Research Article

Prevalent Poverty Incidence and Technological Innovations: Implications for Agricultural Development in West Africa

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Abstract | This study investigated the impact of agricultural innovation technology on poverty and the feedback effect of widespread poverty on agricultural development in West Africa. The study used 25-year (1991-2015) panel data from the Statistics on Public Expenditure for Economic Development, the United States Department of Agriculture, the Penn World Table, and the World Bank's World Development Indicators. The study's data set included information on agriculture's value added (as a percentage of GDP), the headcount ratio of people living in poverty at $1.9 per day, farm mechanization, government agricultural expenditure, irrigation, human capital, and telecommunications technology. The results of this study show that, despite an increasing trend in agricultural technology improvements, poverty is still a regional problem in West Africa. It was noted that the value added by agriculture (as a percentage of GDP) was increasing at a decreasing rate. Additionally, the findings demonstrate that West Africa's high rate of poverty has a significant linear influence on agricultural development, and that on the other hand, agricultural development significantly contributes to the continent's effort to eradicate poverty. The study concluded that development of agriculture sector is a crucial first step in creating efficient approaches to poverty alleviation in West Africa. However, the right agricultural innovation technologies, such as irrigation, mechanization, and human capital, must be pursued in order to optimize the effects on poverty reduction.

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Introduction

The West African sub-region is made up of seventeen countries with diverse ethnicities, cultures, and traditions. It has a population of about 250 million people, with Nigeria accounting for roughly half (50%) of this figure. The issue of poverty and how to address it remains one of the region's most pressing concerns. Rural areas have a higher concentration of poor people, which means that agricultural development and rural development are critical to economic growth and poverty reduction (Dorward *et al*., 2004).

According to World Bank (2007), agriculture provides millions of rural poor people with golden opportunities to escape poverty. There are some indications that the long-standing neglect of agriculture is changing as a result of the development cooperation's recent resurgence in studying the dynamics of agriculture and promoting rural growth. Policymakers now understand that focusing on agricultural development can help to accelerate the reduction of poverty in developing countries.

As part of the MDG goal to reduce the number of people living in severe poverty by 50 %, some developing countries have made desirable progress. Several countries, however, fall short, and agriculture-dependent people in West Africa are often much poorer than people who work in other economic sectors.

Addae-Korankye (2014) noted that despite the renewed commitment over the years, the progress to this end remains disappointing. Dorward *et al*. (2004) established that increases in agricultural income are more effective in producing a desired or intended outcome in lowering poverty than expansion in other sectors. Therefore, it is imperative to examine the influence of technological innovation on agricultural development and impact of agricultural development on poverty exit.

Access to technological innovation is critical if agriculture is to become the primary driver of pro-poor growth. It has the potential to improve agricultural responsiveness and competitiveness. Technological innovation is regarded as an essential component of the agricultural reform package required to stimulate agricultural development and alleviate poverty. It is increasingly obvious that technological innovation can helps to accelerate agricultural development and forestall rural poverty in developing countries, but evidence-based macroeconomic policies and tools are required.

In this paper, Agricultural development was proxy by value added to agriculture as a percentage of GDP, while the poverty headcount ratio at $1.90 per day was used to measure poverty. Technological innovation was captured by introducing some indicators like agricultural expenditure, farm mechanization, irrigation, human capita and telecommunication. Unlike some of the previous studies, this study used the Generalized Method of Moments (GMM) method and a dynamic panel data approach.

The results of this study will lay the groundwork for long-term and sustainable agricultural development in West Africa as well as a quantitative policy framework to address the poverty issues that have severely harmed the region's economy. The goal of this study is to examine how agricultural innovation technology affects poverty and how widespread poverty in West Africa affects agricultural development.

Direct and indirect effects of agricultural technological innovation on poverty

Technology advancement provides farmers with new opportunities, benefits, and efficiency gains, resulting in more competitive utilization of production factors (Jinbaani *et al*., 2016). The development of new, better, or more efficient processes, technology, or ideas for the production of goods and services is referred to as innovation. However, innovation by itself is insufficient. It is useful when markets, governments, and society adopt and use it.

