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Aligning policy for success in developing countries: evidence from the poultry sector of Ghana

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Abstract

This paper examines policy coherence in Ghana's poultry sector by assessing potential interactions between policy objectives. Using panel simultaneous equation models and the data-driven synthetic control method, we analyze the effects of policy interventions on domestic poultry production during 1999–2019. Our findings underscore the impact of policies enacted during this period on the growth of domestic poultry production. However, growth in production remains notably lower than the escalating imports of frozen poultry meat. Our coherence analysis identifies lowering production costs and enhancing productivity as crucial policy objectives that could positively affect food security and rural development. Nonetheless, we caution against prioritizing one objective over others, as this may adversely affect overall policy coherence and outcomes. Specifically, our study emphasizes the importance of striking a balance between fostering domestic production and ensuring food security.

Keywords: Policy coherence, Synergies, Synthetic control method, Poultry, Ghana

JEL Classification: Q10, Q18

Introduction

The agricultural sector plays a critical role in providing employment and livelihood opportunities across many Sub-Saharan African (SSA) countries (FAO 2021). However, despite decades of policy interventions aimed at enhancing agricultural productivity and achieving self-sufficiency, a significant portion of the population in SSA continues to suffer from severe food insecurity, malnutrition, and poverty (IFAD 2019; World Bank 2018). According to FAO et al. (2021), SSA has the world's highest prevalence of moderate and severe food insecurity as well as undernourishment. Paradoxically, many SSA countries remain heavily reliant on food imports, raising critical questions about the effectiveness of domestic policies intended to strengthen food production and address food insecurity (Rutten et al. 2013).

Considering that policies are pivotal in determining the success or failure of agricultural sectors, their design and implementation should balance competing objectives, such as enhancing domestic production, ensuring food security, and promoting

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sustainable development (FAO 2020). These competing objectives inevitably result in synergies and trade-offs that impact stakeholders in different ways. For instance, while subsidies for imported poultry may address immediate food security concerns by reducing consumer prices, they can simultaneously undermine domestic poultry producers by eroding their market competitiveness (Chibanda et al. 2022; Boimah et al. 2022). However, there is limited empirical analysis on the extent to which policy interventions in Sub-Saharan Africa's agricultural sectors, particularly in the poultry industry, influence domestic production and food security. Existing studies have primarily examined policy coherence in climate change adaptation (see, e.g., Kalaba et al. 2014; Antwi-Agyei et al. 2017; England et al. 2018; Ahmed et al. 2022).

In Ghana, the case study country, policies aimed at boosting domestic production have historically struggled to balance these objectives effectively. For example, while import restrictions may create synergies by fostering local employment and stimulating value-added activities in the supply chain, they also introduce trade-offs, such as increasing consumer prices, which can limit access to affordable protein for vulnerable populations (Mensah et al. 2019). These tensions underscore the complexity of designing policies that successfully reconcile multiple objectives while minimizing unintended consequences.

Despite the importance of understanding these dynamics, significant gaps remain in the literature. First, while policy interventions in Ghana's poultry sector have been numerous and varied since the 1990s, there is limited empirical evidence assessing whether these measures have effectively promoted domestic poultry production. Second, there is a lack of comprehensive analysis regarding how these policies interact, particularly concerning their coherence and the synergies or trade-offs they generate. These gaps are especially concerning given the sector's ongoing struggle to achieve substantial growth in domestic production amidst rising imports (Boimah et al. 2022; Chibanda et al. 2022). Bridging these gaps is essential to equip policymakers with the insights required to craft more impactful and cohesive interventions.

This study aims to address these gaps by examining policy coherence in Ghana's poultry sector. Specifically, it evaluates the effectiveness of policy interventions and investigates the alignment of multiple objectives within these policies. Ghana was selected as the focus because it represents the challenges faced by many Sub-Saharan African countries in balancing domestic production objectives with broader economic and social priorities. To the best of our knowledge, no previous study has provided a comprehensive assessment of the long-term impact of Ghana's poultry policies or analyzed the coherence of these policies in fostering synergies and mitigating trade-offs.

This study makes three key contributions to the literature. First, it provides a critical and comprehensive review of public interventions in Ghana's poultry sector, addressing the gap in historical and contextual analyses. Second, it employs an evidence-based analytical framework to evaluate the impact of these policies on domestic production and to analyze the synergies and trade-offs between policy objectives. Third, the findings offer actionable insights for policymakers, not only in Ghana but also in other regions with similar policy contexts. The study's implications extend beyond Ghana, delivering valuable guidance for regions grappling with comparable challenges in aligning agricultural policy objectives. By evaluating the effectiveness of specific interventions and examining the synergies and trade-offs they generate, this research provides a robust framework for

crafting cohesive policies that advance domestic production, strengthen food security, and promote sustainable agricultural development. These lessons are particularly pertinent for regions with analogous policy landscapes and development aspirations.

To achieve these objectives, two complementary analytical approaches are utilized: the synthetic control method (SCM) and panel cointegration analysis. The SCM evaluates the impact of policy interventions since the 1990s on Ghana's poultry production trajectory, providing a robust comparison of specific interventions against a counterfactual scenario. Panel cointegration analysis examines the interactions among key policy objectives—domestic production, food security, and agricultural value-added—offering a deeper understanding of potential synergies and trade-offs. The panel cointegration technique also facilitated the estimation of a simultaneous equation model that integrates these central policy components. By focusing on the importance of policy coherence in multi-objective agri-food policies within African contexts (Ayerakwa et al. 2020; Dutilly et al. 2020), this method enabled a detailed assessment of spillover effects and alignment among policy objectives. These approaches collectively emphasize the critical role of coherence in achieving sustainable agricultural outcomes and balancing competing policy goals.

The paper is structured into five sections. The next section offers an overview of Ghana's poultry sector, discussing both historical and current poultry policies along with their impacts. The third section details the study's methodology, including the tools and data used. The fourth section presents the findings and analyzes the economic impacts of specific policies implemented in the poultry sector. Finally, the fifth section concludes with actionable recommendations that are relevant not only for Ghana but also for other developing countries in Africa and beyond.

