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Assessment of home-grown school feeding program on school enrolment, performance, attendance and nutrition status of public elementary school pupils in Nigeria

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Submitted by

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In

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Declaration

I hereby declare that I have done this thesis entitled "**Assessment of home-grown school feeding program on school enrolment, performance, attendance and nutrition status of public elementary school pupils in Nigeria"** independently, all texts in this thesis are original, and all the sources have been quoted and acknowledged by means of complete references and according to Citation rules of the FTA.

In Prague 22 July 2022

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Bulus Barnabas

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Abstract

Many children in developing nations are malnourished. To address this, school feeding programs have been implemented with the goal of alleviating hunger, improving nutrition, and improving student performance. The program also included smallholder farmers selling their products to food vendors and processors, who then cook for the pupils in the beneficiaries' schools. However, in the Nigerian context, very little attention has been paid to the impact of the feeding program on all of the expected outcomes. As a result, the study aims to add to the existing literature by providing a first-hand analysis of the effects of the school feeding program on elementary pupils' enrollment, attendance, academic performance, and nutritional status in northeastern Nigeria, where malnutrition and out-of-school children are prevalent. Furthermore, the study assesses the food safety knowledge, attitude, and practice of the food vendors hired to cook for the pupils, as well as the effect of the homegrown school feeding program on smallholder farmers' household food security. The findings can provide policymakers with relevant evidence on program impact to help them design policies to expand and sustain the school feeding program. The empirical analysis makes use of data collected from 180 class teachers, 780 pupils (600 SFP beneficiaries and 180 non-beneficiaries), 240 smallholder farmers, and 240 food vendors from Adamawa, Bauchi, and Gombe States in Northeastern Nigeria. The study first evaluates the impact of school feeding programs on pupils' enrollment, attendance, and academic performance. It also uses linear regression to examine the impact of program duration on academic performance. Second, using propensity score matching and endogenous switching regression to account for sample selectivity bias, we will investigate the effect of school feeding programs on pupils' nutritional status. Third, using endogenous switching regression that accounts for sample selectivity bias, analyze the effect of linking smallholder farmers to school feeding programs on smallholder farmers' household food security status, and finally, using the linear regression model, determine the food safety knowledge, attitude, and practice of food vendors participating in school feeding programs. The empirical findings indicate that the school feeding program has a positive effect on pupils' enrollment, attendance, performance, and class participation. Furthermore, the results of the linear regression model revealed that the duration of the

feeding program has a significant positive effect on the academic performance of pupils. Findings also revealed that the school feeding programme positively influenced dietary diversity score and height-for-age; however, the feeding programme had a significant reductive effect on BMI-for-age because better nutrition reduces obesity and being overweight. The regression results show that access to credits, farmers' link to caterers, farmers' link to processors, and access to input subsidies positively affect farmers' food security. The endogenous switching regression revealed that the feeding program improved the food security of smallholder farmer households. Finally, the findings revealed that increased education and access to information via radio, television, and food inspection institutions improve food safety knowledge and attitude. Given the positive effects of the program on improving students' academic performance, nutrition, and smallholder farmers' household food security, it is critical to expand access and intensify the school feeding program in Nigeria and other similar countries.

Keywords: School feeding, child nutrition, smallholder farmers Nigeria

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List of the abbreviations used in the thesis

ANOVA	Analysis of Variance
ATT	Average Treatment Effect on the Treated
ATU	Average Treatment Effect on the Untreated
AUDA	African Union Development Agency
BMI	Body Mass Index
CFIA	Canadian Food Inspection Agency
DDS	Dietary Diversity Score
DTM	Displacement Tracking Matrix
ESR	Endogenous Switching Regression
FANTA	Food and Nutrition Technical Assistant
FAO	Food and Agriculture Organization
FCS	Food Consumption Score
FCT	Federal Capital Territory
FEWSNET	Famine Early Warning Systems Network
FIML	Full Information Maximum Likelihood
FMoH	Federal Ministry of Health
HGSF	Home Grown School Feeding Program
IDP	Internal Displaced Persons
IFAD	International Fund for Agricultural Development
IIEP	International Institute for Educational Planning
IMR	Inverse Mills Ratios
IPWRA	Inverse Probability Weighted Adjusted Regression
KAP	Knowledge Attitude and Practice
MAM	Moderate Acute Malnutrition

NAFDAC	National Agency for Food and Drug Administration and Control
NBS	National Bureau of Statistics
NCE	National Certificate in Education
NEPAD	Neighbourhood Economic Development Advocacy Project
NHGSFP	National Home Grown School Feeding Programme
NPC	National Population Commission
NPFSIS	National Policy for Food and Implementation Strategy
OCHA	United Nations Office for the Coordination of Humanitarian Affairs.
PSM	Propensity Score Matching
SAM	Severe Acute Malnutrition
SDG	Sustainable Development Goals
SFP	School Feeding Program
UIS	The UNESCO Institute for Statistics
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNICEF	United Nations Children's Fund
USD	United State Dollar
USDA	United States Department of Agriculture
WFP	World Food Program
WHO	World Health Organisation

1. Introduction

The school feeding program (SFP) is the world's largest and most widespread social safety net, benefiting 388 million children across 163 countries (WFP, 2020). Among which about 53 million beneficiaries are in Sub-Saharan Africa, these figures include 17 million children receiving WFP school meals in 2019 (WFP, 2020). The program benefits approximately 9.8 million pupils in 53,000 public primary schools across Nigeria (AUDA-NEPAD, 2022). These feeding programs effectively address short-term hunger, improve nutrition, and improve school children's cognitive capacities by delivering free meals in schools (WFP, 2013; Munthali et al., 2014). Given that many of these school feeding programs are typically seen as poverty and hunger alleviation measures (Jomaa et al., 2011; WHO/FAO, 2010).

Despite Sustainable Development Goals 1 and 2 which target to end "poverty and hunger", goal 4 aims to "ensure that all girls and boys complete free, equitable and quality primary and secondary education leading to relevant and effective learning outcomes by 2030", there are still about 260 million children who do not attend primary or secondary school globally (OCHA, 2020; UIS, 2019; Theirworld, 2020). Although primary education is officially free and compulsory in Nigeria, approximately 10.5 million children aged 5-14 are not enrolled (Government of Nigeria, 2018; UNICEF, 2019). The picture is even bleaker in the country's north part where the study was conducted, where school attendance is only 53%. Out of these attendees, only 47.7%, are female, implying that, more than half of the girls in this region are not in school (UNESCO, 2019; UNICEF, 2019).

World food program reported that around 73 million primary school children in 60 countries who live in extreme poverty require immediate nutritional assistance because they go to school hungry (WFP, 2020). Starvation may impair attention and motivation, while under-nutrition at this age may impair cognitive abilities (Fink et al., 2016; Bryan et al., 2004; Wong et al., 2014; Read et al., 1973; Kristjansson et al., 2015; Afridi et al., 2019), and school performance (Zenebe et al., 2018; Gelli et al., 2016; Bundy et al., 2009; Adelman et al., 2019). Furthermore, malnutrition and child well-being are strongly interrelated dimensions of poverty. Low socioeconomic status, accompanied by food insecurity, has been linked to malnutrition among children,

resulting in childhood thinness, being overweight, obesity, and stunted growth worldwide (Rossen & Schoendorf, 2012; van Stralen et al., 2012 WHO, 2021). These forms are primarily emerging due to the increased intake of energy-dense foods high in fat and carbohydrates but low in proteins, vitamins, minerals and other healthy micronutrients (Anderson and Butcher, 2006).

In 2020, 149.2 million children under the age of 5 were stunted globally, 45.4 million wasted, and 38.9 million overweight (UNICEF, 2021a). The number of children with stunting is declining in all regions except Africa (FAO et al., 2021). UNICEF reported that more than 800,000 children are expected to suffer from acute malnutrition in northeast Nigeria, with nearly 300,000 at risk of death due to severe acute malnutrition (WFP, 2020; UNICEP, 2020); highlighting the challenge of getting out-of-school children back into school.

In recent years, the SFPs' objectives were extended and included smallholder farmers to improve their livelihood and food security status which is referred to as the Home-grown school feeding program (HGSF) (WFP, 2019; WFP and Anthrologica, 2018; World Bank, 2012; Masset and Gelli, 2013). The objective of HGSF in this context is the integration of smallholder farmers into the local value chain of government-run SFP to supply locally grown food items (FAO and WFP, 2018). The market guarantee through HGSF can stimulate an increase in agricultural productivity and reduce marketing risks (Bundy, 2009; Masset and Gelli, 2013; Sumberg and Sabates-Wheeler, 2011; Morgan et al., 2007). When smallholder farmers have a market guarantee, they are more likely to produce and market non-staple perishable foods such as vegetables and legumes (Joshi et al., 2006; IFAD 2014). The HGSF also creates a market for farmers to sell their products to processors, especially during harvest season or during school breaks, to avoid losses encountered, especially by vegetable farmers (WFP, 2014; FAO and WFP, 2018).

The HGSF employs local women mostly as "caterers," purchasing agricultural products made by "smallholder farmers," who cook and supply the meal to schools under the program and promotes local economic activity through the multiple effects that reduced poverty among the local community's (NHGSFP, 2016; UNICEF, 2020). As a result, the Nigerian government hired approximately 107,550 caterers (food

vendors) and supported 150,000 smallholder farmers in 33 states around the country to cook while being paid for their services (WFP, 2019; NHGSFP, 2020). However, despite the benefits of HGSF improving caterers' household livelihood and food security status (Zenebe et al. 2018; Gelli et al. 2016; Bundy et al. 2009), the program still possesses a high risk of food contamination in the beneficiary pupils, as the case in South African (Nzimande, 2014) and in India (BBC NEWS, 2013).

To summarize our introduction; The Nigerian Home-Grown School Feeding programme called the National Home-grown School Food Program (NHGSFP) aims to deliver a government-led, cost-effective school feed program using food locally grown by smallholder farmers. Children benefit from a hot nutritionally balanced school meal that reduces hunger and improves educational outcomes, farmers benefit from improved access to school food markets and communities benefit from new catering, processing and food handling jobs. It has a multiplier effect that will stimulate economic activity (NHGSFP, 2016).

1.1. Significance of the Study

The study's conclusions and recommendations will help all parties involved in education and nutrition, including the Ministry of Education, Ministry of Agriculture, teachers, smallholder farmers, caterers and parents, as well as decision-makers outside of the country, understand the significance of pupils' academic performance, nutrition status and the contribution of the program to improve the livelihood of caterers and smallholder farmers household, fully support school feeding programs.

The findings can be used to add to the body of literature on the impact of homegrown school feeding programs on pupils' school performance, nutritional status, and household food security in other developing countries. The study will also make policymakers aware of how critical it is to create a prerequisite for hiring caterers to reduce the incidence of food contamination. In a similar way, it will highlight additional program benefits to parents as a substitute for food availability or non-availability at home. It is hoped that guidance will be provided to parents, educators, and the government on how to start and maintain school feeding programs in their schools.

1.2. Organisation of the study

The research is divided into five chapters. The first chapter provides a general introduction and emphasizes the significance of the research and organisation of the study. The background of the homegrown school feeding program is discussed in subchapter 1.3. It also discusses the literature on the benefits of HGSF as it relates to pupils' educational performance, nutritional status, smallholder farmers' household food security status, and the food safety of caterers who cook for the pupils. Chapter 2 contains the study's objectives, research questions, and conceptual and empirical framework.