Farmers will be able to enhance yields, manage inputs more effectively, and incorporate new innovations if they adopt innovative technologies and methods. Agricultural technological innovation has the potential to reduce poverty in both direct and indirect ways. Technological advancements can help poor farmers in a variety of ways. According to Berdegue and Escobar (2002), increased profit was one of the direct benefits that farmers obtained from employing technical advancement. Berdegue and Escobar (2002) noted that the benefits distributed to others by the farmers who actually implement the changes are indirect effects of technological innovation on poverty reduction. A few examples of these benefits are decreased food prices brought on by higher agricultural productivity and output, a rise in agricultural employment, and broad-based economic growth as a result of connections between agricultural production and consumption and the non-farm economy.

The rapid expansion of the technologies used in modern information and communication, particularly mobile phones, has had a tremendous effect on the advancement of agriculture in West Africa. Mobile phone use by farmers and traders has increased market fusion (Aker, 2010; Aker and Mbiti, 2010) and the expansion of their use as an agricultural extension program tool in rural regions creates new potential their usage (Hollinger and Staatz, 2015).

Review of empirical studies

Several studies have found links between agriculture and poverty reduction. According to Gallup *et al.* (1997), the earnings of the poorest 20 % of the population grow by 1.61 % for every 1% increase in agricultural output per capita. According to a cross-country study by Thirtle *et al.* (2001), for every 1 % rise in agricultural output, the number of impoverished people (those subsisting on less than $1 per day) decreased by 0.8 %.

Chikelu (2016) examined how developments of human capital influence poverty reduction in Nigeria. The findings indicate positive relationship between reduction of poverty and development of human capital. The work of Bart and Barrett (2008) on poverty, agricultural technology, and productivity showed that agricultural production is an important component of any strategy to eliminate poverty and food insecurity in rural Madagascar. In a similar line, Osabohien *et al.* (2019) investigated the relationship between reduction in poverty, agricultural development and employment in West Africa. The study found that poor people can enhance their income through agriculture and break out of the cycle of poverty.

Dhrifi (2014) Dhrifi (2014) identified two research issues about the importance of agricultural productivity and its effect on reducing poverty as well as the connection between technological innovation, agricultural productivity, and poverty. The study used annual panel data from 1990 to 2011 from 32 Sub-Saharan African (SSA) nations, and the results suggest that agricultural growth significantly lowers poverty in SSA.

Diao *et al.* (2009) analyse the effects of various growth strategies on the eradication of poverty in six low-income African nations. Their findings confirmed that poverty can be decreased more effectively through agricultural growth than through industrial growth.

Table 1 showed value added to agriculture as a percentage of GDP of fifteen (15) countries that were selected for this study.

Materials and Methods

In this study, panel data from 1991 to 2015 (twenty-five year period) was used. The data used for this study were obtained from Statistics on Public Expenditure for Economic Development (SPEED), Penn World Table, United States Department of Agriculture (USDA) and World Bank's World Development indicators (WDI).

Table 1: *Agriculture, value added (% of GDP) of selected countries.*

Country	2000	2005	2010	2015
Benin	22.89	24.71	22.74	22.49
Burkina Faso	30.79	35.29	32.54	30.27
Cote d'Ivoire	24.99	22.59	24.53	22.74
Cabo Verde	12.87	9.00	7.99	8.74
Ghana	35.27	37.45	28.04	20.25
Guinea	20.98	22.28	17.48	18.48
Gambia, The	24.53	27.07	28.95	23.55
Guinea-Bissau	41.73	44.36	45.09	46.79
Liberia	76.07	66.03	44.80	34.37
Mali	32.90	32.38	33.02	37.72
Mauritania	34.37	28.17	20.29	24.52
Niger	37.84	24.73	40.90	36.33
Nigeria	21.36	26.09	23.89	20.63
Senegal	16.86	14.61	15.84	14.28
Sierra Leone	55.01	49.39	52.94	58.65

Source: *World Bank's World Development indicators.*

The data focused on value added to agriculture as a percentage of GDP (AGR), the poverty headcount ratio at $1.90 per day (POV) and technological innovation in agriculture which was accessed by introducing some indicators like agricultural expenditure (EXPD), farm mechanization (MECH), Irrigation (IRRG), human capital (HCAP) and telecommunication technology (TEL). A list of the data used for this study, its sources, and its units of measurement are shown inTable 2.