Ghana's poultry sector and policy landscape

Among the poultry species raised in Ghana—including turkeys, guinea fowls, ducks, ostriches, and pigeons (Aning 2006)—chickens dominate, accounting for approximately 92 percent of the total production (Ashitey 2017; FAO 2014). Poultry meat production systems are typically divided into two main categories: traditional free-range systems and commercial broiler production systems. The traditional free-range system, predominantly found in rural areas, focuses on the production of local poultry breeds for household consumption. In contrast, commercial production systems are business-oriented and further classified into three scales based on output: small (less than 5000 birds/year), medium (5000–20,000 birds/year), and large (more than 20,000 birds/year) (Chibanda et al. 2022).

From 2001 to 2014, poultry meat production in Ghana steadily increased (Fig. 1), primarily due to the expansion of production in the southern regions of the country, driven by growing urban demand for poultry meat (FAO 2014). However, from 2015 to 2020, growth in production slowed significantly. In contrast, poultry meat consumption has continued to rise markedly, with per capita consumption increasing from 1.6 in 1999 to 9.6 kg/person in 2018 (Zamani et al. 2021a, b). This growth in consumption is attributed to rapid population growth, urbanization, and rising incomes (Alagidede et al. 2013). The decline in domestic production, however, is largely due to high production costs, inefficient production technologies, and unreliable input

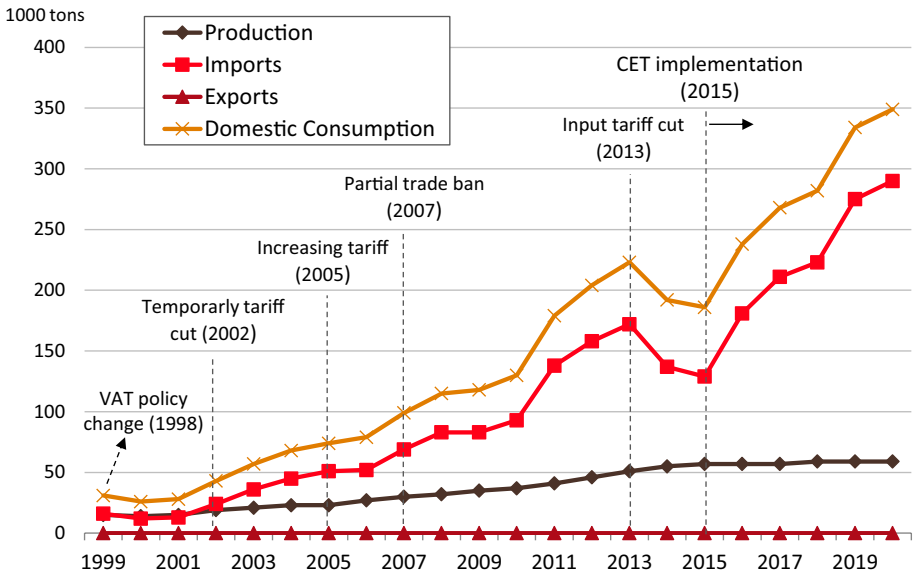


Fig. 1 Development of poultry production, imports, exports, and consumption in Ghana (in 1000 metric tons). *Source*: Own presentation using USDA dataset (2020)

supplies (Ashitey 2017; Amanor-Boadu et al. 2016; Boimah et al. 2022; Chibanda et al. 2022). As a result, Ghana imports approximately 79 percent of the poultry meat consumed domestically (Zamani et al. 2021a, b). Most of these imports consist of frozen chicken cuts—including thighs/drumsticks, wings, backs, feet, and gizzards—originating from the USA, Brazil, and Europe (Asante-Addo and Weible 2019).

Since gaining independence in 1957, Ghana has introduced a range of policies to support its poultry sector. These policies can be broadly divided into two categories: trade-related and non-trade-related policies. Non-trade-related policies focus on boosting domestic poultry meat production. Since the 1990s, Ghana's poultry policies have largely centered on trade liberalization while seeking to enhance competitiveness through cost-reduction strategies (Naggujja et al. 2020). This section reviews the two categories of policies implemented since the 1990s.

In 1998, the Ghanaian government introduced a 12.5 percent Value-Added Tax (VAT) on the duty-inclusive value of all imports (Yahuza 2008). This measure temporarily increased poultry tariffs in response to the rising volume of imports during the 1990s. However, the tariff rate was not sustained, as the government reduced import duties to 10 percent and eventually abolished them entirely in 2002 under a trade liberalization policy. In 2003, responding to mounting pressure from poultry farmers who viewed imported poultry as a threat to their livelihoods, the government reintroduced a 40 percent import tariff after Parliament passed Act 641 in April 2003 (Sumberg et al. 2017). Nevertheless, this policy, barely two months old, was repealed due to international pressure (Naggujja et al. 2020), paving the way for an influx of cheap frozen chicken cuts. Johnson (2011) highlights how Ghana's government has refrained from implementing trade protection measures like those enacted by neighboring countries, such as Senegal and Cameroon, leaving local producers at a competitive disadvantage amid rising imports.

As a member of the Economic Community of West African States (ECOWAS), Ghana adopted the 20 percent Common External Tariff (CET) rate in 2005, which was subsequently increased to 35 percent in 2015 (Naggujja et al. 2020). In 2013, the Ghanaian government removed customs duties on key poultry production inputs, including feed, drugs, and vaccines (Netherlands Enterprise Agency 2019). However, this policy had little measurable impact on the sector. Banson et al. (2015) identify high feed costs—aggravated by inefficient feed conversion rates and competition from imported frozen chicken—as the primary factors hindering the growth of the domestic poultry industry. In 2014, the government introduced the ten-year Ghana Broiler Revitalization Project (GHABROP) with the aim of reducing poultry imports to 60 percent. While the project has had limited success in transforming the sector, it did contribute to a temporary reduction in poultry meat imports in 2015 and 2016 (Netherlands Enterprise Agency 2019).

The Ghanaian government has occasionally implemented short-term partial bans on poultry imports. A partial ban restricts imports from specific countries rather than imposing a total ban. For example, in 2020, the government enacted a partial ban on poultry imports from countries experiencing outbreaks of Avian Influenza. This ban affected imports from the Netherlands, Germany, Russia, Denmark, and the UK (Zamani et al. 2022). The primary objective of these partial bans was to temporarily shield the domestic poultry sector from the risks associated with Avian Influenza. However, as Zamani et al. (2022) note, the policy had only a minor impact on imports, as market shortages were easily offset by alternative suppliers.

Over the years, various domestic poultry policies have been implemented to enhance local production. These measures include initiatives to combat poultry diseases, subsidies for feed production, training and extension services, and the distribution of day-old chicks. Notably, the government has consistently organized mass vaccination campaigns, supported local vaccine production, and strengthened disease surveillance efforts (Sumberg et al. 2017).