In chapter 3 the study areas, research design, analytical framework, and econometric strategies used are all discussed in Chapter 3.1. Furthermore, it goes over the data and descriptive statistics for the variables used in the analysis. Chapter 4 results and discusses in detail, while Chapter 5 conclusion and recommendations as well as their policy implications and future research directions.

1.3. Literature review

1.3.1. Introduction

This subchapter provides the necessary background for the homegrown school feeding program as well as an overview of the program's impact across all sectors linked to the program. It also includes a review of the literature on the potential benefits of school feeding programs on academic performance, nutrition, and smallholders. Furthermore, the This chapter's subheadings are theoretical framework, conceptual framework, School Feeding Program Worldwide, School Feeding Program in Developing Countries, and School Feeding Program in Nigeria.

1.3.1.1. Home grown school feeding program resource framework

At least 368 million children are fed every day at school around the world as a result of school feeding programs, which are managed to varying degrees by national governments. In addition to nourishing children and enhancing their health, school feeding is essential for facilitating access to education by boosting enrolment,

attendance, and completion rates. Additionally, the advantages of school feeding for health and education have long-lasting effects. With the goal of advancing local agriculture, bolstering local food systems, and assisting in the emancipation of people from poverty, many governments are increasingly sourcing food for school meals locally from smallholder farmers. Encouraging increased food production and diversification as well as positive economic effects on local communities, such Home-grown school feeding (HGSF) effectively strengthens the impact of regular school feeding programs (FAO & WFP. 2018).

Homegrown School Feeding programs can make a significant contribution to the achievement of the SDGs, particularly SDG 2 (on ending hunger, achieving food security and improved nutrition, and promoting sustainable agriculture) and SDG 4. (on quality education). As a result, many governments and regional organizations, including the African Union and the Community of Latin American and the Caribbean States, are incorporating these initiatives into their strategies for achieving food security and implementing the 2030 Development Agenda. The program provides a predictable outlet for local farmers' products, resulting in a stable income, more investments, and higher productivity. The children enjoy eating healthy, varied foods, which increases the likelihood that they will stay in school, perform better, and improve their adult job prospects. At the community level, Home Grown School Feeding initiatives promote nutrition education and healthier eating habits, as well as production diversification with a focus on local crops. In turn, community involvement improves program sustainability (FAO & WFP. 2018).

WFP collaborates with governments to develop national policies and strategies for Home Grown School Feeding programs and to design or implement such initiatives directly where necessary, drawing on its expertise in food security, procurement, logistics, and school feeding. The contribution of local producers to the programs and the benefits they receive are influenced by context-specific factors such as the variety of actors involved, the scope and specific goals of the program, the quantity and kind of food needed, as well as other purchasing and contractual factors. Because of this, models can vary from one country to the next and even within the same country's borders (FAO & WFP. 2018).

1.3.1.2. Nigeria homegrown school feeding programme

The National Home-Grown School Feeding Programme (NHGSFP) is a government-led initiative in Nigeria that aims to improve the health, nutrition, and educational outcomes of public primary school pupils. Every day, it serves nutritious mid-day meals to students made from farm produce grown locally by smallholder farmers (see Figure 1). The programme is designed so that the federal government feeds pupils in grades one through three, while state governments interested in feeding pupils in grades four through six. The program has undoubtedly had a significant economic impact on local agricultural production, as well as benefited communities by hiring vendors who are responsible for cooking to the pupils. The scheme is currently benefiting over nine million pupils from 54,619 schools, with the participation of 150,000 farmers and the engagement of over 102,097 food vendors across 35 states in the country. In 2021, the Federal Government announced that it will enrol an additional 5 million pupils in its NHGSFP by 2023, with the new pupils joining the over 9 million students already enrolled in the programme (NHGSFP, 2017).

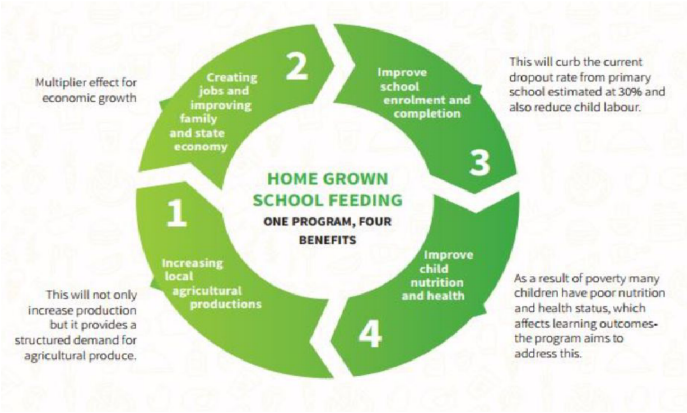

Figure 1: Concenpt of Nigeria homegrown school feefing programme

Source: NHGSFP, (2017)

1.3.1.3. Theoretical framework underpinning pupils' school feeding *program*

The Vroom expectancy theory of motivation guided this study. This theory states that individuals are motivated to perform when they know that their extra effort will be rewarded (Vroom, 1964). In other words, the theory states that the intensity of

an expectation that performance will be followed by a specific outcome, as well as the appeal of the outcome to an individual, influences the intensity of the tendency to perform in a certain way. As a result of the school feeding program, school attendance and morale may improve. Hungry children not only go to school to be fed but also receive an education, thus meeting their physiological needs (food, water, shelter, and rest) (Maslow, 1943). Adequate food supplies are required as the body grows. Malnutrition has a wide range of consequences for a child's ability to learn and develop their brain. Malnourished children have a weakened immune system, making them more susceptible to diseases, infections, and frustrations than well-fed children (Alderman and Bundy, 2012). Furthermore, if children's basic nutritional needs are not met, they cannot concentrate or pay attention to academic pursuits (Kristjansson et al., 2015; Afridi et al., 2019).

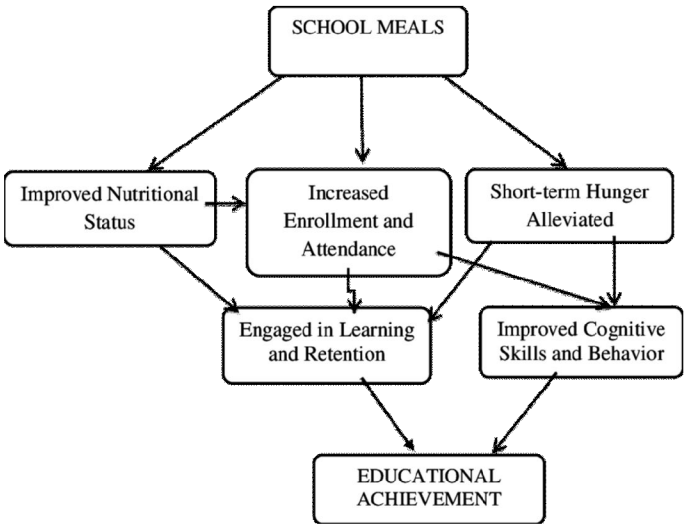

Figure 2: Conceptual framework on school feeding program

Source: Grantham-McGregor et al. (1988) and Jacoby et al. (1998)

1.4. School feeding program and pupils' academic performance

1.4.1. School feeding program and school enrolment

The first indicator of assessing pupils' academic performance is the school enrollment rate. The school feeding program influences the household's decision to send

their pupils to a school who would not have otherwise been enrolled, the inclusion of school in meals could then increase school enrolment. Additionally, these families must be persuaded that the "net benefits of participating in the program exceed the gap between direct and opportunity cost of schooling and the expected benefit of schooling" for them to enrol their children (Adelman et al., 2008). The lack of food raises the need to work and generate income instead of going to school. Drake et al. (2012) found that one-tenth of the world's poorest children are less likely to participate in school because of the lack of income and the need to work, perpetuating intergenerational poverty cycles.

1.4.2. Empirical studies on the effect of SFP on pupil's school enrolment

Several studies have investigated the effect of SFP on children's school enrolment around the world with contradicting results. Some studies, for example, in Nigeria, Peru, Mali, Sri Lanka, Ghana, Bangladesh, and Ethiopia found an increase in the number of pupils enrolled in SFP (Metwally et al., 2020; Taylor and Ogbogu, 2016; Tijjani et al., 2017; Jacoby et al., 1996; Masset and Gelli, 2013; He, 2009; Sulemana et al., 2013; Ahmed, 2004; Zenebe et al., 2018; Alderman and Bundy, 2012; Hinrichs, 2010). Other studies conducted in Kenya, Ethiopia, Laos, for example, found no evidence of an increase in the number of children enrolled in schools that implemented school feeding programs (Meme et al., 1998; Dheressa, 2011; Buttenhein et al., 2011).

1.4.3. The state pupils' school enrolment in Nigeria

School enrolment can be defined as access to schooling in a population, which is simply a count of the number of children who have registered with all schools in a country. As of 2018, the gross enrolment rate for elementary schools in Nigeria was 68.3%. The highest percentages were found in the North-Western states, with men accounting for 70.3 % and women accounting for 71.1 %. Rivers and Zamfara had the lowest rates, while Katsina and the Federal Capital Territory (FCT) had the highest nationwide (see figure 3). In contrast to the gross enrolment rate, which tracks enrolment rates for pupils of any age, the net enrolment rate only includes pupils who are the legal age for that particular educational level (World Bank, IIEP-UNESCO, 2021).

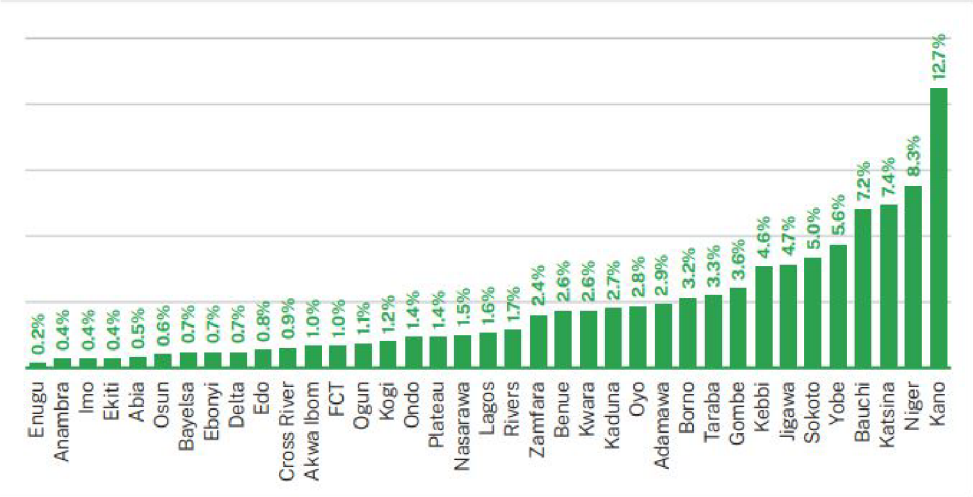

Figure 3: Percentage of out-of-school children in Nigeria by states

Source: World Bank, IIEP-UNESCO Dakar (2021)

1.4.4. School feeding program and school attendance

Class attendance is the second indicator of assessing academic performance in this study. Since pupils can only get meals at school, it is thought that school meals can help raise class attendance by motivating them to attend school. Knowing educational development is crucial for growth, the absence of pupils from the school environment has the potential to cause or exacerbate deviations in normal development (Heyne et al. 2019). Nonattendance has a negative impact on learning and achievement (Carroll, 2010), and higher rates of nonattendance are linked to lower achievement levels (Steward et al., 2008; Gottfried, 2014). Poor attendance at school can lead to pupils dropping out, who then become juvenile offenders, triggering the school-to-prison pipeline and putting an end to their education (Garry, 1996).