Generalized Method of Moments was adopted to examine the impact of agricultural development and technological innovation on poverty reduction. The feedback effect of poverty and agricultural technological innovation on agricultural development was also analysed by Generalized Method of Moments.

Generalized Method of Moments (GMM) Technique

A statistical method known as the Generalized Method of Moments (GMM) combines real-world economic data with knowledge of population moment conditions to forecast the unknown parameters of an economic model (Newey and Windmeijer, 2009). It is founded on a dynamic panel data model with fixed

Table 2: *Data description and sources of data.*

Variable Code	Functional description of the Variables	Unit of Measurement	Sources
AGR_{it}	Agriculture, value added (% of GDP)	Percentage	WDI, 2018
POV_{it}	Poverty headcount ratio at $1.90 a day (2011 PPP) (% of population)	Percentage	WDI, 2018
$EXPD_{it}$	Outflow of resources from government to agricultural sector of the economy	Constant 2005 US dollar	SPEED, 2017
$MECH_{it}$	Farm mechanization is proxy by total stock of farm machinery in 40 CV Tractor-Equivalents in use (4w, 2w tractors, harvester-threshers, milking machines, aggregated by CV/ machine weights)	Number	USDA, 2017.
$IRRG_{it}$	Area equipped for irrigation. Irrigation is the supply of water to crops to help growth, typically by means of channels.	Hectares	USDA, 2017. Database
$HCAP_{it}$	Human capital index, based on years of schooling and returns to education; (Human capital in Penn World Table, PWT9).	Index	2017 Penn World Table, version 9.0
TEL_{it}	Number of people with access to telecommunication	Number	WDI, 2018

$$POV_{it} = \beta_0 + \beta_1 AGR_{it} + \beta_2 EXPD_{it} + \beta_3 MECH_{it} + \beta_4 IRRG_{it} + +\beta_5 HCAP_{it} + \beta_6 TEL_{it} + \mu_t \dots\dots(1)$$

$$AGR_{it} = \beta_0 + \beta_1 POV_{it} + \beta_2 EXPD_{it} + \beta_3 MECH_{it} + \beta_4 IRRG_{it} + + \beta_5 HCAP_{it} + \beta_6 TEL_{it} + \mu_t \dots\dots(2)$$

effects for the country. All endogenous variables in this model are instrumented by their respective lags to avoid spurious correlation between these variables and the error term.

In static panel data models with regressors connected to country-specific effects, the so-called fixed effects (FE) estimator is frequently utilized. The fixed effects estimator requires, however, the explanatory factors' strict exogeneity in relation to the random error term, because the dependent variable and repressors are transformed using country-specific time averages where the temporal averages at time t are associated with the random shocks at a previous time, then the instrumental variable estimators based on fixed effects transformation and the fixed effects estimator are incompatible.

In order to examine the impact of agricultural development (AGR) and technological innovation (EXPD, MECH, IRRG, HCAP and TEL) on poverty incidence (POV), we introduce poverty Equation 1.

The feedback effect of poverty incidence (POV) and agricultural technological innovation (EXPD, MECH, IRRG, HCAP and TEL) on agricultural development (AGR) was captured using Equation 2.

Where;
AGR_{it}: Agriculture, value added (% of GDP); POV_{it}: Poverty headcount ratio at $1.90; $EXPD_{it}$: Agricultural expenditure; $MECH_{it}$: Farm mechanization; $IRRG_{it}$: Area of agricultural land equipped for irrigation; $HCAP_{it}$: Human capital; $\beta_5 TEL_{it}$: Telecommunication; μ_t: Errors term.

The μ_{it} are decomposed into time invariant country specific effects, μ_t, and random noise, ε_{it}, such that: $\mu_{it} = \mu_t + \varepsilon_{it}$.

Results and Discussion

Covariance analysis

Studies in the empirical literature have demonstrated that researchers would need to conduct an analysis of the correlation between the variables of estimates to detect whether the variables have high multicollinearity among themselves. As a result, the first step in our estimation process involved determining the degree, kind, and direction of the explanatory variables' collinear relationship.

The correlation matrix (covariance analysis) in Table 3 suggests that there is no serious issue with the collinear relationship which indicate that the adopted model is free of multicollinearity with the low degree of correlation between the explanatory variables.