Between 2007 and 2008, several initiatives were introduced to address high feed costs in Ghana's poultry sector. This effort was driven by the country's persistent inability to consistently produce a surplus of maize, a key ingredient in poultry feed (Sumberg et al. 2017). As noted by Andam et al. (2017), the availability and price of maize are crucial to the profitability of Ghana's poultry sector; however, substituting poultry meat imports with local production remains a significant challenge. Despite this, Ghanaian consumers exhibit a clear preference for locally produced poultry over imports, showing an increased willingness to pay premiums for domestic poultry, particularly for products that are antibiotic- and hormone-free (Asante-Addo & Weible 2020a). However, these preferences are unlikely to be fulfilled under the current conditions of the domestic industry. Additionally, research by Boimah et al. (2022) attributes the sector's underperformance to inadequate coordination among value chain actors and insufficient commitment from stakeholders.

Method and data

Our empirical analysis consists of two primary components. First, we used the data-driven Synthetic Control Method to estimate the aggregate effects of major policy interventions on domestic poultry production. Second, we applied the panel cointegration technique to examine the interactions among various policy objectives and their

theoretical linkages. This comprehensive approach allowed us to uncover both policy synergies and trade-offs.

Synthetic control method (SCM)

A lack of data renders the empirical identification of the effects of the interventions on the agri-food sector of African countries a difficult task (Sumberg et al. 2017). To overcome the identification problem, the SCM is proposed (Olper et al. 2018). Developed in the context of comparative case studies, SCM is applied to investigate a wide range of policy interventions (see, e.g., Hodler 2019; Gibson 2020, 2023; Luo and Kostandini 2021; Zamani et al. 2023).

The SCM estimates treatment effects by constructing a weighted average of control units that reflect the treated unit in the absence of receiving the intervention (Kreif et al. 2016). Dwelling on the method of Abadie et al. (2015), we assume that there are $j+1$ countries in the sample where only country 1 (the treated unit) is affected by the policy of interest. The remaining j countries are potential comparison countries, the so-called donor pool. Additionally, we assume our analysis includes T periods, which the first part (T_0) represents the pre-intervention period. For each country, j, and time, t, we observe the outcome of interest denoted by $Y_{j,t}$. Then we define $Y_{j,t}^I$ to be the value of outcomes when country j is exposed to specific policy intervention and $Y_{j,t}^N$ to be the corresponding outcome observed in the absence of the intervention. For the pre-intervention period, i.e., $t \leq T_0$, we assume $Y_{1,t}^N = Y_{1,t}^I$. Accordingly, the potential effect of the intervention for the affected country in the post-intervention periods, i.e., $t > T_0$, is estimated by the gap between $Y_{j,t}^N$ and $Y_{j,t}^I$ (Abadie et al. 2010). We define D_{jt} as an indicator that takes value one if the country j is affected by the intervention when $t > T_0$ (i.e., $Y_{j,t} = Y_{j,t}^N + \beta_{j,t} D_{j,t}$). Thus, the effects of intervention for the first country (country "one") at time t is denoted by,

$$E_{1,t} = Y_{1,t}^I - Y_{1,t}^N = Y_{1,t} - Y_{1,t}^N \tag{1}$$

Since $Y_{1,t}^I$ is observed, $E_{1,t}$ can be calculated by estimating $Y_{1,t}^N$. Abadie et al. (2010) show that the outcome values $Y_{1,t}^N$ depend on the treatment effect $E_{1,t}$, which deviates from zero for the impacted country $t > T_0$,, alongside a common factor component, and the error terms. Assuming that $Y_{1,t}$ Eq. 1 is observed, the main challenge of estimating the intervention effect is to calculate $Y_{1,t}^N$ in Eq. (1). The SCM estimates the value of the outcome variable "using one unaffected unit or a small number of unaffected units that have similar characteristics as the affected unit at the time of the intervention" (Abadie 2021; p 394). Given a set of weights for each unaffected unit $W = \left(w_2, \ldots, w_{j+1}\right)'$, a synthetic control estimator $Y_{1,t}^N$ is estimated by,

$$\hat{Y}_{1,t}^N = \sum_{j=2}^{J+1} w_j Y_{j,t} \tag{2}$$

where $\hat{Y}_{1,t}^N$ stands for counterfactual domestic production. The weights are assumed to be nonnegative and sum up to one, i.e., $\sum_{j=2}^{J+1} w_j = 1$. To identify the best possible counterfactual country j from a set of countries, the SCM uses pre-intervention information on the variable of interest and other relevant explanatory variables. The synthetic country

j is identified by selecting optimal weights in Eq. 2. Following Abadie and Gardeazabal (2003), an optimization algorithm is applied to determine the optimal weights (w_j) by minimizing the deviation of the outcome variable path of the synthetic treatment country for the pre-intervention period. Accordingly, Eq. (1) is reformulated as;

$$\hat{E}_t = Y_{1,t} - \hat{Y}_{1,t}^N \text{ for } t > T_0 \tag{3}$$

where $\hat{E}_t$ is an unbiased estimator of E_t. Equation 3 is used to estimate the effects of policy intervention. The factual domestic production ($Y_{1,t}$) and counterfactual domestic production ($\hat{Y}_{1,t}^N$) are compared for the period of post-intervention, and the potential effects in each year are given by the difference between them. Finding suitable comparison units (e.g., countries) that best resemble the characteristics of a country that is not affected by the policy is the main challenge of comparative analysis (Farzanegan 2022). Thus, weights for units can be determined through various methods, including data-driven optimization, covariate matching, and cross-validation techniques (Abadie et al. 2015; Abadie 2021).

Policy coherence analysis

An examination of policy interventions in Ghana reveals that public efforts have sought to address multiple, often interrelated objectives simultaneously. To avoid unintended negative externalities, such as trade-offs, or to maximize potential benefits, such as synergies, it is essential to account for the relationships between various policy objectives during the policymaking process (OECD 2021). The significance of adopting a dynamic framework for analyzing livestock policies in sub-Saharan Africa has been highlighted in previous studies (e.g., Dutilly et al. 2020; Zamani et al. 2023).