1.4.5. Empirical studies on the effect of SFP on pupil's class attendance

School feeding programs have also been shown to reduce absenteeism, increasing attendance. On one hand, program evaluation findings from Nigeria, the United States, Chile, the United Kingdom, Ghana, Ethiopia, and Laos show a positive relationship between the SFP and pupils' school attendance rates (Falade et al., 2012; Tijjani et al., 2017; Hinrichs, 2010; Wang and Fawzi, 2020; McEwan, 2013; Belot and

James, 2011; Gelli et al., 2016; Zenebe et al., 2018; Alderman and Bundy, 2012). On the other hand, studies in Ethiopia and Burkina Faso have confirmed that there has been no significant increase in school attendance in schools participating in the feeding program (Asmamau, 2014; Kazianga et al., 2010). Regarding gender, studies in Malawi and India reported that girls were more likely than boys to attend school (Edstron et al., 2007; Afridi, 2011).

1.4.6. The state of school attendance in Nigeria

School attendance is defined as the number of children who attend school and the duration of their attendance. The north of Nigeria has the lowest percentage of school attendance in the country, with only 61% of children aged 6 to 11 regularly attending primary school (see figure 4) (World Bank, IIEP-UNESCO, 2021). The picture is even bleaker in the country's north, where school attendance is only 53%. Out of these attendees, only 47.7%, are female, implying that, more than half of the girls in this region are not in school (UNESCO, 2019; UNICEF, 2019).

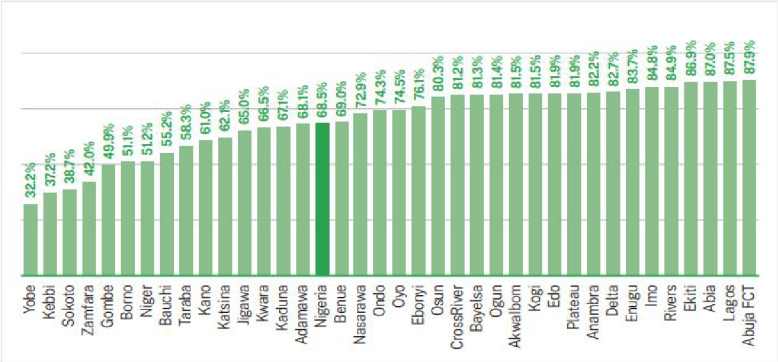

Figure 4: Percentage primary school attendance rate in Nigeria

Source: World Bank, IIEP-UNESCO (2021)

1.4.7. School feeding program and academic performance (Test Score)

The third indicator for assessing the academic performance of pupils benefiting from the school feeding program is the comparison of Math and English test scores before and after the program's implementation. Greenhalgh et al. (2008) explain that school feeding programs help with nutritional deficiencies which improve pupils'

calorie intake and raise literacy levels as a means of escaping the cycle of poverty. A number of other studies, including Adekunle and Ogbogu (2016) and Falade et al (2012), have demonstrated how SFPs help to improve pupils' IQs.

1.4.8. Empirical studies on the effect of SFP on pupils' academic performance

Even in populations who are not severely malnourished, breakfast consumption has been shown to improve cognitive function and educational outcomes. It is known that eating a healthy diet can enhance cognition and academic performance (Littlecott et al., 2015). The provision of school food for children increases pupils' academic performance, studies were conducted in different geographical locations such as Nigeria, the United Kingdom, Ethiopia, Ghana, Burkina Faso, Kenya, India, and Bangladesh. Various studies reported that school feeding programs significantly improved child academic performance (Tijjani et al., 2017; Belot and James 2011; Zenebe et al., 2018; Gelli et al., 2016; Kazianga et al., 2010; Lawson 2012; Dreze and Goyal, 2003; Kristjansson et al., 2007; Bundy et al., 2009; Chepkwony et al., 2013). On the contrary, several studies conducted in Ghana, Malawi, India, Burkina Faso, and Kenya found no significant effect between the school feeding program and pupils academic performance (Gelli et al. 2019; Edstron et al., 2007; Afridi et al., 2014; Obonyo, 2009; Kazianga et al., 2009).

1.4.9. Longer duration of the SFP effect pupils' academic performance.

Studies in India and Zambia reported that prolonged exposure (the longer the duration) to school feeding programs has a robust positive effect on learning achievement (Chakraborty and Jayaraman, 2019; Singh et al., 2014). However, Afridi et al. (2014) reported that upper primary school pupils (grades 6–8) who benefited from midday school meals for four months had no improvement in academic test scores.

1.5. School feeding program and pupils' nutritional status

Sub-Saharan Africa's malnutrition situation is characterized by the double burden of malnutrition (DBM), with a high prevalence of undernutrition and rising

obesity, as well as diet-related noncommunicable diseases (NCDs) (WHO, 2017, 2018;). Decades ago, school feeding programmes (SFPs) were introduced to address food nutrient imbalances, obesity, being underweight and stunting (Gelli et al., 2016; Anderson et al. 2018; Gelli et al. 2016; Zenebe et al. 2018).

The authors' studies on the effect of SFPs on children's nutrition are contradictory in terms of results. For instance, Alderman and Bundy (2012) and Zenebe et al. (2018) reported an improvement in beneficiary pupils' nutrition status. Similarly, SFPs appear to promote macronutrients effectively and micronutrient adequacy in the diet (Jomaa et al., 2011), which helps to alleviate anemia and support improved cognition (Abizari et al. 2014; Finkelstein et al., 2015). Against this, in a reduced number of studies, Abizari et al. (2014) reported a negative effect on beneficiary pupils. In addition, Gelli et al. (2019) reported no significant impact between beneficiaries and non-beneficiaries.

1.5.1. Empirical studies on the effect of SFP on pupil's dietary diversity score

There are many studies on the impact of school feeding programs on nutritional status, which have yielded different results. On the one hand, studies conducted by a large group of authors (Ayehu and Sahile, 2021; El Hioui et al., 2016; Zenebe et al., 2018; Bundy et al., 2018; Gelli et al., 2016; Neervoort et al., 2013) in various countries, namely Ghana, Ethiopia, the Lao PDR, Bangladesh, and Morocco found that the effect of school feeding programs on pupils BMI-for-age was significantly high/positive. Studies conducted by Teo et al. (2021); Chen et al. (2020); Gelli et al. (2019); Anderson et al. (2018); Miyawaki et al. (2018), and others found a significant reduction in the beneficiaries' BMI-for-age compared to non-beneficiaries. The adverse impact of SFPs on body weight may result from the fact that nutrient imbalances may cause a tendency to be overweight and increased obesity in children, and the introduction of SFP has the potential to provide needed proteins, vitamins, minerals, and other healthy micronutrients, which can result in a drop in the body weight. Another factor could be that many children have reported being denied breakfast (food) at home because they are expected to eat at school.

1.5.2. Empirical studies on the effect of SFP on pupil's BMI-for-age

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1.5.3. Empirical studies on the effect of SFP on pupil's height-for-age index

Several studies have also observed the effect of school feeding programs on pupils' height-for-age, yielding differing results. On the one hand, studies conducted in Ghana, Ethiopia, Uganda, and the Lao PDR found that SFP participants revealed a significantly higher height-for-age index among beneficiary pupils than non-beneficiaries (Gelli et al., 2016; Zenebe et al., 2018; Jamie et al. 2017). Other studies conducted in Ghana and Burkina Faso (Aurino et al. 2020; Gelli et al. 2019; Kazianga et al. 2009) found no significant difference in Height-for-age between beneficiaries and non-beneficiaries. These differences might have come about due to the effect of dietary intake substitution as a result of the effects of the low-income head of household decisions on the children. Many children have reported being denied breakfast (food) at home because they were expected to eat at school, to help the household save food (Rampersaud et al., 2005; Murphy, 2007). An additional reason for the absence of positive effects from SFPs on height-for-age is that school-aged children may be too old

to experience catch-up growth or recover from growth stalls (Behrman et al., 2004; World Bank, 2006).

1.5.4. Prevalence of stunting among children in Nigeria

Stunting is measured using the height-for-age index, this is defined as a measure of linear growth retardation and cumulative growth deficits. The prevalence of stunting varies greatly by region. The proportion of stunted children is highest in the Northwest (57%) and lowest in the Southeast (18%). Stunting is most common in Kebbi (66%) and least common in Anambra (14%). The proportion of wasted children is roughly twice as high in the Northeast (10%) and Northwest (9%) as in the other zones (4% -6 %). Children in rural areas are nearly twice as likely to be stunted, wasted, or underweight (45 %, 8 %, and 27 %, respectively) than those in urban areas (27 %, 5%, and 15 percent, respectively) (NPC and ICF, 2019).

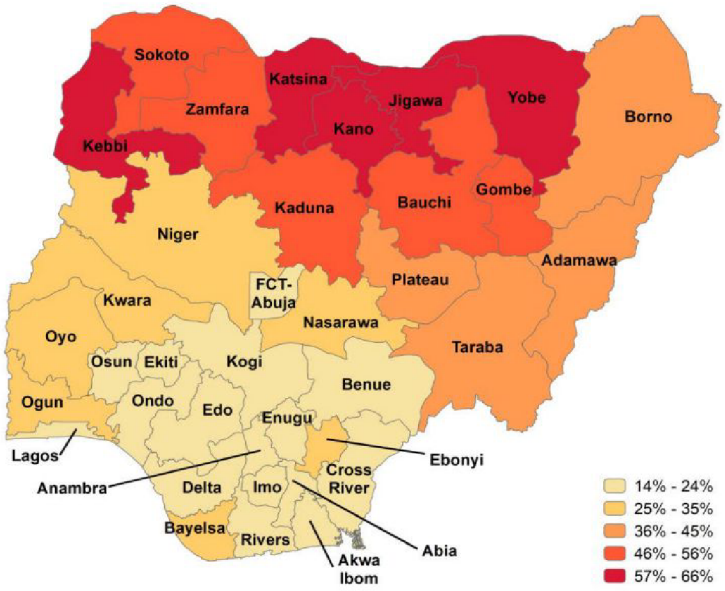


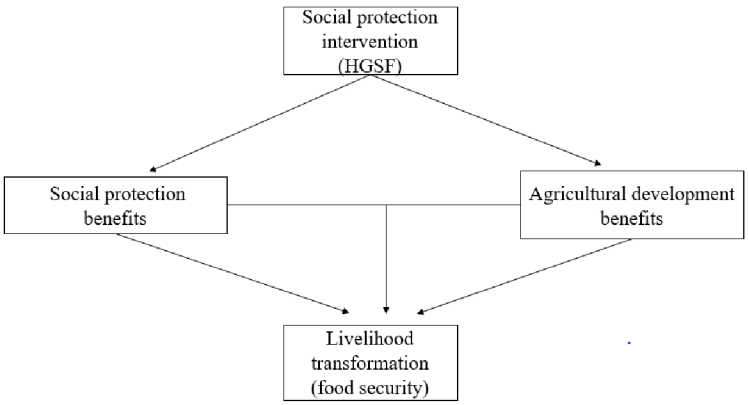
Figure 5: Prevalence of stunting among under-fives children in Nigeria

Source: National Population Commission (NPC) [Nigeria] and ICF (2019).

