalence of schistosomiasis and LF, as well as the sex disaggregated prevalence were accessed on 17 Feb 2023 and 28 May 2023, respectively.

[3] All these measurements are from the data sources, except net exports which is by the authors.

Table 1
Summary statistics of variables,1990–2019.

Variable	Obs	Mean	Std. Dev.	Min	Max
Macroeconomic output	30	3.024e+10	1.511e+10	1.317e+10	6.247e+10
Schistosomiasis (Overall)	30	0.278	0.068	0.131	0.351
Schistosomiasis (Males)	30	0.297	0.069	0.139	0.377
Schistosomiasis (Females)	30	0.259	0.068	0.123	0.328
Lymphatic filariasis (Overall)	30	0.048	0.031	0.009	0.089
Lymphatic filariasis (Males)	30	0.054	0.036	0.01	0.102
Lymphatic filariasis (Females)	30	0.042	0.027	0.008	0.077
FDI	30	3.957	2.815	0.251	9.467
Inflation	30	23.912	15.195	8.481	80.755
Regulatory quality	30	−0.227	0.225	−0.713	0.099
Domestic investment	30	20.577	4.923	11.764	29.002
Consumption	30	91.48	6.885	78.399	102.963
Net exports	30	−12.655	5.944	−25.273	−1.049