To evaluate the relationships among various policy components and objectives, we employed a simultaneous equation model using panel data. This method has been widely used to analyze interconnections across sectors and markets (Omri 2013; Ozturk and Bilgili 2015; Mensah et al. 2019). A key advantage of panel data is its ability to increase the degrees of freedom and improve the efficiency of econometric estimates, especially in contexts of data scarcity (Hsiao 2007). While time series data for Ghana is insufficient to accurately estimate the effects of policy interventions using econometric methods, the panel dataset encompassing all ECOWAS members offers greater degrees of freedom. This dataset also allows for the examination of spillover effects of production on other factors. Although the SCM, as discussed earlier, estimates the potential impacts of major policy interventions on poultry production in Ghana, it does not capture interactions among variables. Thus, the simultaneous equation model complements the SCM by providing a more comprehensive analytical framework.

After considering the availability of data and insights from existing literature, we have identified proxy variables for each goal, which are domestic production, consumption (as a proxy for food security), and agricultural value-added (as a proxy for improved rural development). In accordance with Ozturk and Bilgili (2015) and Mensah et al. (2019), these variables were used both as endogenous and exogenous in our estimation. As a result, we present a simultaneous equation model to estimate the interrelationships among these variables as follows:

$$\begin{aligned}\ln(\text{prod}_{i,t}) = \gamma_0 &+ \gamma_1 \ln\left(\text{imp}_{i,t}\right) + \gamma_2 \ln\left(\text{val}_{i,t}\right) \\ &+ \gamma_3 \ln\left(\text{cons}_{i,t}\right) + \gamma_4 \ln\left(\text{lab}_{i,t}\right) \\ &+ \gamma_5 \ln\left(\text{maiz}_{i,t}\right) + \varepsilon_{1i,t}\end{aligned} \tag{4}$$

$$\begin{aligned}\ln\left(\text{cons}_{i,t}\right) = \beta_0 &+ \beta_1 \ln\left(\text{imp}_{i,t}\right) + \beta_2 \ln\left(\text{val}_{i,t}\right) + \beta_3 \ln\left(\text{prod}_{i,t}\right) \\ &+ \beta_4 \ln\left(\text{pop}_{i,t}\right) + \beta_5 \ln\left(\text{CPI}_{i,t}\right) + \varepsilon_{2i,t}\end{aligned} \tag{5}$$

$$\begin{aligned}\ln\left(\text{val}_{i,t}\right) = \alpha_0 &+ \alpha_1 \ln\left(\text{lab}_{i,t}\right) + \alpha_2 \ln\left(\text{prod}_{i,t}\right) \\ &+ \alpha_3 \ln\left(\text{cons}_{i,t}\right) + \alpha_4 \ln\left(\text{lab}_{i,t}\right) + \alpha_5 \ln\left(\text{CPI}_{i,t}\right) + \varepsilon_{3i,t}\end{aligned} \tag{6}$$

where $\ln(\text{prod}_{it})$, $\ln(\text{cons}_{it})$, $\ln(\text{val}_{it})$, $\ln(\text{imp}_{it})$, $\ln(\text{lab}_{it})$, $\ln(\text{pop}_{it})$, $\ln(\text{maiz}_{it})$, and $\ln(\text{CPI}_{it})$ denote the logarithm of domestic production and consumption of poultry meat, agricultural value-added, poultry meat imports, agricultural labor, population, maize production, and consumer price index, respectively. Additionally, ε_{it} represents error terms. The explanatory variables are selected based on theoretical insights from previous studies. We use the logarithmic form of variables to stabilize variance and mitigate the influence of potential outliers, thereby enhancing estimate accuracy. Moreover, it enables a more intuitive interpretation of percentage changes in the dependent variable.

In the current study, a Cobb–Douglas (CD) functional form is used to estimate the agricultural value-added and poultry production in Ghana (i.e., Eqs. 4 and 6). As already mentioned, feed costs including maize are the main cost of poultry production in Ghana. However, maize is an important staple crop in Ghana and hence, essential for food security. Thus, we include maize as a determinant of poultry production (Eq. 4) and food security (Eq. 5). The equation of poultry consumption is designed according to the equality between total supply and total demand.

To estimate this and other related equations, we use a technique called Fully Modified Ordinary Least Squares (FMOLS), which is commonly applied in studies dealing with relationships between variables that change over time. FMOLS is particularly useful because it addresses two common challenges in such data: trends that persist over time (known as "non-stationary" behavior) and the possibility of a long-term connection between variables (referred to as "cointegration").

By using FMOLS, we can obtain more reliable estimates even when some variables have persistent trends or are interconnected in the long run. This method extends the traditional OLS technique by making adjustments to handle issues that could otherwise distort the results, such as when variables influence each other in both directions (a situation known as "endogeneity"). Additionally, FMOLS can account for differences across data groups (or "heterogeneity"), which means it provides flexibility to handle variations in the relationships between the variables. This flexibility is particularly relevant in our case, where factors influencing poultry consumption may vary across regions or over time. Our choice of FMOLS is supported by previous studies, such as Banerjee (1999), which found that FMOLS produces consistent results even when variables show long-term trends. Thus, using FMOLS helps us achieve more accurate and interpretable estimates in analyzing the demand and supply dynamics of Ghana's poultry sector.

Data

In the SCM, we use panel data comprising domestic poultry production, poultry meat imports, GDP (in US dollars), poultry production, and population from 1980 to 2019. The data are sourced from FAOSTAT and the World Bank dataset. A synthetic control group is created using a weighted combination of potential comparison countries in Africa. These comparison countries are selected based on various indicators, including poultry market characteristics. In total, 34 countries are included in the donor pool for analyzing the poultry sector. As shown in Fig. 1, the period following 1999 in Ghana's poultry industry is widely recognized as the trade liberalization era (Naggujja et al. 2020). During this time, the primary objective of policies was to promote trade. Consequently, our empirical analysis primarily focuses on the poultry policies implemented from 1998 onwards.

Next, we use a panel data set to estimate and evaluate policy coherence in the poultry sector of Ghana. The panel dataset covers 11 Economic Community of West African States (ECOWAS) members from 1991 to 2019. Overall, our sample includes 308 observations ($i=11$ and $T=28$). The data on production, consumption, imports, and population are taken from FAOSTAT, and the agricultural value-added, consumer price index, and agricultural labor are from the World Bank dataset. Table 1 presents an overview of the variables included in the model.