1.6. Impact of HGSF on smallholder farmers' household food security status

1.6.1. Theoretical framework linking smallholders to caterers and processors

The HGSF is underpinned by the theory of change (Wess, 1995), which is a model that explains how strategies, activities, or programs contribute to a set of specific outcomes through a series of intermediate outcomes in a systematic way. Even though there is no unified model of HGSF, the programs are clearly distinct in important ways across many countries. Those who argue that the HGSF can provide both social protection and agricultural development benefits draw heavily on Chilean and Brazilian experiences and reports by Morgan et al. (2007) and Espejo et al. (2009), who reported that the primary goal of the SFP is to provide meals to children (Sumberg and Sabates-Wheeler, 2011). However, HGSF aims to help to improve food security in smallholder farmers' households' livelihood indirectly (Morgan et al., 2007; Espejo et al., 2009; Sumberg and Sabates-Wheeler, 2011). Given that smallholder farmers are disproportionately poor due to a lack of access to assets, limited use of productivity-enhancing technologies and practices, such as hybrid seeds and fertilizers, characterizes their farming practices. They are also poor because, even when they adopt improved production methods, they often find it difficult to sell their produce in thin and unpredictable (Morgan et al., 2007). The HGSF is theorized, can produce a wide range of outcomes, and have the potential to trigger an improvement in household income and food security status. Thus, by farmers accessing funds to improve production, linking farmers to caterers (linking to market and value chain) who purchase their products for cooking to pupils across the beneficiary schools (Espejo et al. 2009), and linking the farmers with processors to sell their surpluses or during periods when schools are on break (Morgan et al. 2007; Espejo et al. 2009; Sumberg and Sabates-Wheeler, 2011).



Source: Adapted from Sumberg & Sabates-Wheeler, (2011)

Figure 6: Conceptual framework of linking smallholder farmers to vendors and processors

1.6.2. Empirical studies on linking smallholder farmer with food vendors and processors

Farmers linked to food vendors

Several studies conducted in Indonesia, Malawi, Ghana, Chile, and Brazil on the effect of linking smallholder farmers with caterers in HGSF revealed that there is a significant positive effect on the farmer household food security status, this is achieved by providing a reliable market for farmers to sell their product will fewer losses (Soares et al., 2017; Singh and Fernandes et al., 2018; Masset and Gelli, 2013; Sumberg and SabatesWheeler, 2011; Gelli et al., 2010; Morgan et al., 2007; Espejo et al., 2009).

Farmers linked to processors

Studies conducted in Chile, Brazil, Tanzania, Ghana, Chad and Ethiopia have reported that creating a linkage between smallholder farmers and processors (value chain) reduces farmer losses and gives a good return, which improves farmers' household food security status (Corsi et al. 2017; Devereux, 2016; Kissoly et al. 2017; Morgan et al., 2007; Herrmann et al. 2018; Geday et al. 2016; Sumberg and SabatesWheeler, 2011).

Farmers with access to credit

Access to credit or loans by smallholder farmers has a significant positive effect on their household food security status as several studies conducted across different African countries reported (Danso-Abbeam et al. 2018; Ogunniyi et al. 2021; Babatunde et al. 2007; Twongyirwe et al. 2019; Wossen et al. 2018; Omotayo et al. 2017; Adenagon et al. 2018).

Household with pupils benefiting SFP

School feeding programs provide a significant new opportunity to help low-income families to feed hungry children while reserving the food at home for others and improving the household food security status. Several studies reported that households where children are benefiting from the feeding program, are more likely to be food secure (Bundy et al., 2009; Alderman and Bundy, 2011; Lesley et al. 2012; Gelli et al. 2016; Afridi et al. 2014; Tijjani et al. 2017).

1.6.3. Food procurement model in HGSF

The centralized model: also known as' single-source procurement,' is the most basic of all. The procuring entity can approach single or multiple suppliers, negotiate contract terms with them informally, and award the contract to the chosen candidate without competition. On the one hand, this procedure is very simple and quick. There is no requirement for specific publicity, a minimum number of potential suppliers to be approached, a standard document to be used, or a public opening of offers, among other things. On the other hand, the principles of competition, equal treatment of suppliers, and transparency are severely limited (WFP, 2018).

Decentralized model of procurement does not follow strict tendering procedures in order to supply food under the school feeding program. As such food caterers procure food from smallholder farmers, traders and on market spot with no restriction. The model also allows other actors to supply food to caterers to enjoy the benefit of the available market (WFP, 2018).

Third-party model: Governments can support smallholder production even if they do not buy directly from the smallholders. Third-party models require governments

to focus on the role and capacity of managing contracts with specialized caterers, ensuring that they purchase efficiently and effectively from smallholder farmers in an inclusive manner that benefits the farmers in terms of timely and fair payment and fair access (WFP, 2018).

Mixed operating models: combine the benefits of both centralized and decentralized strategies. Countries may choose, for instance, to buy certain product categories like cereals through a more centralized approach at the regional level while buying fresh goods through a more decentralized approach (WFP, 2018).

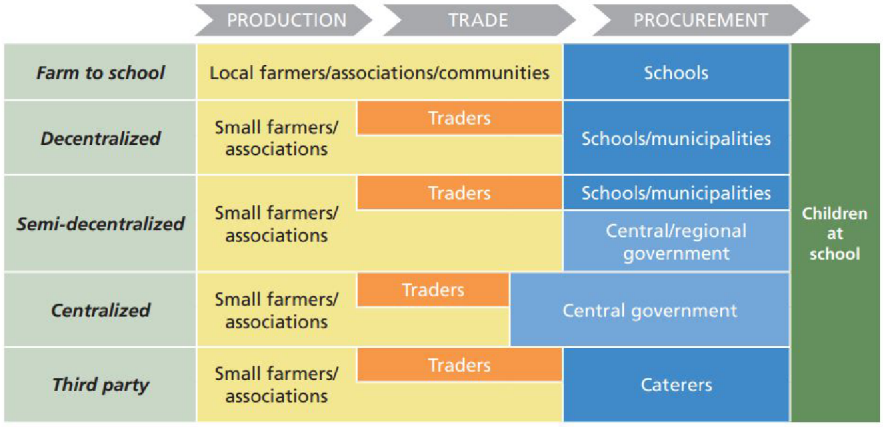


Figure 7: Methods of food procurement in HGSF

Source: WFP, (2018)

1.6.4. Food security in Nigeria

Food security in Nigeria is worst in the northern part of the country. About 29% of Nigerian households consume insufficient amounts of food (food insecurity). Comparing this to the last year 2021, there has been an increase of two percentage points. In terms of food consumption, coping strategies, and non-financial poverty, the northeast and northwest states exhibit noticeably higher levels of deprivation and vulnerability. During the lean season in Nigeria, 19.5 million people are expected to experience crisis-level or worse acute food insecurity, of which 1.2 million will experience food insecurity that is life-threatening. Acute food insecurity levels are likely to increase due to the likelihood of regionally below-average harvests, high food, fuel,

and fertilizer prices, macroeconomic challenges, and insecurity (FEWS NET, 2022 and WFP and FAO, 2022)

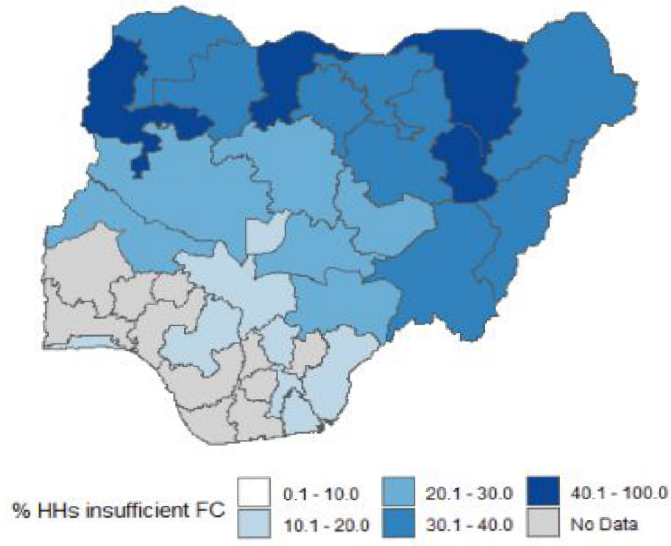


Figure 8: Percentage of household insufficient food consumption level (food insecurity)

Source: WFP and FAO, (2022)

2. Aims of the Thesis

2.1. Objective of the study

The broad objective of the study is the assessment of home-grown school feeding programs on school enrolment, performance, attendance and nutrition status of public elementary school pupils in Nigeria. While specifics objectives are.

1. To assess the effect of school feeding programs on pupils' school enrollment, attendance and academic performance.
2. To investigate the effect of school feeding programs on pupils' nutritional status.
3. To analyze the effect of linking smallholder farmers to school feeding programs on smallholders' farmers' household food security status, and,
4. To determine the food safety knowledge, attitude and practice of food vendors engaged in the school feeding programs.

2.2. Research questions

The study will attempt to answer the following research questions in order to answer the state objectives of the school feed program and to provide useful knowledge to policymakers.

1. What is the effect of a school feeding program on pupils' school enrollment, attendance, and performance; what is the effect of the duration of the feeding program on pupils' academic performance?
2. What is the effect of school feeding programs on pupils' dietary diversity score, BMI-for-age and height-for-age?

3. What is the effect of linking the school feeding program on smallholder farmers household food security status?
4. What is the food safety knowledge, attitude and practice of food vendors engage in the school feeding program?

2.3. Definition of key terminologist

1. **School enrolment** refers to the number of pupils registered in a school.
2. **School attendance** refers to both daily going to school of a pupils and available in class to learn.
3. **Performance** refers status of a pupil in respect to the attainment of knowledge and skills in comparison with others and usually evaluated through formal examination (test score).
4. **Nutrition** refers to the study of nutrients in food, how the body uses them, and the relationship between diet, health, and disease.
5. **Food safety** refers to handling, preparing and storing food in a way to best reduce the risk of individuals becoming sick from foodborne illnesses.
6. **Food security** refers to means that all people, at all times, have physical, social, and economic access to sufficient, safe and nutritious food that meets their food preferences and dietary needs for an active and healthy life.
7. **Home grown school feeding program** (HGSF) is a federal government-led initiative in collaboration with the state's government that aims to improve the health and educational outcomes of public primary school pupils using food that is locally grown by smallholder farmers.

3. Methodology

3.1. Introduction

Chapter 3 focuses on describing the study areas, research design and implementation. While the latter focuses on the analytical framework and econometric approaches used in each of the different respondents in the study, the former discusses the various data collection approaches, sampling techniques, and descriptive data analysis. The variables used in the study and the testing of the research hypotheses are further described.

The study employs correlation, paired t-test, linear regression, probit regression, propensity score matching (PSM), inverse probability weighted adjusted regression (IPWRA), and endogenous switching regression (ESR) models to examine the impact of school feeding programs on pupils' school performance, nutritional status, factors influencing smallholder farmer household food security, and food safety knowledge of caterers involved in the HGSF.