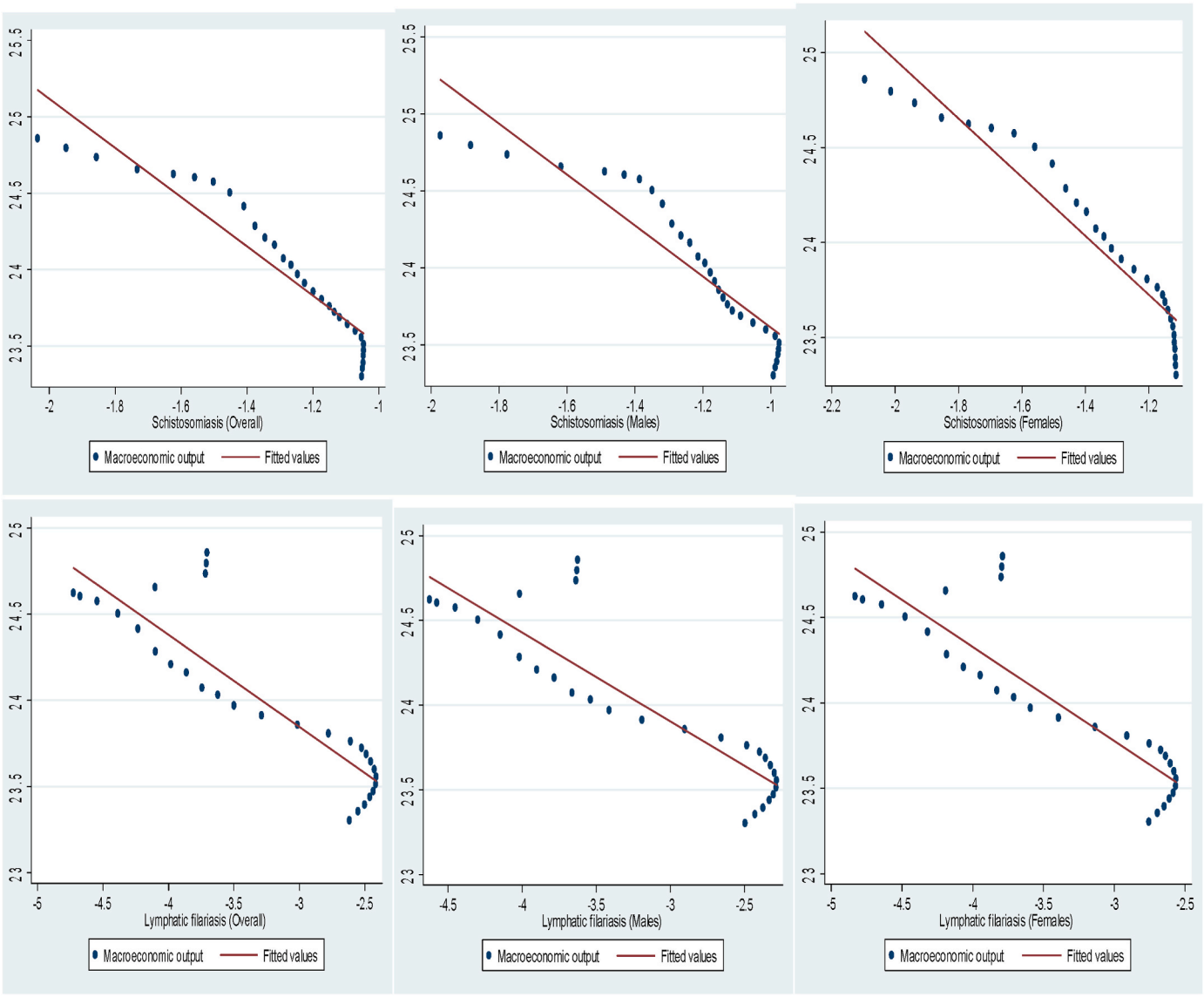

Fig. 1. Scatter plot of the relationship between schistosomiasis and LF, and macroeconomic output in Ghana, 1990–2019.

Hansen test of overidentification (HO). In addition, the Durbin-Wu-Hausman test of endogeneity (DH) is used to check if the chosen NTDs are endogeneous. The significance of the p-value of the UI indicates the absence of underidentification, while the insignificance of the p-values of the HO and the DH indicates the absence of overidentification and endogeneity (i.e OLS regression is adequate), respectively. Higher critical value of the WI relative to the Stock-Yogo critical values indicates the absence of weak identification.[23–28]

Our estimates are free from potential heteroscedasticity and serial correlation because we use robust standard errors. In order to estimate

Table 2
OLS regression estimates of the effects of schistosomiasis and LF on macroeconomic output in Ghana.

	(1)	(2)	(3)	(4)	(5)	(6)
	Macroeconomic output	Macroeconomic output	Macroeconomic output	Macroeconomic output	Macroeconomic output	Macroeconomic output
Schistosomiasis (Overall)	−1.367[c]					
	(0.133)					
FDI	0.027[b]	0.040[b]	0.013	−0.005	−0.006	−0.004
	(0.012)	(0.015)	(0.008)	(0.021)	(0.021)	(0.022)
Inflation	0.001	0.001	0.001	−0.005[b]	−0.005[b]	−0.005[b]
	(0.001)	(0.001)	(0.001)	(0.002)	(0.002)	(0.002)
Regulatory quality	0.411[b]	0.405[a]	0.446[c]	0.712[c]	0.707[c]	0.718[c]
	(0.174)	(0.224)	(0.129)	(0.214)	(0.207)	(0.223)
Domestic investment	0.009	0.013	0.003	−0.007	−0.007	−0.008
	(0.018)	(0.021)	(0.016)	(0.023)	(0.022)	(0.023)
Consumption	0.003	0.004	0.002	−0.026	−0.026	−0.026
	(0.019)	(0.023)	(0.016)	(0.023)	(0.023)	(0.024)
Net exports	−0.000	0.004	−0.005	0.003	0.003	0.003
	(0.019)	(0.024)	(0.017)	(0.023)	(0.023)	(0.024)
Schistosomiasis (Males)		−1.285[c]				
		(0.161)				
Schistosomiasis (Females)			−1.405[c]			
			(0.093)			
Lymphatic filariasis (Overall)				−0.339[c]		
				(0.061)		
Lymphatic filariasis (Males)					−0.337[c]	
					(0.057)	
Lymphatic filariasis (Females)						−0.342[c]
						(0.067)
Constant	21.706[c]	21.793[c]	21.817[c]	25.733[c]	25.767[c]	25.698[c]
	(1.841)	(2.284)	(1.613)	(2.303)	(2.254)	(2.374)
Observations	30	30	30	30	30	30
R^2	0.973	0.960	0.982	0.920	0.923	0.916
F-stat.	166.441	100.559	287.768	43.794	44.689	42.716
F-stat. p-value	0.000	0.000	0.000	0.000	0.000	0.000