To estimate the simultaneous equations, the univariate characteristics of all the variables are tested with the unit root test proposed by Im et al. (2003). The null hypothesis of the test is that each series in the panel dataset contains a unit root while alternatively, at least one of the individual series in the panel is stationary. As shown in Table 2, all the series are non-stationary. Thus, given the unit root results, the exercise proceeds by testing for the existence of cointegration.

We use a panel-based Kao (1999) cointegration test to determine whether our variables are cointegrated or not. The test is based on the principle of common factor restrictions, where the null hypothesis (H_o) is that there exists no cointegration among the variables, and the alternative hypothesis is that there exists at least one cointegrating vector. As Table 3 shows, for all tests under both alternative hypotheses, the data reject the null hypothesis of no panel cointegration at a more than 1% significance level. This provides statistical support for the existence of a long-term equilibrium relationship

Table 1 Descriptive statistics of model variables

Measure	Definition	Mean	Min	Max	Std.D
$\ln(cons_{i,t})$	Logarithm poultry consumption	2.837	0.693	5.598	1.270
$\ln(pop_{i,t})$	Logarithm population	8.834	6.772	10.301	0.959
$\ln(CPI_{it})$	Logarithm consumer price index (CPI)	4.296	0.770	5.610	0.641
$\ln(maiz_{i,t})$	Logarithm maize production	11.808	6.886	15.103	2.082
$\ln(val_{i,t})$	Logarithm agricultural value-added	25.794	17.769	29.521	2.545
$\ln(prod_{i,t})$	Logarithm production	9.299	6.411	11.492	1.238
$\ln(imp_{i,t})$	Logarithm poultry import	6.006	0	12.192	3.453
$\ln(lab_{i,t})$	Logarithm agricultural labor	14.062	11.666	15.663	1.118

Overall variation is the movements over time and regions. Variation shows the movements over time. Between variations represent the movements across regions. Source: World Bank and FAOSTAT

Table 2 Panel unit root tests. *Source*: Own calculation

Variables	At level	At 1st Difference
Levin, Lin & Chu (LLC)—Panel Unit Root Test		
Ln(production)	7.12	− 10.70***
Ln(consumption)	8.20	− 11.43***
Ln(value-added)	10.84	− 6.44***
Ln(labor)	3.90	− 4.29***
Ln(imports)	2.62	− 15.88***
Ln(maize)	6.40	− 14.78***
Ln(population)	8.69	− 3.06***
Ln(CPI)	6.35	− 4.63***
Breitung—Panel Unit Root Test		
Ln(production)	5.73	− 13.20***
Ln(consumption)	4.54	− 10.61***
Ln(value-added)	8.50	− 8.22***
Ln(labor)	9.56	− 4.07***
Ln(imports)	0.53	− 14.06***
Ln(maize)	1.29	− 14.26***
Ln(population)	15.22	− 2.90***
Ln(CPI)	7.50	− 4.55***

Levin, Lin & Chu (LLC)—Panel Unit Root Test H0: unit root

***$p < 0.01$, **$p < 0.05$, *$p < 0.1$

Table 3 Panel cointegration tests. *Source*: Own calculation

Statistic	Production equation	Food security equation	Rural development equation
Modified Dickey–Fuller	1.18	− 4.33***	− 2.07**
Dickey–Fuller	− 1.49*	− 3.91***	− 2.75***
Augmented Dickey–Fuller	1.65**	− 2.76***	− 2.49***
Unadjusted modified Dickey–Fuller	− 1.67**	− 5.46***	− 2.20**
Unadjusted Dickey–Fuller	− 1.74**	− 4.25***	− 2.80***

H0: no cointegration

***$p < 0.01$, **$p < 0.05$, *$p < 0.1$

between retail and import prices as described by Eq. (1). Furthermore, the cointegration test results are validated by Westerlund's (2007) cointegration test results as well.

Robustness check

To ensure the robustness of our findings, we performed sensitivity analyses, testing various estimators and confirming that the estimation results remained consistent across different methods. Additionally, we conducted placebo tests as proposed by Abadie and Gardezabal (2003). These tests assess whether our findings are sensitive to the inclusion of a single influential country in the synthetic control unit, which could potentially bias the estimates. To perform the placebo tests, we iteratively re-estimated the baseline model to generate placebo estimates for each country in the donor pool that did not experience the same policy interventions as Ghana. Specifically, we applied the same

set of predictors and estimation methods as in the baseline model but replaced Ghana with each control country in turn. This approach provided a distribution of placebo effects, serving as a reference for evaluating the estimated impact of policy interventions in Ghana. Appendix 1 presents the results of the placebo tests for Ghana's poultry sector and each country in the donor pool. In each figure, the gray lines depict the gap in domestic production between each donor pool country and its synthetic counterpart, while the black line represents the gap estimated for Ghana. The results indicate that the estimated effect of policy interventions in Ghana lies outside the distribution of placebo effects for all control countries, demonstrating that our findings are not influenced by a single dominant country in the synthetic control unit.

Results and discussion

The potential effects on Ghanian poultry production

As mentioned earlier, the purpose of our study is to examine the effects of post-1998 policies, specifically trade liberalization, on Ghana's poultry sector. Initially, we compared the pre-treatment characteristics of the predictor variables to those of synthetic Ghana.[1] Our findings indicate that synthetic Ghana could precisely reproduce the actual trend of poultry production as well as explanatory variables. Figure 2 illustrates the trends in Ghana's domestic poultry meat production compared to a synthetic control, which represents what production might have been without policy changes, over the period from 1980 to 2019. The figure reveals a clear divergence between Ghana's actual production trajectory and the synthetic counterpart following the implementation of policy interventions starting in 1998. This production gap quantifies the impact of these interventions, demonstrating that Ghana's poultry production grew significantly more than the synthetic control estimate after the policy changes. The policies implemented during the study period increased domestic production by an average of 18,278 tons annually from 1998 to 2019 (Fig. 2). Overall, production rose by 293 percent from 1998 to 2018, with the consecutive policy interventions contributing to a 215 percent increase during the study period.[2]

Despite the growth in poultry production during this period, a significant gap remains between the demand for and domestic supply of poultry meat. Several factors contribute to this gap. First, the high cost of feed renders domestic chicken uncompetitive in price compared to imported chicken. As a result, consumers tend to prefer imported chicken for most of the year, opting for domestic chicken mainly during festive seasons such as Christmas and Easter, when they are willing to pay higher prices (Boimah et al. 2022). Consequently, domestic chicken production is not consistently profitable throughout the year. Second, poultry production in Ghana is predominantly conducted by smallholders, who raise fewer than 5000 birds per cycle (Chibanda et al. 2023), a scale insufficient to meet national demand. Third, limited infrastructure for processing means that domestic chicken is typically sold as live birds or whole dressed chickens, which are more expensive than imported chicken sold in cut portions. This pricing structure

[1] The data are available upon request.