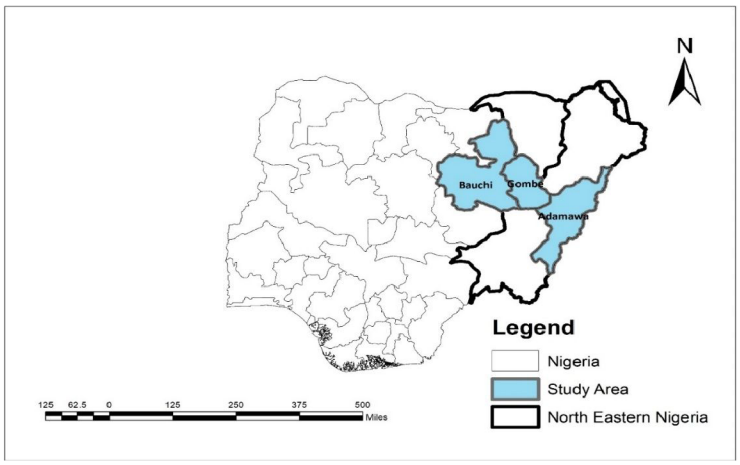
3.2. Study area

Nigeria's population was 213 million in 2021, more than 41% of the population is under the age of 14, and with a population growth rate of 3.2% annually and a mortality rate of below five years of 101 per 1,000 live births, the country is expected to have 410 million inhabitants by 2050. (NBS, 2021). The unemployment rate in Nigeria is at 33.3% recorded in Q2, 2022 (NBS, 2022). Minimum wages in Nigeria remained unchanged at 30,000 NGN/month in 2020 equivalents ($73) (World Bank, 2020). Primary school enrolment (% gross) in Nigeria was reported to be 87.45 % and the graduation rate for boys and girls was 70.8 % (NBS, 2020).

Northeast Nigeria comprises six states, namely, Adamawa, Bauchi, Borno, Gombe, Taraba, and the Yobe States, which occupy slightly fewer than 1/3 of Nigeria's total area and has a population estimated at 23.5 million people or 13.5%. (NBS, 2020). North-eastern Nigeria comprises six states: Adamawa, Bauchi, Borno, Gombe, Taraba and the Yobe States, with an estimated population of 23.5 million inhabitants or 13.5%

of the overall national population and an area that occupies slightly less than 1/3 of the total national landmass (Figure 9) (NBS, 2020). In this region live 60% of Nigeria's 10.5 million out-of-school children (UNICEF, 2020a). Food security has deteriorated in the region compared to previous years, with poor and borderline food consumption (reported by 44% of households) nearly as high as at the crisis peak caused by the political and religious turmoil of Boko Haram (NBS, 2020; WFP, 2020a). Most households lack the financial resources to meet basic needs, and 60% of the population is highly vulnerable (NBS,2020; WFP, 2020a), with about 2.17 million Internally Displaced Persons (IDPs) identified in 446,740 households (DTM, 2022).

Acute malnutrition in the Northeast region of Nigeria is anticipated to affect more than 1.74 million children under the age of five between September 2021 and August 2022. This includes more than a million cases of moderate acute malnutrition (MAM) and nearly 614,000 cases of severe acute malnutrition (SAM) (IPC, 2022). Very poor food consumption (quantity and quality), population displacement, and insecurity that prevents the delivery of humanitarian aid are the main immediate causes of acute malnutrition (IPC, 2022). Due to these conditions, in 2016, SFPs were launched, which benefited a cumulative number of about 9.9 million pupils in over 56,000 public primary schools across 33 Nigerian states. Non-beneficiary schools were mainly community primary schools established by local communities and supported sporadically by philanthropists and international organizations.



Source: Author's illustration with data from diva-gis.org

Figure 9: Map of Nigeria showing North-eastern region and selected study area.

Table 1. Research design

Indicator/Respondents	Teachers	Pupils	Smallholder farmers	Food vendors
Target group	Teachers in schools the benefiting SFP	Beneficiaries and non-beneficiaries' pupils of SFP	Smallholder farmers linked to caterers under the SFP	Vendors cooking food for pupils benefiting the SFP
Period of survey	November 2020 – February 2021	November 2020 – February 2021	December 2020 – February 2021	December 2020 – February 2021
Type of data	Cross-sectional data			
Sampling procedure	Multi-stage sampling technique	Multi-stage sampling technique & Systematic random sampling	Multi-stage sampling technique	Multi-stage sampling technique
Sample size	180 teachers (60 primary schools)	780 (600 beneficiaries and 180 non-beneficiaries)	240 smallholder farmers	240 food vendors
Data collection instrument	Face-to-face interview & structured questionnaire administration using kobotoolbox web application			
Econometric approach	Linear regression model	Linear regression, PSM, IPWRA and ESR models	Linear regression, PSM, IPWRA and ESR models	Linear regression and correlation analysis

SFP: School feeding programme,
PSM: Propensity score matching.
IPWRA: Inverse Probability Weighted Adjusted Regression
ESR: Endogenous switching regression.

3.3. Data collection and sampling technique

3.3.1. Sampling technique and data collection for teachers

The field survey was conducted in Nigeria's north-eastern region between November 2020 and February 2021. These regions were specifically chosen due to the high number of out-of-school children in the country as a result of Boko Haram kidnappings and attacks on school infrastructure, which have negatively impacted pupils' enrolment, attendance, and academic performance. The field survey was conducted in Nigeria's north-eastern region between November 2020 and February 2021. These regions were specifically chosen due to the high number of out-of-school children in the country because of Boko Haram kidnappings and attacks on school infrastructure (Bertoni et al., 2019; Abayomi, 2018), which have negatively impacted pupils' enrolment, attendance, and academic performance (UNICEF, 2020).

For the selection of class teachers, a multi-stage sampling procedure was used. The first step was to purposively select a sample of three states from six in north-eastern Nigeria, namely Adamawa, Bauchi, and Gombe. These states were selected because they are less vulnerable to Boko Haram terrorist attacks in Nigeria's north-eastern region. In the next stage, four local government areas from each of the three states were selected purposefully. This was done to avoid local government areas with a high rate of kidnappings and banditry. Then, five wards from the initial list of local government areas were selected at random. The final stage involved a random selection of one primary school in each of the wards and then three class teachers (grades one-three) were selected for the study forming 180 respondents.

The questionnaire included questions regarding teachers' perceptions of the SFP effect on pupils' enrolment, attendance, academic performance and class participation. *Secondary data* were obtained from unpublished schools' records (school enrolment record book, class attendance register, and students' results report cards) at the same schools where primary data was collected. The data included information on staff from school records (staff-to-student ratio, teacher education qualification, years of teaching

experience) as well as pupils' school enrolment, attendance, and academic performance (Math and English scores) for grades 1-3 before and after the SFP intervention.

3.3.1.1 Analytical tools for assessing the effect of SFP on pupils' academic performance

The following analytical tools help to answer several research questions about the impact of school feeding programs on pupils' academic performance: (1). Is there an effect of school feeding programs on pupils' school enrolment, attendance rate, pupils' performance and class participation? and (2). Is there an effect of the duration of the feeding program on performance?

First, a paired-sample t-test was used to compare the means of selected variables before and after the intervention (enrolment, attendance, and performance). Second, a linear regression model was used to determine the effect of the school feeding programs on education performance (using Mathematics and English scores as dependent variables) adopted from Chakraborty and Jayaraman (2019) and Afridi et al. (2014) using STATA 14 statistical software.

Linear Regression

Models specification:

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + .. + \beta_n X_n + \epsilon \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (1)$$

Where:

Y = Dependent variable (Pupil's mathematics (model 1) and English (model 2) score)

β_0-β_n= Regression coefficients

X_1-X_n= Independent variables (Duration of the feeding program, age of teacher, gender, education qualification of teachers, teachers' pupil ratio, number of pupils in a class, average boys child school attendance rate, and average girl child school attendance rate)

ϵ =Error term

The model was tested for multi-collinearity using a correlation matrix, coefficients of tolerance, and a variance inflation factor (VIF), which indicated that the variables were independent. The Durbin-Wu-Hausman test did not indicate any effect of potential endogeneity.

The dependent variable, which was a continuous variable, showed that pupils' average English and Mathematics scores were like those found in previous studies (Zenebe et al., 2018; Gelli et al., 2016; Kazianga et al., 2013; Lawson, 2012).

3.3.1.1. Sample description of teachers

Table 2 presents the descriptive statistics of the variables included in the regression model. The mean score for Math was 48.77 and 48.21 for English after SFP was introduced. The average age of teachers was 41 years, most of who were male (57.2%). About 23% of teachers possessed a graduate degree and 3.9% with a postgraduate degree as their highest qualification. The teachers in the sample had an average of 16 years of teaching experience.

The SFP in the beneficiary schools was introduced on average 15 months before the survey. On average, the teacher/pupil ratio was 34 pupils per teacher with a minimum of 7 and a maximum of 67. The average number of pupils in a class was 64. The average school attendance in 100 school days was 90.3% among boys and 89.4% among girls.

Table 2. Description of variables in the linear regression model

Variables	Description	Mean	Std. Dev.	Min	Max
Dependent Variables					
Math score	Math score measured on a point scale of 0-100	48.77	9.357	15	66.5
English score	English score measured on a point scale of 0-100	48.21	8.533	15	68
Teachers' characteristics					
Gender	Male = 1, female = 0	0.572	0.496	0	1
Age	in years	41.21	8.139	26	55
Teaching experience	years of teaching experience	15.73	7.094	2	30
Graduate education	Graduate=1 others=0	0.233	0.424	0	1
Postgraduate	Postgraduate=1 others=0	0.039	0.194	0	1
School characteristics					
Duration of the SFP	Months	15	2.971	8	24
Teachers' pupils' ratio	Number of pupils per teacher in a school	33.78	14.81	7.69	66.66
Pupils in a class	Number of pupils in a class	64.05	18.72	35	120
Average school attendance boys	% of school attendance in 100 days	90.34	2.321	88	100
Average school attendance girls	% of schools attendance in 100 days	89.4	3.176	85	100

SFP: School feeding program

3.3.2 Sampling technique and data collection for beneficiaries and non-beneficiaries' pupils

Between November 2020 and February 2021, a field survey was conducted in Nigeria's north-eastern region. These areas were chosen specifically because of the high prevalence of acute malnutrition among the children in the study area. This was exacerbated by attacks on communities and public infrastructure, which resulted in a high number of cases of Internally Displaced Persons (IDP) and parents unable to cultivate their farms and provide food for their households. This prompted the Federal

Government to implement the SFP to alleviate hunger, improve nutritional status, and encourage pupils to attend school (UNICEF, 2021a; WFP, 2020a).

The study selected 780 pupils enrolled in primary schools ages between 6 and 13 years, where 600 studied in public SFP beneficiary schools (the treated group) and 180 from non-beneficiary schools (the control group). All schools selected were from rural areas with similar socioeconomic characteristics; the majority of pupils' parents were farmers who cultivate an average farm size of 2 hectares. Consequently, the household characteristics of the pupils in both schools share similar patterns in terms of socio-demographics, farm size, crop type, and level of income.

To obtain insight to appropriately select the sample, in-depth interviews and informal conversations were conducted with beneficiaries and non-beneficiaries on their physical, monetary, environmental, personal, social, cultural, and knowledge-based environment, focusing on post-conflict situations. A multi-stage sampling procedure was used to select pupils for the study. In the first step, three states in north-eastern Nigeria, namely Adamawa, Bauchi, and Gombe, were chosen as being less vulnerable to Boko Haram attacks and kidnapping, thereby being safer for study implementation while still having high vulnerability from the legacy of the conflicts in the recent past. In the second step, four local government areas from each of the three states were randomly selected, resulting in 12 local government areas. In the third step, five wards per local government area (a *ward* is an administrative division of a city or borough that elects and represents a councillor) were randomly selected from the initial local government areas resulting in 60 wards selected for the survey. The fourth step entails a random selection of one primary school in each ward, then a systematic random selection of 10 pupils from a school in each ward (5 boys and 5 girls), a sample of 600 beneficiaries of SFPs provided in the selected areas.