Robust standard errors in parentheses; Macroeconomic output, and the prevalence of schistosomiasis and LF variables are log transformed; Macroeconomic output is the dependent variable.
[a] $p < 0.1$.
[b] $p < 0.05$.
[c] $p < 0.01$.

the degree of responsiveness of macroeconomic output to changes in the point prevalence of schistosomiasis and LF, we take natural logarithms of these variables.[29] Before the regression estimates, we present descriptive statistics (including scatter plots) of the variables. The data are analysed using Stata version 14.0.

3. Results

In this section, we present the results of the study. The descriptive statistics (including the scatter plots) are presented followed by the regression results.

3.1. Descriptive results

Over the study period, the overall average point prevalence of schistosomiasis is 0.28%. Regarding males and females, on the average, the point prevalence of schistosomiasis are 0.30% and 0.26% respectively. The overall average point prevalence of LF is 0.05% while the average point prevalence among males and females are 0.05% and 0.04% respectively. The average macroeconomic output in Ghana over the study period is thirty billion two hundred and forty million US Dollars (Table 1).

Fig. 1 shows a negative association between the prevalence of schistosomiasis and LF on one hand, and macroeconomic output on the other hand. Thus, rising prevalence of schistosomiasis and LF are associated with a decrease in macroeconomic output.

3.2. Regression results

In this sub-section, we present the OLS and IV2SLS estimates of the effects of schistosomiasis and LF on economic output at the macrolevel in Ghana (Tables 2 and 3).

In the OLS estimates, the findings show that schistosomiasis and LF have negative significant association with macroeconomic output in Ghana. Specifically, a percentage increase in the point prevalence of schistosomiasis (overall) is associated with a 1.37% decrease in macroeconomic output at the 1% level of significance. Similarly, a percentage increase in the point prevalence of schistosomiasis among males and females is found to be associated with a fall in macroeconomic output by 1.29% and 1.41%, respectively, at the 1% level of significance. Concerning LF, we find that, when the point prevalence of LF (overall) increases by 1%, it is associated with a 0.34% fall in macroeconomic output at the 1% level of significance. In addition, a 1% increase in the point prevalence of LF among males and females are found to be associated with a 0.34% fall in macroeconomic output at the 1 % level of significance (Table 2).

We find FDI to have a positive significant association with macroeconomic output. Specifically, a unit increase in FDI is found to be associated with a 0.03 (Table 2, Model 1) and 0.04 (Table 2, Model 2) units increase in macroeconomic output at the 5% level of significance. Similarly, a unit enhancement in regulatory quality is found to be associated with 0.41–0.72 units enhancement in macroeconomic output at conventional significance levels (1%, 5% and 10%). Conversely, we find a unit increase in inflation to be associated with a 0.01 unit decrease in macroeconomic output at the 5% level of significance (Table 2). It should however be noted that, since the control variables are not in

Table 3
IV2SLS regression estimates of the effects of schistosomiasis and LF on macroeconomic output in Ghana.