[2] Without intervention, production would have increased by 78% during the same period which is the difference between the policy contributions (215%) and the overall production percentage changes (293%).

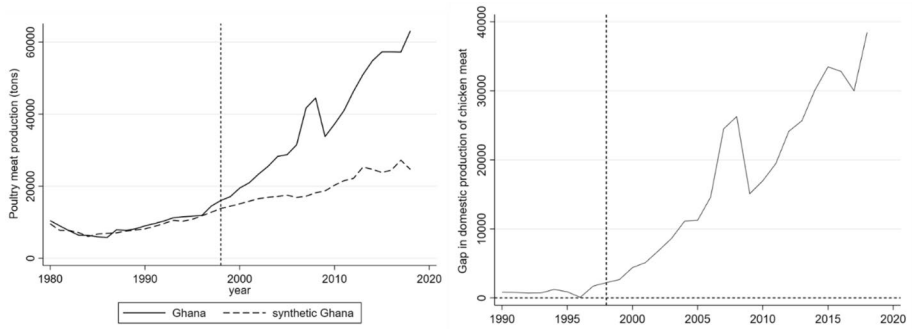


Fig. 2 Trends (left panel) in poultry meat production and the gap (right panel) between poultry meat production in Ghana and synthetic Ghana. *Source*: Own results using STATA 17

allows low-income consumers to purchase imported chicken in quantities that fit their budgets (Asante-Addo and Weible 2019). As a result, the importation of frozen poultry meat has risen dramatically—by 3195 percent from 1998 to 2019—compared to a 293 percent increase in domestic production over the same period. These findings align with Sumberg et al.'s (2017) argument that Ghana's poultry policies lack consistency and sector-wide coherence, failing to significantly reduce reliance on imports. Other challenges, such as climate conditions and resource constraints, particularly financing, also hinder growth in the sector. Commercial poultry producers rely on importing foreign breeds of chicks from temperate regions. The hot and humid tropical climate adversely affects the growth and development of these birds, leading to mortality rates of up to 10 percent—more than double the rate observed in Germany (Chibanda et al. 2023).

Policy coherence

In the preceding section, we made estimations regarding the potential impacts of significant policy interventions on poultry production in Ghana. However, it is crucial to consider that these policies could indirectly influence other policy objectives. This section aims to evaluate the correlation between different policy goals and captures the externalities of production changes. We used fully modified OLS to estimate panel data simultaneous equation models in Eqs. (7) through (9), as illustrated in Table 4. The results show that although the synergistic effect between production and consumption is more substantial, there exists a tradeoff between value-added and consumption. The negative impact of poultry meat consumption on value-added is explained by the significant amount of poultry meat that West Africa imports, which can reduce the demand for domestically produced agricultural products, thereby reducing the value-added by the agricultural sector.

Based on the estimates of the empirical model, Fig. 3 presents a simplified framework for understanding the interconnections among policy objectives. The analysis reveals a positive relationship between food security, rural development, and poultry meat production. The positive impact of value-added on production is attributed to how rural development—proxied by value-added—improves the infrastructure and resources necessary for poultry production. Additionally, domestic production directly influences food security, with the coefficient nearly equal to the reverse effect of food security on

Table 4 Fully modified OLS results of production–food security–value-added nexus. *Source*: own calculations

Variables	Production equation Dependent variable	Food security equation	Rural development equation
	Ln(production)	Ln(consumption)	Ln(value-added)
Ln(production)	–	0.47***	0.03
Ln(consumption)	0.48***	–	− 0.10***
Ln(value added)	0.08***	0.07	–
Ln(labor)	0.39***	–	1.60***
Ln(imports)	− 0.03***	0.14***	–
Ln(maize)	− 0.02*	0.10	–
Ln(population)	–	0.62***	2.67***
Ln(CPI)	–	− 0.01**	0.01
Observations	336	336	336
Number of ids	12	12	12

***$p < 0.01$, **$p < 0.05$, *$p < 0.1$

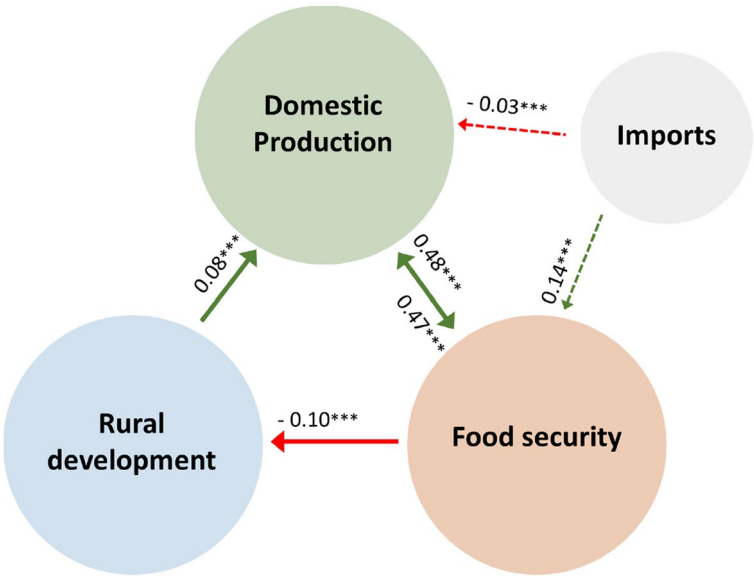


Fig. 3 The relationship between policy objectives in the Ghanaian poultry sector. *Note*: The parameters and directions of effects are determined by Table 4. *Source*: own elaboration

domestic production. Notably, the positive impact on food security is amplified when increased production reduces consumer prices. Lower prices encourage greater consumption of domestic poultry meat, which can subsequently attract investments into the sector, further promoting rural development. This dynamic is significant because, although Ghanaian consumers exhibit a strong preference for domestic poultry, its current price is more than double that of imported chicken (Asante-Addo and Weible 2019), which explains the high reliance on imported poultry meat. Imports on the other hand are negatively correlated with domestic production but have a positive effect on food security which is in line with economic theories. It is important to note that the