Similarly, for non-beneficiary pupils, samples were selected using the same procedure but obtaining three local governments and then choosing one ward in each. One school not benefiting from public SFPs was chosen in each ward, and 20 pupils were selected per school, which overall amounted to a lesser but comparable number of pupils not being subjects of public SFPs. The non-beneficiary schools were community primary schools in the areas established by the people themselves to reduce the

challenge of walking long distances to school, with little support from philanthropists and international organizations in hiring teachers.

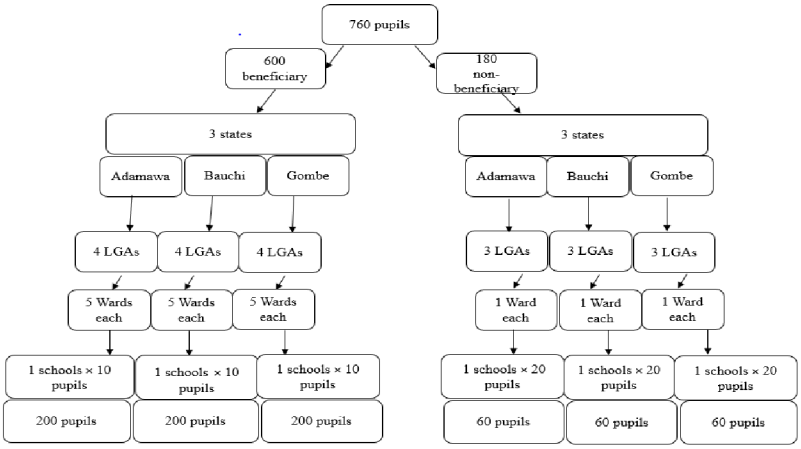


Figure 10: Sampling Procedure and Sample Size

Source: Authors illustration

The study questionnaire was based on a literature review and in-depth interviews and was explicitly designed for the pupils and was divided into three sections. The first section included information from the pupil's household, such as the parents' education, household size and pupils' main characteristics such as age, gender, grade and duration in the SFP in the beneficiaries' case. The second section of the questionnaire involved anthropometric data such as the pupils' height and weight to assess the pupils' nutritional status (Height-for-age and BMI-for-age). The pupil's height and weight were measured following the same procedure by Gelli et al (2016), Zenebe et al (2018) and Ayehu and Sahile, (2021).

The third section of the questionnaire involved the individual DDS questions. The DDS questionnaire was adapted from the Food and Nutrition Technical Assistant (FANTA, 2006) guidelines. A twelve-food group DDS scale was used to assess the quality of diet based on foods consumed in the last 24 hours of the survey by the pupils, adopted from Deitchler et al. (2011) and Zenebe et al. (2018). Anthropometric measurement is used to measure children's nutritional status (WHO, 2007). The World

Health Organization (WHO) child growth standards median was used to categorize pupils' height-for-age and BMI-for-age to identify stunted, thinness, being overweight, and obesity (See Table 3).

Table 3: Anthropometry Nutritional Status of Children and Adolescents (5–19 Years Old) z-score

Anthropometric Indicator and Condition	**Age**	**< -3**	**≥ -3 to < -2**	**≥ -2 to < -1**	**≥-1 to ≤ +1**	**> +1 to ≤ +2**	**> +2 to ≤+3**	**> +3**
Height-for-age	5–19 years	Severe stunting	Moderate stunting	Normal				Extreme tallness indicates endocrine disorder.
BMI-for-age	5–19 years	Severe thinness	Moderate thinness	Normal		Overweight	Obesity	

Source: 2007 WHO Growth Reference

3.3.2.1 Analytical tools for assessing the effect of SFP on pupils' nutrition status

The following subsection presents tools of analysis to answer the following research question. 1). What is the effect of school feeding programs on pupils' dietary diversity score, BMI-for-age and height-for-age? 2). What are the factors influencing pupils' dietary diversity score, BMI-for-age and height-for-age? And 3). What is the pupils' nutritional status? BMI-for-age and height-for-age were assessed using WHO Anthro plus software [version1.0.4] based on the WHO (2007) growth reference data. To determine factors influencing pupils' nutritional status using linear regression and propensity score matching (PSM), inverse probability weighted adjusted regression (IPWRA), and endogenous switching regression (ESR) models to control for endogeneity to analyse the effect of SFP on pupils' nutritional status using STATA 14 statistical software.

Models specification:

$Y=b_0+b_1X_1+b_2X_2+ \ldots +b_nX_n+e \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots$ (2)

Y=Dependent variable (Dietary diversity score… (model 1), (BMI-for-age… (model 2), and (Height-for-age… (model 3)

b_0-bn= Regression coefficients

X_1-X_n= Independent variables (school feeding programme, age in months, gender, household size, mothers' education, and fathers' education).

e=Error term

Treatment effect analysis

Identifying the causal effects of SFP on pupils' nutritional status using the DDS, height-for-age, and BMI-for-age variables can be challenging due to the risk of endogeneity bias. Due to observed and unobserved individual characteristics, selection bias may persist in the absence of random assignment. To measure SFPs' impact accurately and account for observable and unobservable characteristics, the observed individuals must be randomly assigned to different treatments. Guided by the work of Agyemang et al. (2020), we followed propensity score matching (PSM), inverse probability weighted adjusted regression (IPWRA), and endogenous switching regression (ESR) models to control for endogeneity bias (Shiferaw et al., 2014; Wossen et al., 2017; Mojo et al., 2017).

Treatments for endogeneity bias

The PSM technique was used to answer the counterfactual question, "*What would have happened to the pupil's nutritional status if they did not have access to the SFP, as beneficiaries (treated) if those same pupils were non-beneficiary (control)*?". The empirical models used are described in detail below.

The probit model: SFP beneficiary pupils and non-beneficiary were considered dependent variables. The binary probit model is defined as follows:

$$Pr\left(Z_i = \frac{1}{x_i}\right) = \phi\left(x'_i\gamma\right) \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 3$$

Where: Z_i is the dependent variable – binary with only two outcomes (denoted by 1= "pupils benefiting from an SFP" and 0 = "pupils non-benefiting from an SFP; *xi* a vector of regressors assumed to influence *Zi; "Pr"* the probability and ϕ the cumulative distribution function of the standard normal distribution and γ a vector of unknown parameters.

Zi^* can then be specified as:

$$Zi *= \Upsilon o \ + \sum_{n=1}^{N} \Upsilon_n x_{ni} + u_i \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 4$$

That: $Z_i = 1_{if\ Zi > 0}$ and $Z_i = 0_{otherwise}$

Where x_i = a vector of explanatory variables (age in months, gender, household size, mothers' education and fathers' education); γ = a vector of unknown parameters and u_i = a random disturbance term. n = total sample size. The unknown parameters are estimated by the method of maximum likelihood, and the marginal effects of the parameters explain the magnitude of relations between the dependent and independent variables.

Since our PSM goal is to estimate the average treatment effect of pupils benefiting from the SPFs, the impact of the SFPs on pupils' nutritional status is given as:

$$E\ (Y_1\text{-}Y_0/X,\ D=1) = E\ (Y_1/X,\ D=1) - E\ (Y_0/X,\ D=1). \quad \ldots\ldots\ldots\ldots\ldots\ldots 5$$

Where E(.) is the operator of expectation; Y_1 is the DDS, Height-for-age, BMI-for-age of beneficiary pupils; Y_0 is the DDS, Height-for-age, BMI-for-age of non-beneficiary pupils; X is a vector of relevant observable covariates related to pupils' characteristics; and D is a binary indicator of beneficiaries, assigning figure 1 when accessing SFP. $E(Y_1/X,\ D = 1)$ is thus the beneficiary pupils' nutritional status; $E(Y_0/X,\ D = 1)$ the nonbeneficiary pupils' nutritional status.

Observing Y_1 and Y_0 at the same time may prove impossible (Heckman et al., 1997; Wadud, 2013) because a pupil is either a benefiter or not. Especially when no baseline data is available and not possible to recall data. We use data on $E(Y_1/X,\ D = 1)$ which are thus readily available, but the econometric problem is to find $E(Y_0/X,\ D = 1)$ because observing the pupil nutritional status of benefiting pupils and the nutritional status of the same pupils had he/she not benefited is impossible. Therefore, we estimate $E(Y_0/X,\ D = 1)$ in a way counter-factual by making some assumptions.

One assumption often made by econometricians is to represent the counter-factual by calculating $E(Y_0/X,\ D = 0)$, the pupil nutritional status of non-benefiting pupils, as a control effect. This causes a bias concerning the difference $E(Y_0/X,\ D = 1)$ $E(Y_0/X,\ D = 0)$, resulting in selection bias (Mayen et al., 2010). Rubin (1977) and

Rosenbaum and Rubin (1985) proposed using propensity scores to match beneficiaries with non-beneficiaries as a solution. This aids in dealing with the biases caused by differences in the characteristics of both pupil groups. As a result, being a beneficiary of the SFP is assumed to be independent of the outcome, given the observed covariates, and the conditional independence assumption: $Y_0 S/X$. (Wadud, 2013).

However, in the presence of mis-specification in the propensity score model, ATT from PSM can still produce biased results (Robins et al., 2007; Wooldridge, 2007, 2010). The use of inverse probability-weighted adjusted regression (IPWRA) could be a potential remedy for such mis-specification bias. According to Wooldridge (2010), IPWRA estimates will be consistent in treatment/outcome model mis-specification, but not both. As a result, the IPWRA estimator has a double-robust property, ensuring consistent results by accounting for mis-specification in both the outcome and the treatment model as adopted (Wossen et al. 2017). ATT in the IPWRA model is estimated in two steps, as described by Imbens and Wooldridge (2009). Assume the outcome model is represented by a linear regression function of the form $Y_i=\alpha_i+\varphi_i x_i+\varepsilon_i$ for i = [0 1], and the propensity scores are given by $p(x;\bar{\gamma})$. The propensity scores are estimated as p(x; γ) in the first step. In the second step, we use linear regression to evaluate (α_0, φ_0) and (α_1, φ_1) using inverse probability weighted least squares, as follows.

$$\frac{min}{\alpha o, \varphi o}\sum_{i}^{N}(Y_i-\alpha o-\varphi o x_i)/p(x,\bar{\gamma}) \text{ if } T_i=0 \quad \ldots\ldots 6$$

$$\frac{min}{\alpha_i, \varphi_1}\sum_{i}^{N}(Y_i-\alpha o-\varphi_1 x_i)/p(x,\bar{\gamma}) \text{ if } T_i=1 \quad \ldots\ldots 7$$

The ATT is then computed as the difference between equation (6) and equation (7)

$$ATT=\frac{1}{N_w}\sum_{i}^{N_w}[(\tilde{\alpha}^1-\tilde{\alpha}^1)-(\tilde{\varphi}^1-\varphi o)x_i \quad \ldots\ldots 8$$

where, ($\tilde{\alpha}_1,\tilde{\varphi}_1$) are estimated inverse probability-weighted parameters for treated pupils while ($\tilde{\alpha}_0,\tilde{\varphi}_0$) are estimated inverse probability-weighted parameters for untreated pupils. Finally, $N_{.W.}$ stands for the total number of treated pupils. On the other hand, matching techniques can only overcome selection bias caused by observables, regardless of mis-specification bias adjustments. When unobservable heterogeneity, such as a pupil's inherent skill, causes endogeneity bias, result matching techniques will

be biased. As a result, we used an ESR model that accounts for observed and unobserved bias sources (Bidzakin et al., 2019; Shiferaw et al., 2014; Ma and Abdulai, 2016; Wossen et al., 2017). The ESR method solves the endogeneity problem by estimating the selection and outcome equations with full information maximum likelihood (FIML) (Ma and Abdulai, 2016; Wossen et al., 2017).