	(1)	(2)	(3)	(4)	(5)	(6)
	Macroeconomic output	Macroeconomic output	Macroeconomic output	Macroeconomic output	Macroeconomic output	Macroeconomic output
Schistosomiasis (Overall)	−1.363[c]					
	(0.121)					
FDI	0.027[c]	0.040[c]	0.014[a]	−0.011	−0.011	−0.010
	(0.010)	(0.013)	(0.007)	(0.019)	(0.019)	(0.020)
Inflation	0.001	0.001	0.001	−0.005[c]	−0.005[c]	−0.005[b]
	(0.001)	(0.001)	(0.001)	(0.002)	(0.002)	(0.002)
Regulatory quality	0.404[b]	0.395[a]	0.437[c]	0.634[c]	0.631[c]	0.638[c]
	(0.167)	(0.211)	(0.128)	(0.190)	(0.185)	(0.197)
Domestic investment	0.008	0.013	0.003	−0.011	−0.011	−0.012
	(0.016)	(0.019)	(0.015)	(0.020)	(0.020)	(0.020)
Consumption	0.003	0.004	0.001	−0.027	−0.027	−0.028
	(0.016)	(0.020)	(0.015)	(0.020)	(0.019)	(0.020)
Net exports	−0.000	0.004	−0.005	0.000	0.000	0.000
	(0.017)	(0.020)	(0.015)	(0.020)	(0.020)	(0.021)
Schistosomiasis (Males)		−1.303[c]				
		(0.150)				
Schistosomiasis (Females)			−1.386[c]			
			(0.083)			
Lymphatic filariasis (Overall)				−0.371[c]		
				(0.055)		
Lymphatic filariasis (Males)					−0.366[c]	
					(0.052)	
Lymphatic filariasis (Females)						−0.378[c]
						(0.060)
Constant	21.739[c]	21.738[c]	21.910[c]	25.823[c]	25.862[c]	25.780[c]
	(1.605)	(1.934)	(1.448)	(1.962)	(1.929)	(2.010)
Observations	29	29	29	29	29	29
Centered R^2	0.971	0.957	0.980	0.915	0.919	0.911
F-stat.	130.924	77.633	217.636	38.069	39.317	36.517
F-stat. p-value	0.000	0.000	0.000	0.000	0.000	0.000
UI	11.912	11.125	12.579	15.565	15.284	15.925
UI p-value	0.003	0.004	0.002	0.000	0.000	0.000
WI	1087.489	467.759	3003.582	85.706	95.747	74.616
HO	0.438	0.031	1.183	0.423	0.459	0.380
HO p-value	0.508	0.861	0.277	0.516	0.498	0.537
DH	0.507	1.086	10.000	1.174	1.060	1.304
DH p-value	0.476	0.297	0.002	0.279	0.303	0.253

Robust standard errors in parentheses; Macroeconomic output, and the prevalence of schistosomiasis and LF variables are log transformed; Macroeconomic output is the dependent variable; UI: The Kleibergen-Paap rk LM underidentification test; WI: The Kleibergen-Paap rk Wald F statistic weak identification test (This statistic is greater than all the Stock-Yogo critical values which are available upon request (and these critical values are for Cragg-Donald F statistic and i.i.d. errors)); HO: The Hansen test of overidentification; DH: The Durbin-Wu-Hausman test of endogeneity.

[a] $p < 0.1$.
[b] $p < 0.05$.
[c] $p < 0.01$.

logarithms, to interpret their effects on macroeconomic output as percentages, we have to exponentiate their coefficients, subtract 1 from the result and multiply it by 100.[31]

Using the IV2SLS regression (Table 3), the effects of schistosomiasis and LF on macroeconomic output are not qualitatively different from that of the OLS results. Specifically, using the IV2SLS regression, we find that when the point prevalence of schistosomiasis (overall) increases by 1%, it is associated with a 1.36% fall in macroeconomic output at the 1% level of significance. In addition, 1.30% and 1.39% fall in macroeconomic output are found to be associated with a 1% increase in the point prevalence of schistosomiasis among males and females, respectively, at the 1% level of significance. Also, a percentage increase in the point prevalence of LF (overall) is found to be associated with a 0.37% decrease in macroeconomic output at the 1% level of significance. Similarly, a percentage increase in the point prevalence of LF among males and females is found to be associated with a fall in macroeconomic output by 0.37% and 0.38%, respectively, at the 1% level of significance.

Regarding the control variables, we find that both FDI and regulatory quality have positive significant association with macroeconomic output (Table 3), hence, not qualitatively different from the OLS results in Table 2. Also, the effect of inflation on macroeconomic output in the IV2SLS regressions is negative and significant (at conventional levels) (Table 3), which is in line with the OLS regression results.

It must be stressed that all our IV2SLS estimates do not suffer from underidentification, weak identification and overidentification. Similarly, both the overall p-values of the OLS and IV2SLS regressions are highly significant (F-stat. p-value of 0.000), confirming the fitness of our models.