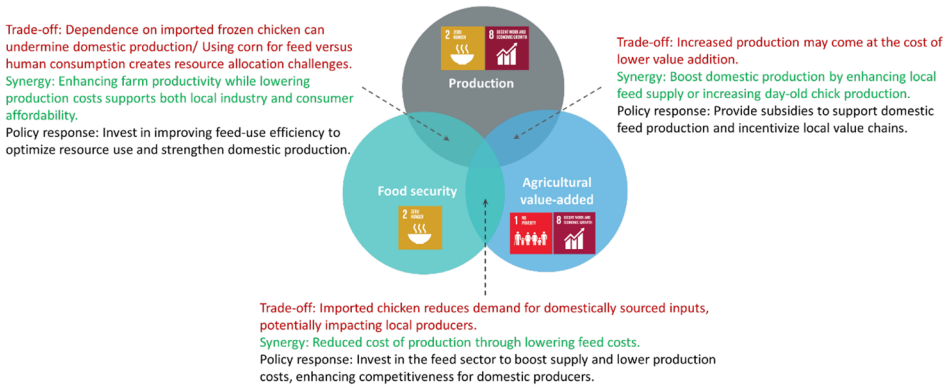


Fig. 4 Synergies and trade-offs in the poultry policy interventions of Ghana. *Source*: own elaboration

negative impact of imports on domestic production ($\gamma_1 = -0.03$) is outweighed by the positive impact on food security ($\gamma_1 = 0.14$).

For Ghana's urban consumers, frozen chicken meat imports are an affordable and easily accessible source of animal protein since domestic poultry meat is considered too expensive (Boimah et al. 2022; Asante-Addo and Weible 2020b). Therefore, the goal of increasing domestic poultry production must be combined with measures intended to reduce production costs in order to make domestic poultry meat affordable. The spillover effects of such policy interventions will not only directly affect food security but will also indirectly impact rural development.

As already mentioned, increasing production to meet domestic demands seems to be the fundamental issue that the Ghanaian policies seek to address (Netherlands Enterprise Agency 2019). Despite having been frequently identified as a priority sector for development in Ghana, the available policy instruments for the poultry sector have majorly aimed at improving Ghana's production competitiveness through increasing trade restrictions (e.g., increasing tariff rate and import ban) and subsidies (e.g., the liberalizing tariff rate of inputs or subsidies) (Sumberg et al. 2017). Following OECD (2021), we use a framework as illustrated in Fig. 4 to explain the possible spillover effects between main policy objectives in the poultry sector of Ghana estimated in the previous section (Fig. 3). We include the SDGs in the policy objectives to elaborate on the relationship between the policies with development goals. More specifically, the policy objectives are reflected by SDG 1 (No Poverty), SDG 2 (Zero Hunger), and SDG 8 (Decent Work and Economic Growth). The goals mentioned can be pursued independently via corresponding policies, however, there might be interactions in the form of synergies and trade-offs between them. For instance, protecting domestic producers against increasing poultry meat imports through measures such as increased tariffs may lead to a rise in domestic prices which in turn threatens food security while raising farm income (reflected by rural development in Fig. 3). Furthermore, the negative effects on rural development may partly cancel out the final effect of protectionist policies on production through the relationship between rural development and domestic production. As Fig. 4 shows, an attempt to develop the poultry sector through policies that lead to lower costs of production and increasing productivity will go a long way to lowering domestic prices. In this case, domestic products

will become more competitive in price and influence increased patronage. This will also likely attract more investments at all levels of the sector.

Conclusion

This paper evaluates the impact of policy interventions in Ghana's poultry sector, focusing on the liberalization efforts initiated in 1998. Using the synthetic control method (SCM), we analyzed the effects of these policies and observed a substantial increase in domestic poultry production—a 215% rise, equating to an average of 18,278 tons annually. However, the findings reveal that despite these notable gains, domestic production growth has fallen short of matching the surge in import volumes, highlighting the inadequacy of current interventions to fully address national demand.

Our analysis of policy coherence, using a simultaneous equation model, demonstrates that policies aimed at supporting domestic poultry production generate benefits beyond their primary objective, contributing to both rural development and food security. A bilateral relationship exists between domestic production and food security: increased local production enhances food availability and stabilizes prices, improving consumer access while maintaining steady demand for poultry products, which in turn reinforces domestic production. The impact on rural development, however, is unidirectional, with higher poultry production driving job creation throughout the supply chain. This includes employment opportunities not only in poultry farming but also in related industries such as feed production, processing, and distribution. This job creation fosters rural economic growth, alleviates poverty, and enhances the resilience of agricultural communities.

While the expansion of domestic production offers significant benefits for local employment and food security, the increasing volume of poultry meat imports presents notable challenges. Competitively priced imports exert downward pressure on local market prices, making it difficult for domestic producers to remain competitive. This competition erodes profit margins for small- and medium-sized poultry farms, restricting their ability to reinvest and improve quality. Moreover, poultry imports pose biosecurity risks, potentially introducing diseases that threaten the health of local poultry populations. Addressing these challenges requires a balanced approach to achieve policy objectives. Strategic measures—such as enhancing disease control protocols, enforcing strict quality standards, and implementing targeted subsidies or tariffs—can safeguard local producers while supporting coherent policy goals that align production, food security, and rural development.

Based on these findings, we propose several policy recommendations. First, achieving poultry-related policy objectives requires a systematic approach that balances synergies and trade-offs across both the formulation and implementation stages. A critical priority is ensuring coherence among policies aimed at feed production (e.g., maize and soy), feed processing, and poultry sector development. For example, as highlighted by Boimah et al. (2022), developing poultry diets using locally available ingredients could reduce reliance on expensive imported feed inputs like soy. Furthermore, providing training and education programs for farmers on best practices in poultry health management, biosecurity, and disease prevention could significantly enhance productivity. Adopting

modern farming technologies, such as automated feeding and watering systems, would further improve efficiency, lower labor costs, and enhance the sector's competitiveness and resilience.

Second, the Ghanaian government should implement policies that encourage private sector investment across the poultry supply chain, including feed mills, slaughterhouses, and hatcheries. Such investments would reduce production costs, improve productivity, and strengthen food security in Ghana. To support these initiatives, the government should offer subsidies or tax exemptions on essential poultry inputs. Currently, a 5% tariff on imported feed ingredients, such as maize, adds a financial burden to producers (Zamani et al. 2021a). Collaboration between research institutions and poultry businesses is also crucial for fostering innovations tailored to local conditions and market demands. Additionally, a comprehensive import policy is needed to mitigate the effects of poultry meat imports on local producers, public health, and food security. This policy should incorporate stringent safety and quality standards for imported poultry products while providing support and incentives for local producers to enhance their competitiveness and reduce dependence on international markets.