Panel unit root test

The stationarity of each panel variable was investigated using Levin-Lin-Chu tests. According to Table 4, some variables are stable at their levels, while others are stationary at their first difference.

Table 3: *Covariance analysis.*

Variables	POV	AGR	EXPD	MECH	IRRG	HCAP	TEL
POV	1.000000						
AGR	-0.221075	1.000000					
EXPD	0.051686	0.203322	1.000000				
MECH	-0.155882	0.156515	0.128436	1.000000			
IRRG	-0.427155	0.053635	0.158646	0.067278	1.000000		
HCAP	-0.507342	0.049890	-0.038276	-0.134243	-0.055706	1.000000	
TEL	0.062673	-0.155857	0.600405	0.072612	0.206312	0.240364	1.000000

Source: *Author's Computation (2019).*

Table 4: *Panel unit root test.*

Variable	Level	First Differences	Order of Integration
AGR	-0.62532	-12.9974***	1(1)
POV	-15.4425***	-	1(0)
EXPD	-1.27340	-3.72635***	1(1)
MECH	-2.36648***	-	1(0)
IRRG	-15.1973***	-	1(0)
HCAP	-12.9323***	-	1(0)
TEL	-12.0122***	-	1(0)

NB: *(***) and (**) denote statistical significance at 1% and 5% level, respectively;* **Source:** *Author's Computation (2019).*

Panel cointegration test

Table 5 displays the Johansen-Fisher Panel Cointegration test outcome. Fisher trace and Fisher max-eigen tests are examined; in both cases, there is a long-term relationship between no more than six (6) variables. At a 5% level of significance, the Johansen-Fisher Panel Cointegration test in both cases showed that we reject the null hypothesis of no cointegration in every case. Thus, the P-value, which is highly significant at the 1% level, provides compelling affirmation that there is a long-run relationship among the variables

Impact of Agricultural Development and Technological Innovation on Poverty Reduction in West Africa

The major objective of this study is to examine the impact of agricultural innovation and development on the prevalence of poverty incidence in West Africa and to evaluate the feedback effect of prevalence of poverty on agricultural development taking into consideration the role of agricultural technological innovation. Thus, Table 6 showed the findings of the panel Generalized Method of Moments (GMM) regression analysis for the dynamic panel data model. The R-squared value is 73.36 %. This means that about 73 % of the variance in poverty (POV) was predicted by the model. This confirmed the goodness of fit of the model. The result of the J-statistic of the model indicates that these explanatory variables are all jointly significant in describing the causes of the dependent variable's variance. The estimated Durbin Watson Statistics of 1.24 demonstrates that the model has no positive autocorrelation.

The AGR coefficient is statistically significant and negative at 1% significance level. Our result indicates that a 1 % increment in agriculture (AGR) will decrease the incidence of poverty (POV) by 0.71 % in West Africa. This result indicates that

Table 5: *Johansen fisher panel cointegration test.*

Series	Hypothesized No. of CE(s)	Fisher Stat.* (from trace test)	Prob.	Fisher Stat.* (from max- eigen test)	Prob.
POV, AGR, MECH, EXPD, IRRG, HCAP and TEL	None	855.5	0.0000	410.6	0.0000
	At most 1	646.7	0.0000	233.4	0.0000
	At most 2	432.4	0.0000	157.5	0.0000
	At most 3	299.1	0.0000	110.1	0.0002
	At most 4	148.7	0.0001	73.42	0.0021
	At most 5	105.6	0.0020	61.51	0.0027
	At most 6	81.56	0.0032	60.83	0.0138

** Probabilities are computed using asymptotic Chi-square distribution;* **Source:** *Author's Computation (2019).*

agricultural development (AGR) played a significant role in reducing poverty in West Africa. Our result is consistent with the earlier findings of Gallup *et al.* (1997) and Thirtle *et al.* (2001). This outcome may be explained by the fact that the poor participate significantly more in the agricultural sector, particularly in low-income countriess, which has a far greater influence on reducing poverty. Our results are consistent with the general idea that improving agricultural development is the key starting point for developing successful poverty reduction strategies in West Africa.