4. Discussion

This study investigates the effects of schistosomiasis and LF on macroeconomic output in Ghana, over the period, 1990–2019, making it the first of its kind in the Ghanaian context. We find a negative significant association between the prevalence of schistosomiasis and LF (including their sex disaggregation) on one hand, and macroeconomic output on the other hand irrespective of the estimation technique used.

Using the average macroeconomic output figure for Ghana (see Table 1), the IV2SLS (OLS) estimates imply that, over the study period, a percentage increase in the overall point prevalence of schistosomiasis and LF are associated with US$411 million (US$414 million) and US $112 million (US$103 million) fall in macroeconomic output,

respectively. These findings are not farfetched because of the huge DALYs and YLDs that are associated with schistosomiasis and LF in Ghana, which greatly reduce the participation of affected persons and their caregivers in economic activities, hence reducing economic output at the macrolevel. Although our data show that the prevalence of schistosomiasis and LF among males are higher than that of females (Table 1), our findings show that, when females are affected by schistosomiasis and LF, they are associated with higher loss in macroeconomic output relative to males (except the OLS estimates for LF where rounding to two decimal places makes the effect in males to be same as that of females). This could be that, since these diseases, especially schistosomiasis mostly affect poor agricultural populations,[1] and females are major contributors of agricultural labour in Ghana, when they are affected by these diseases, their huge contribution to the agricultural sector is lost or reduced, which negatively affects economic output at the macrolevel, especially since Ghana is agrarian.

There is therefore the need to increase efforts towards tackling these diseases. These should include building strong and efficient health systems, ensuring equity in accessing healthcare services and enhancing access to quality but affordable medicines. In addition, increasing access to improved sanitation and safe water, improving behaviour change and hygiene education, as well as ensuring community ownership of interventions are also important. Moreover, ensuring strong partnership among sectors such as water, agriculture, environment, education and finance is important towards addressing issues that cut-across in controlling these diseases.[1,30]

Our findings are not different from those of past studies. For instance, in Burkina Faso, untreated schistosomiasis has been found to be linked with a fall (loss) in GDP by 0.8%.[6] In a similar fashion, among patients and households in India, lost (reduced) working time and treatment costs due to LF are estimated to amount to an annual loss of US$ 842 million.[11]

Concerning the control variables, the finding on inflation having a negative association with macroeconomic output is not farfetched because rising prices make inputs of production expensive, limiting the ability of producers to produce more. This finding is consistent with some past studies.[14,15,17]

The finding on regulatory quality having a positive association with macroeconomic output is not farfetched since it (regulatory quality) can enhance the growth of the private sector, which is important for enhancing economic output.[22] Also, since FDI can supplement domestic resources,[25] it is not surprising that it is positively associated with macroeconomic output. Nonetheless, the finding on FDI is not in line with some previous studies.[13,14]

5. Conclusion

Schistosomiasis and LF are some of the common NTDs in Ghana, causing severe pain and disability among several number of people. These pain and disability have the potential of preventing or reducing the participation of affected persons and their caregivers in economic activities, hence, negatively affecting economic output at the macrolevel. Notwithstanding, as far as we are aware, there is no empirical evidence of the effects of schistosomiasis and LF on macroeconomic output in Ghana. Hence, this study attempts to fill this void using annual time series data on Ghana over the period, 1990–2019, while employing the OLS and IV2SLS regressions as estimation techniques. We find a negative significant association between schistosomiasis and LF on one hand, and macroeconomic output on the other hand irrespective of the estimation technique used. Our findings highlight the need to enhance measures (as outlined in the discussion) towards combatting these diseases in Ghana in order to significantly reduce the huge economic losses associated with them.

Ethics approval and consent to participate

Consent to participate and ethical approval are not required because the study employs secondary data.

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Authors' contributions

Conceptualisation: MI; Data acquisition: MI, KGK, IA, MAZ, AKM, AM, MKB, TJMK; Analysis and interpretation: MI; Original draft: MI, KGK, IA, MAZ, AKM, AM, MKB, TJMK; Critical revision for important intellectual content: MI. All the authors read and approved the final version of the manuscript.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to have influenced the work reported in this paper.

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