We assume that a particular group of pupils would consider receiving treatment if the expected benefit of the treatment (in terms of nutritional status) is positive. Let f_0 be the nutritional status of pupils without treatment (that is, not benefiting from the SFP) and let f_1 be the corresponding nutritional status with treatment (that is, benefiting from the SFP). The household head will choose for the pupil to be in the treatment if the nutritional status improves, defined as, $Y_i^*=F_1-F_0$, which is positive. However, the pupil nutritional status that the pupil derives from treatment (Y_i^*) is a latent variable determined by observed characteristics (Z_i) as follows:

$$Y_i* = \beta^0 + \gamma Z_i + \mu_i \text{ with } T_i = \begin{cases} 1 \ if \ Y_i*>0 \\ 0 \ if \ Y_i*\leq 0 \end{cases} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 9$$

Variables affecting the expected benefits of benefiting from the SFP are represented by the vector Z. The conditional outcome function can then be specified as an ESR model in the following way.

Regime1: $Y_{1i} = \gamma_1 x_{1i} + \varepsilon_{1i}$ if $T_i = 1$ 10

Regime2: $Y_{2i} = \gamma_2 x_{2i} + \varepsilon_{2i}$ if $T_i = 0$ 11

where Y_{1i} is the outcome indicator for treated pupils and Y_{2i} is the outcome indicator for untreated pupils, and xi is a vector of exogenous variables. The outcome variable's error term is in the selection equation (9), and the outcome equation (10) and (11) the error terms are assumed to have a trivariate normal distribution with mean zero and covariance matrix (Ω) in the following way:

$$\Omega = \begin{bmatrix} o_u^2 & o_{1\mu} & o_{2\mu} \\ o_{1\mu} & o_1^2 & . \\ o_{2\mu} & . & o_2^2 \end{bmatrix}$$

Where $o_u^2 = var(\mu_i)$, $o_1^2 = \text{var}(\varepsilon_1)$, $o_2^2 = (\varepsilon_2)$, $o_{1\mu} = cov(\mu_i, \varepsilon_1)$, $o_{2\mu} = cov(\mu_i, \varepsilon_2)$

Furthermore, o_u^2 = is estimable up to a scale factor and can be assumed to be equal to 1

(Maddalla, 1983) and cov(ε_1, ε_2) is not defined as Y_1 and Y_2 cannot be observed simultaneously. Moreover, the correlation between the error term of the selection equation and the outcome equation is not zero (i.e., corr(μ_1, ε_1) $\neq 0$ and corr(μ_1, ε_2) $\neq 0$) which creates selection bias. ESR addresses this selection bias by estimating the inverse Mills ratios (IMR) (λ_{1i} and λ_{2i}) and the covariance terms ($\sigma_{1\mu}$ and $\sigma_{2\mu}$) and including them as auxiliary regressors in equations (10) and (11). If $\sigma_{1\mu}$ and $\sigma_{2\mu}$ are significant, we reject the absence of selection bias. In addition, $\sigma_{1\mu} < 0$ represents positive selection bias (i.e., pupils with above-average nutritional status are more likely to choose to be in the treatment). The ESR model estimates can then be used to estimate ATT (Average treatment effect on untreated households) as follows:

$$E(Y_{1i}|T_i = 1) = \gamma_1 x_{1i} + \lambda_{1i}\ \sigma_{1\mu} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ 12$$

$$E(Y_{2i}|T_i = 0) = \gamma_2 x_{2i} + \lambda_{2i}\ \sigma_{2\mu} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 13$$

$$E(Y_{2i}|T_i = 1) = \gamma_2 x_{1i} + \lambda_{1i}\ \sigma_{2\mu} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ 14$$

$$E(Y_{1i}|T_i = 0) = \gamma_1 x_{2i} + \lambda_{2i}\ \sigma_{1\mu} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ 15$$

The actual expectations observed in the sample are represented by equations (12) and (13) along the diagonal of Table 4. The counter-factual expected outcome is described by equations (13) and (15). In addition, following Heckman et al. (2001), we calculate the average treatment of the treated "on beneficiary pupils" on the treated (ATT) as the difference between equations (12) and (14),

$$ATT = E(Y_{1i}|T_i = 1) - E(Y_{2i}|T_i = 1) = x_{1i}(\gamma_1 - \gamma_2) + (\sigma_{1\mu} - \sigma_{2\mu})\lambda_{1i} \quad \ldots\ldots\ldots\ldots 16$$

which represents the effect of SFP benefits on the BMI-for-age, height-for-age, and DDS of the beneficiary pupils Similarly; for non-beneficiaries of the SFP, we calculate the effect of treatment on the untreated (TU) as the difference between equations (15) and (13).

$$ATU = E(Y_{1i}|T_i = 0) - E(Y_{2i}|T_i = 0) = x_{2i}(\gamma_1 - \gamma_2) + (\sigma_{1\mu} - \sigma_{2\mu})\lambda_{2i} \quad \ldots\ldots\ldots\ldots 17$$

To account for the effects of heterogeneity, we use the expected outcomes described in equations (a) - (d) in Table 4. For example, beneficiaries of the SFP may have a higher

BMI-for-age, height-for-age, and DDS than non-beneficiaries regardless they benefited from SFP or not, but this may be due to unobservable characteristics such as their skills.

$BH_1 = E(Y_{1i}|T_i = 1) - E(Y_{1i}|T_i = 0) = (x_{1i} - x_{2i})\,\lambda_{1i} + {}^{O}{}_{1\mu}\ (\lambda_{1i} - \lambda_{2i})$ 18

We investigated "transitional heterogeneity" (TH), or whether the effect of SFP was larger or smaller for SFP beneficiaries or non-beneficiaries in the counter-factual case that they did benefit, which is the difference between equations (16) and (17) (i.e., ATT and ATU).

$BH_2 = E(Y_{2i}|T_i = 1) - E(Y_{2i}|T_i = 0) = (x_{1i} - x_{2i})\,\lambda_{2i} + {}^{O}{}_{2\mu}\ (\lambda_{1i} - \lambda_{2i})$ 19

Table 4. Conditional Expectations, Treatment, and Heterogeneity Effects

	Decision stage		
Sub-samples	Beneficiaries	Non-beneficiaries	Treatment effects
SFP Beneficiary pupils	(a) $E(Y_{1i}\|T_i = 1)$	(c) $E(Y_{2i}\|T_i = 1)$	ATT
SFP Non-beneficiary pupils	(d) $E(Y_{1i}\|T_i = 0)$	(b) $E(Y_{2i}\|T_i = 0)$	ATU
Heterogeneity effects	BH_1	BH_2	TH

Note:(a) and (b) represent observed expected pupils BMI for age, height for age and DDS ;(c) and (d) represent counter-factual expected pupils BMI for age, height for age and DDS.

Ti = 1if pupils are beneficiaries of the SFP; Ai = 0 if pupils are non-beneficiaries of the SFP;

Y1i: changes in BMI-for-age, height-for-age and DDS if pupils are beneficiaries of the SFP;

Y2i: changes in BMI-for-age, height-for-age and DDS if pupils are non-beneficiaries of the SFP;

ATT: Average effect of the treatment (i.e., the SFP) on the treated (i.e., beneficiary pupils of the SFP);

ATU: the effect of the treatment (i.e., the SFP) on the untreated (i.e., non-beneficiary pupils of the SFP);

BHi: the effect of base heterogeneity for beneficiary pupils of the SFP (i = 1), and non-beneficiaries pupils (i = 2);

TH = (TT - TU), i.e., transitional heterogeneity

3.3.1.2. Sampling description for pupils in the study

Table 5 presents the descriptive statistics of the variables included in the linear regression, PSM, IPWRA and ESR models. The mean score for pupils' dietary diversity score is 5.67 on a scale 1-11, pupils have a BMI-for-age mean z-score of -0.49 with -4.72 minimum and 2.29 maximum z-scores. Pupils' height-for-age mean z-score was found to be -1.20. age of pupils was measured in months and the mean age was found to be 106.37 and mean household size of 8.44. pupils mean weight was found to be 24.7 kg and the mean height of the pupils was 124.44 centimeter.

Table 5. Description of variables in linear regression, PSM, IPWRA and ESR models (n = 780)

Variables	Description	Mean	Std. Dev.	Min	Max
Dependent variables					
Dietary diversity score (DDS)	Number of classes of food consumed within 24 hrs.	5.65	1.855	1	11
BMI-for-age	z-score value from each child	-0.49	1.132	-4.72	2.29
Height-for-age	z-score value from each child	-1.20	1.202	-4.45	2.66
Independent variables					
SFP	Beneficiary =1, non-beneficiary =0	0.77	0.422	0	1
Demographic information of pupils					
Age of pupils	Age of pupils in months	106.37	20.964	60	156
Gender	Male = 1, female = 0	0.50	0.500	0	1
Household size	Number of persons in household	8.44	3.538	1	40
Mothers' education	Quranic/non formal= 1, Primary =2, Secondary= 3, NCE/Diploma = 4, Graduate= 5	2.38	1.028	1	5
Fathers' education	Quranic/non formal= 1, Primary =2, Secondary = 3, NCE/Diploma = 4, Graduate= 5	2.83	1.062	1	5
Pupil weight	Weight measured in kilogram (kg)	24.70	4.567	13.8	53.8
Pupil height	Height measured in centimeters (cm)	124.44	8.767	102	160

SFP: School feeding program; PSM: Propensity score matching; IPWRA: Inverse Probability Weighted Adjusted Regression; ESR: Endogenous switching regression.
NCE: National Certificate in Education

3.3.2. Sampling technique and data collection for smallholder farmers

For the selection of smallholder farmers, a multi-stage sampling procedure was used. The first approach entails the purposeful selection (due to accessibility and low risk of death) of three states in north-eastern Nigeria, namely Adamawa, Bauchi, and Gombe, which were less vulnerable to the Boko Haram attack and kidnapping. Stage two involved a random selection of four local government areas from each of the three states, resulting in a total of 12 local government areas. In stage three, five wards are selected randomly from the initial selected local government areas to give us 60 wards (a ward: a city or borough administrative division that elects and represents a councillor). The fourth stage involves a random selection of four smallholder farmers in each of the wards to form 240 respondents.

The study is based on structured face-to-face survey data collected using a mobile phone web application "kobotoolbox ". Data was collected from 240 smallholder farmers in three states of Northern Nigeria. The data gathered was used to compare treatment effect outcomes between beneficiaries of HGSF and non-beneficiaries farmers.

The study questionnaire was based on a literature review and in-depth interviews and was explicitly designed for smallholder farmers and was divided into four sections. Section one includes information on farmers' socio-economics variables such as (age, years of farming experience, level of education, marital status, household size and number of pupils benefiting school feeding program). The second section contains information on the benefits of farmers' engagement in HGSF such as (access to credit, farmers' link to caterers and farmers' link to processors). The third section includes information on institutional factors affecting smallholder farmers' food security status, such as (access to extension services, access to market information, membership in the cooperative society and access to input subsidy). The fourth section of the questionnaire deals with food security measurement using the food consumption score (FCS) indicator, a seven-days recall period of the food consumed by the household.