Table 6: *Impact of agricultural development and technological innovation on poverty reduction in West Africa Using Panel GMM.*

Variable	Coefficient	Std. Error	t-Statistic	Prob.
AGR	-0.714497***	0.225605	-3.167034	0.0045
EXPD	-0.024661	0.089561	-0.275352	0.7856
MECH	-0.004806	0.483226	-0.900097	0.3778
IRRG	-0.223687***	0.052257	-4.280535	0.0001
HCAP	-1.953712***	0.100326	-4.043063	0.0005
TEL	0.113153	0.005339	1.127851	0.2715
C	4.110356**	2.110039	2.701570	0.0137
R-Squared:	0.733613			
Adj. R-Squared	0.655117			
Durbin Watson Stat	1.244989			
J-Statistics	4.965871			
Instrument rank	25			

NB: *(***) and (**) denote statistical significance at 1% and 5% level respectively;* **Source:** *Author's Computation (2019).*

Table 6 shows that the irrigation (IRRG) coefficient is negative and statistically significant at the 1% level. The coefficient of IRRG (-0.223687), represent the percentage change in incidence poverty associated with a 1% increase in irrigation. This imply that a 1% increase in irrigation facility will decreases poverty by 0.22 %. Our findings are consistent with a priori expectations because irrigation helps the poor by increasing productivity and yield, reducing crop failure risk, and enabling year-round farming. Irrigation allows smallholder farmers to diversify their planting patterns and shift from low-value subsistence farming to high-value, market-oriented production, thus poverty alleviation will be complemented with an expansion in irrigation application in West Africa. This study further corroborates the earlier findings of Hussain and Munir (2004) and Adugna *et al.* (2014).

As reported in Table 6, human capital (HCAP) coefficient is negative and statistically significant at 1 % level. Our findings showed that that an increase in HCAP by one point will leads to a reduction in poverty incidence by 1.95 point. This suggests that years of education and returns to education are likely to improve labour's ability to employ new technology more effectively. Our observation is in line with a *priori* expectation and corroborates the earlier view of Chikelu (2016), who concluded that the growth of human capital and the eradication of poverty are positively correlated.

Impact of Poverty and Agricultural Technological Innovation on Agricultural Development in West Africa. This section evaluates how poverty affects agricultural growth taking into consideration the role of agricultural technological innovation. Table 7 showed the feedback effect result using the panel GMM approach. The R-squared value is 69.41 %, which suggest that 69 % of total variance in AGR is explained by the model. This supported the model's goodness of fit. Likewise, the explanatory variables jointly explained the variance in the dependent variable, according to the J-statistic result. The estimated Durbin Watson Statistics of 1.48 revealed that there is no positive autocorrelation in the model. From Table 7, it was observed that the coefficients of all variables (POV, EXPD, MECH, IRRG and HCAP) were positive and conforms to a *priori* expectation except that of TEL that did not conform with a *priori* expectation.

The feedback relationship between poverty incidence and agricultural development reveals a significant linear effect. The coefficient of poverty (POV) is positive and statistically significant at 1 % level of significance. Our result indicates that an increase in poverty (POV) by 1 % will enhance percentage contribution of agriculture, value added (AGR) by about 0.59 % in West Africa. This suggests that increase in poverty level tend to push people into agricultural sector, this does not necessarily translates to economic growth, rather it might only increase the percentage contribution of agriculture, value added (AGR) in West Africa. This outcome can be explained by the fact that the poor people participate much more in agricultural sector. Therefore, when the numbers of poor people increase, especially in low income countries, it will push labour from other non-agricultural sector to agricultural sector, thereby reducing the percentage contribution of non-agricultural sector to GDP, thus, resulting to an increase in percentage contribution of agricultural sector to GDP.

Table 7: *Impact of poverty and agricultural technological innovation on agricultural development in West Africa Using Panel GMM.*

Variable	Coefficient	Std. Error	t-Statistic	Prob.
POV	0.587182***	0.197917	2.966801	0.0074
EXPD	1.301738	1.053782	0.426271	0.6742
MECH	0.174486**	0.097313	2.113316	0.0467
IRRG	0.342766**	0.168942	2.028899	0.0473
HCAP	2.533919**	1.199025	2.113316	0.0467
TEL	-3.710007	2.420007	-0.838718	0.4111
C	-5.389001	2.947771	-1.828161	0.0818
R-Squared:	0.694050			
Adj. R-Squared	0.610775			
Durbin Watson Stat	1.481306			
J-Statistics	4.181222			
Instrument rank	26			