Despite being an effective statistical tool that can be used to evaluate policy interventions, the synthetic control method has some limitations. One primary limitation is the quality of data used in the analysis. Incomplete or inaccurate data can result in an inaccurate representation of the counterfactual, leading to potential biases. To mitigate this, we relied on official statistics provided by the FAO, ensuring a reliable data source, and excluded any regions with incomplete or missing data from our sample to maintain data integrity.

Another limitation of the SCM is the selection of control units. If the chosen control countries are not sufficiently similar to Ghana, the synthetic control may not accurately reflect what would have happened in Ghana in the absence of the intervention. We addressed this by carefully selecting control units with economic and political characteristics comparable to Ghana, and by conducting sensitivity analyses to confirm the robustness of our results. Furthermore, SCM relies on assumptions, such as the parallel trends assumption and the assumption that the treatment only impacts Ghana. Violations of these assumptions could compromise the validity of our findings. To address this, we tested the assumptions rigorously and conducted additional sensitivity analyses to ensure robustness.

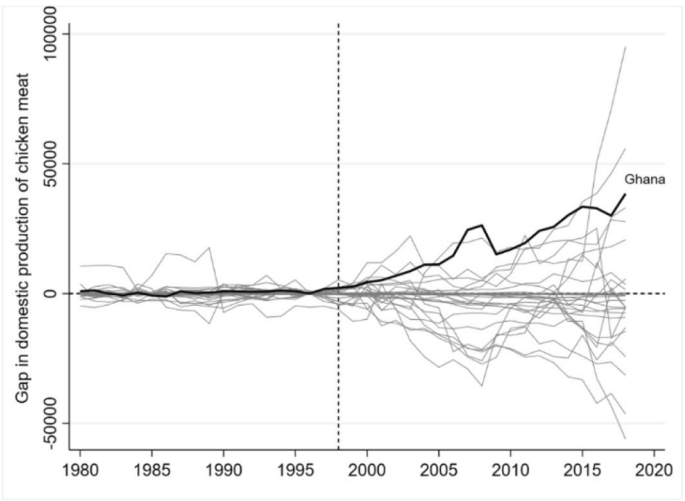
Another challenge with SCM is interpreting results, as the synthetic control unit is an artificial construct rather than an actual unit, which can make drawing precise conclusions more complex. We addressed this by carefully interpreting the results within the context of Ghana's policy objectives and clearly explaining the implications for policy. Importantly, our policy recommendations are grounded in these empirical findings, not on external opinions. The findings highlight the importance of designing poultry policies in a way that considers trade-offs, such as the impact of imports on local production and the role of local feed sources in reducing production costs.

Despite these efforts, limitations remain. For instance, the SCM does not account for all potential confounding factors or external shocks that may have influenced poultry production in Ghana. Future research could address this by using complementary methods, such as dynamic panel data models, to capture more complex interactions over time. Additionally, further studies could expand this analysis by exploring similar policy interventions in

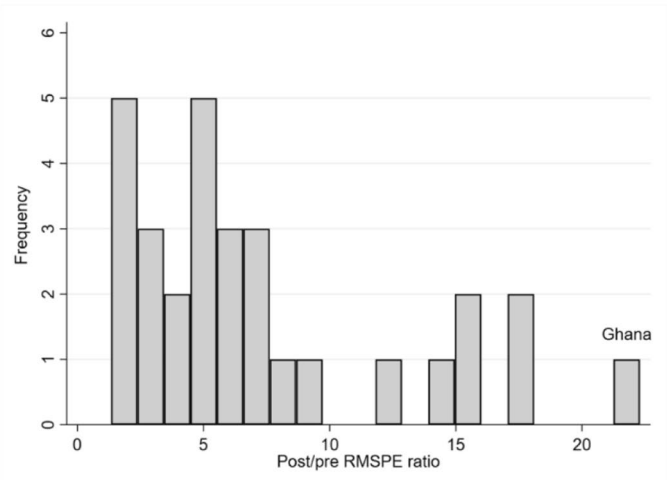
other sectors to assess cross-sectoral impacts and better understand the broader implications of agricultural policies on rural development and food security in Ghana.

Appendix 1

See Fig. 5.



a) **Domestic poultry production gap**



b) **Placebo gaps in the control states**

Fig. 5 (a) Domestic poultry production gap. (b) Placebo gaps in the control states. *Source*: own elaboration. *Note*: Panel a) shows the production gap in the poultry sector and panel b) presents the post-/pre-intervention mean-squared prediction error. We employ the root mean square percentage error (RMSPE) as a measure of the magnitude of the gap in the domestic production of the poultry sector between each country and its synthetic counterpart. Specifically, we calculate the post-/pre-intervention RMSPE ratios for Ghana and all the countries in the donor pool and compare them to assess whether the estimated effect for Ghana is significant relative to the other countries. As shown in Appendix 1II, Ghana exhibits the highest RMSPE ratio for both sectors, indicating a larger gap in domestic production compared to other countries. This suggests that the policy interventions implemented in Ghana had a significant impact on the poultry sector relative to the other countries in the donor pool.

Additionally, we examine different policies and starting years, yet the results remain consistent and robust. Moreover, we investigate the potential influence of omitting countries with higher weights on the estimated effect of policy interventions in Ghana. We find that our main results remain unchanged even after excluding these countries.

Abbreviations

SCM	Synthetic Control Method
VAT	Value-Added Tax
ECOWAS	Economic Community of West African States
FMOLS	Fully Modified OLS

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Will be submitted later.

Author contributions
Omid Zamani contributed to conceptualization, investigation, data curation, formal analysis, methodology, software, roles/writing—original draft, visualization, and validation. Craig Chibanda contributed to conceptualization, investigation, data curation, formal analysis, methodology, software, roles/writing—original draft, visualization, and validation. Mavis Boimah contributed to supervision, formal analysis, resources, writing—review and editing, and project administration. Collins Asante-Addo contributed to supervision, formal analysis, resources, writing—review and editing, and project administration.

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Availability of data and materials
Data are available upon request.

Declarations

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

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