NB: *(***) and (**) denote statistical significance at 1% and 5% level respectively;* **Source:** *Author's Computation (2019).*

The coefficient of farm mechanization (MECH) is positive and significant at the 5% level of significance. The coefficient of farm mechanization indicates that 1 % increase in MECH will increase percentage contribution of agriculture to GDP by about 0.17 % in West Africa. This outcome conforms to our a *priori* expectation which further corroborate the earlier findings of Eboh *et al*. (2012), Shittu and Odine (2014) and Osinowo and Sanusi (2018). Farm mechanization enhances commercial-scale farming that boosts farmers' marginal productivity. This suggests that increasing farm mechanization will significantly advance agricultural growth in West Africa.

The irrigation (IRRG) coefficient is positive and significant at 5 % level. From Table 7, the study showed that an increase in irrigation facilities by 1 % will improve percentage contribution of agriculture to GDP (AGR) by about 0.34 % in West Africa. This further supports the earlier study of Enrique *et al*. (2010) and Osinowo and Sanusi (2018) who asserted that improved irrigation will boost agricultural output.

The coefficient of HCAP as showed in Table 7 is positive and significant at 5 % level. Table 7 showed that an increase in the level of human capital (HCAP) will enhanced percentage contribution of agriculture to GDP (AGR) by about 2.53 % in West Africa. This observation met our a *priori* expectation and supports the earlier findings of Nehru and Dhareshwar (1994), Sabir and Ahmed (2008) and Khalil and Anthony (2012). This finding is consistent with endogenous growth theory.

Conclusions and Recommendations

This study examined the impact of Agricultural development and agricultural technological innovation on prevalent of poverty incidence and evaluates the feedback effect of poverty incidence on agricultural development taking into consideration the role of agricultural technological innovation in West Africa. Overall, the study found that agriculture value added (% of Gross Domestic Product), irrigation and human capital significantly decreased the poverty incidence (poverty headcount ratio at $1.9 a day) in West Africa. On the other hand, the feedback effect of poverty incidence on agricultural development reveals a positive significant linear effect. The evidence provided in this study established that poverty headcount ratio at $1.9 a day, farm mechanization (MECH), Irrigation (IRRG) and human capital (HCAP) significantly increase percentage contribution of agricultural sector to GDP in West Africa. The study concluded that improving agricultural development is the crucial starting point for developing effective strategies for reducing poverty, and that a better policy environment is required to encourage farmers to invest more in institutional innovations and productivity-enhancing technologies.

1. There was evidence of decrease in poverty incidence (POV) with additional increase in agriculture, value added (AGR). This study therefore suggests that government in West Africa should adopt appropriate macroeconomic policies and sound institutional framework targeted to boost agricultural output.
2. It is worthy of note that additional usage of irrigation infrastructure (IRRG) significantly decreased poverty incidence (POV) and increase agriculture, value added (AGR) in the feedback effects equation. Therefore, this study suggests improved irrigation systems that will help small scale farmers grow crops all year round.

3. The coefficient of human capita (HCAP) was found to significantly contributes to reduction of poverty incidence (POV) and increase in agriculture, value added (AGR). The study therefore recommends increase in budget and funding of educational sectors. This will enhances intellectual capacity of the people which will in turn lead to increase in production capacity of the economy and hence a reduction in poverty level.
4. There was evidence of increased agriculture, value added (AGR) with additional used of farm machinery (MECH). This study recommends that the government of West Africa should buy additional farm machineries, which would be subsidized and made available to farmers. The government should also implement programs to inform and educate farmers about the value of mechanized farming practices, which will help to boost agricultural output.

Novelty Statement

This research work provide basis for formulating a policy on the factors to be targeted in an effort to accelerate the level of agricultural development and contribute to poverty exit in West Africa.

Author's Contribution

Olatokunbo Hammed Osinowo: Conceived the idea, wrote abstract, introduction, methodology, data analysis, interpretation of result and discussion. He was responsible for the overall management of the article.
Maria Gbemisola Ogunnaike: Data computation, data cleaning and proofreading of the manuscript.
Esther Toluwatope Tolorunju: Downloaded literature materials, review of theoretical and empirical literature and data gathering.

Conflict of interest
The authors have declared no conflict of interest.

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