3.3.2.2 Analytical tools for examining the impact of HGSF on smallholder household food security

The empirical approach included two main parts. First, the Food Consumption Score (FCS) was used to assess smallholder farmer household food security status. Second, a binary probit model was used to analyze factors influencing food security among smallholder farmer households (Kissoly et al., 2017; Herrmann et al., 2018; Geday et al., 2016; Ogunniyi et al. 2021). Furthermore, we used the PSM, IPWRA and ESR to estimate the effect of farmers having access to credit, being linked to caterers and linking to processors on their food security status. The PSM, IPWRA, and ESR help eliminate selection bias (i.e., observable and unobservable) associated with establishing conditional causality with observational data when randomized trials are infeasible (Guo et al., 2020; Peel, 2018).

Binary Probit Model

A binary probit model was used to determine the influence of socioeconomic characteristics and institutional factors affecting the level of food security using Stata 14 statistical software. Marginal effects are presented in the results part.

The binary probit model in the following form was used:

$Yik = \beta 1 Xi + \varepsilon i$ ……..…. (20)

where Xi represents a set of all explanatory variables presented in the study, β_1 is a vector of estimated parameters and εi is an error term. Yik is the level of consumption score where 0 = poor and borderline food security with FCS up to 35; 1 = acceptable food security with FCS higher than 35 points.

The system of equations describing binary choices of smallholder farmers is given as follows:

$$Yik = \{1 if Yik > 0$$

$$0 \quad otherwise \qquad (2)$$

Treatment Effect Analysis

As a result of the endogeneity bias, identifying the causal effects of access to credit, farmers' links to caterers, and farmers' links to processors on household food security is not easy. Individuals must be randomly assigned to different treatments to accurately measure impacts to account for both observable and unobservable characteristics. Selection bias may persist if observed and unobserved individual characteristics are not treated with appropriate quasi-experimental methods in the absence of random assignment. We use the propensity score matching (PSM), inverse probability weighted adjusted regression (IPWRA), and endogenous switching regression (ESR) methods to control for observed and unobserved (i.e., the endogeneity problem) bias in this study.

Propensity Score Matching

The PSM technique was used to answer the counterfactual question, "*What would have happened to the food security status of a smallholder farmer who has*

access to credit, linked to caterers and linked to processors (i.e., treated) if that same farmer did not have access to credit, not linked to caterers and not linked to processors (control)?". The empirical models used are described in detail below. *First, we estimated separately*, with a probit model, factors affecting farmers' access to credit, farmers' linkage to caterers, and farmers' linkage to processors. The binary probit model used is defined as:

$$Pr\left(Z_i = \frac{1}{x_i}\right) = \emptyset(x'_i\gamma) \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 21$$

Where: Z_i is the dependent variable – binary with only two outcomes (denoted by 1= "farmers with access to credit" and 0 = "farmers without access credit", or 1= "farmers linked to caterers" and 0 = "farmers not linked to caterers", 1 = farmers linked to processors and 0 = farmers not linked to processors = 0); *xi* a vector of regressors assumed to influence *Zi; "Pr"* the probability; ϕ the cumulative distribution function of the standard normal distribution and γ a vector of unknown parameters.

Zi^* can then be specified as:

$$Zi * = \Upsilon o + \sum_{n=1}^{N} \Upsilon_n x_{ni} + u_i \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 22$$

That: $Z_i = 1_{if\ Zi\ >\ 0}$ and $Z_i = 0_{\text{otherwise}}$

Where x_i = a vector of explanatory variables is (marital status, education qualification, years of farming experience, gender, age, household size, etc.,); γ = a vector of unknown parameters and *ui* = a random disturbance term. N = total sample size. The unknown parameters are estimated by the method of maximum likelihood and the magnitude of relations between the dependent and independent variables are explained by the marginal effects of the parameters.

The goal of using the r propensity score matching is to estimate the average impact of access to credit, farmers linked to caterers, and farmers linked to processors. The impact of the treatment variables (i.e., access to credit, farmers linked to caterers, and farmers linked to processors) on household food security are given as:

$E\ (Y_1\text{-}Y_0/X,\ D\ =1) = E\ (Y_1/XX,\ D\ =1) - E\ (Y_0/X,\ D\ =1).$ ……. 23

Where E(.) is the expectation operator; Y_1 is the food security status of a beneficiary; Y_0 is the food security status of a non-beneficiary; X is a vector of relevant observable covariates related to farmers' personal characteristics; and D is a binary indicator of beneficiaries, taking one when a farmer access credit, is linked to caterers and linked to processors. $E(Y_1/X, D = 1)$ the beneficiary's food security status; $E(Y_0/X, D = 1)$ the beneficiary's food security status if the farmer had not benefited.

Observing Y_1 and Y_0 at the same time is impossible (Heckman et al. 1997; Wadud, 2013), because a farmer is either a beneficiary or not, i.e., a) no baseline exists and, b) not possible to recall data. Data on $E(Y_1/X, D = 1)$ are thus easily available, but the econometric problem is to find $E(Y_0/X, D = 1)$ because observing the food security status of a benefiting farmer and the food security status of the same farmer had that farmer not benefited is impossible. We can estimate E(Y0/X, D = 1), the counterfactual by making assumptions.

One assumption often made by econometricians is to represent the counterfactual by $E(Y_0/X, D = 0)$, the food security status of a non-benefiting farmer, the control group. This causes a bias concerning the difference $E(Y_0/X, D = 1)E(Y_0/X, D = 0)$, resulting in selection bias (Mayen et al., 2010). Rubin (1977; Rosenbaum and Rubin (1985) proposed using propensity scores to match beneficiaries with non-beneficiaries as a solution. This helps in controlling the biases caused by differences in the characteristics of both smallholder farmer groups. As a result, access to credit, farmers' links to caterers, and farmers' links to processors are assumed to be independent of the outcome given the observed covariates, conditional independence assumption: Y_0S/X (Wadud, 2013).

However, in the presence of misspecification in the propensity score model, ATT from PSM can still produce biased results (Robins et al., 2007; Wooldridge, 2010). The use of inverse probability-weighted adjusted regression (IPWRA) could be a remedy for such misspecification bias. According to Wooldridge (2007), IPWRA estimates will be consistent in the presence of treatment/outcome model misspecification, but not both. As a result, the IPWRA estimator has the double-robust property, which ensures reliable estimates by accounting for misspecification in both the outcome and the treatment model (Wossen et al. 2017; 2018). Imbens and

Wooldridge (2009) proposed two steps for estimating ATT in the IPWRA model. Assume the outcome model is represented by a linear regression function of the form $Y_i=\alpha_i+\varphi_i x_i+\varepsilon_i$ for i = [0 1] and the propensity scores are given by $p(x;\bar{\gamma})$. The propensity scores are estimated in the first step as $p(x;\gamma)$. In the second step, we use linear regression to estimate (α_0, φ_0) and (α_1, φ_1) using inverse probability weighted least squares as the regression model.

$$\frac{min}{\alpha o,\varphi o}\sum_i^N(Y_i-\alpha o-\varphi o x_i)/p(x,\bar{\gamma}) \text{ if } T_i=0 \quad \ldots\ldots 24$$

$$\frac{min}{\alpha_i,\varphi_1}\sum_i^N(Y_i-\alpha o-\varphi_1 x_i)/p(x,\bar{\gamma}) \text{ if } T_i=1 \quad \ldots\ldots 25$$

The ATT is then computed as the difference between Equation (24) and Equation (25)

$$ATT=\frac{1}{N_w}\sum_i^{N_w}[(\bar{\alpha}^1-\bar{\alpha}^1)-(\bar{\varphi}^1-\varphi o)x_i \quad \ldots\ldots 26$$

where, ($\bar{\alpha}_1$,$\bar{\varphi}_1$) are estimated inverse probability-weighted parameters for treated households while ($\bar{\alpha}_0$,$\bar{\varphi}_0$) are estimated inverse probability-weighted parameters for untreated households. Finally, N_W stands for the total number of treated households.

Matching techniques can only overcome selection bias caused by observables, regardless of misspecification bias adjustments. When unobservable heterogeneity, such as a farmer's inherent skill, causes endogeneity bias, estimates of the matching technique will be biased. As a result, we used the endogenous switching regression (ESR) model in the final step to account for both observed and unobserved bias (Bidzakin et al., 2019; Shiferaw et al., 2014; Ma and Abdulai, 2016; Wossen et al. 2017). The ESR method solves the endogeneity problem by estimating the selection and outcome equations with full information maximum likelihood (FIML) (Ma and Abdulai, 2016; Wossen et al., 2017).

Furthermore, proper ESR identification necessitates the use of at least one instrumental variable that influences the treatment rather than the outcome of interest. Three different ESR models were examined in this study: (i) farmers' access to credit, (ii) farmers linked to caterers, and (iii) farmers linked to processors. The possible instrument in the first ESR model for example "farmers' access to credit" was identified as "access to input subsidy". Thus, from the question "do you have access to input

subsidy?" we created a dummy variable "those with access to input subsidy" that takes a value of 1, otherwise 0. The assumption is that farmers who have access to input subsidies have a better chance to access credit. However, access to credit is not supposed to have a direct impact on the outcome variables of interest because simply having access to credit does not improve or decrease household food security. A similar methodology was applied to identify instrumentals variable for "farmers linked to caterers" which are level of education and access to market information. Finally, third model "farmers linked to processors" uses the instrumental variable that is access to credit as adopted from (Adjin et al., 2020).

We assume that a particular farm household would consider receiving treatment, i.e., access to credit, link to caterers and link to processors, if the expected benefit of the treatment (in terms of food security status) is positive. Let F_0 be the food security status of farmer households without access to credit, not linked to caterers and not linked to processors (i.e., control group) and let f_1 be the corresponding food security status of the treatment group. The farmer will choose to be in the treatment if the food security improves defined as, $Y_i^*=F_1-F_0$, which is positive. However, the food security status that the farmer derives from treatment (Y_i^*) is a latent variable determined by observed characteristics (Z_i) as follows:

$$Y_1* - \beta^0 + \gamma Z_1 + \mu_i \text{ with } T_i = \begin{cases} 1 \ if \ Y_i*>0 \\ 0 \ if \ Y_i*\leq 0 \end{cases} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 27$$

Variables affecting expected benefits from having access to credit, farmers' links to caterers, and farmers' links to processors are represented by the vector Z. The conditional outcome function can then be specified as an ESR model in the following way.

$$\text{Regime1: } Y_{1i} = \gamma_1 x_{1i} + \varepsilon_{1i} \quad \text{if} \quad T_i = 1 \ \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 28$$

$$\text{Regime2: } Y_{2i} = \gamma_2 x_{2i} + \varepsilon_{2i} \quad \text{if} \quad T_i = 0 \ \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 29$$

where Y_{1i} is the outcome indicator for treated farmer households and Y_{2i} is the outcome indicator for untreated farmer households, and xi is a vector of exogenous variables. The outcome variable's error term is in the selection equation (i.e., Eq. 27) and the outcome equation (i.e., Eqs. 28 and 29) the error terms are assumed to have a trivariate normal distribution with mean zero and covariance matrix (Ω) in the following way:

$$\Omega = \begin{bmatrix} \sigma_u^2 & \sigma_{1\mu} & \sigma_{2\mu} \\ \sigma_{1\mu} & \sigma_1^2 & . \\ \sigma_{2\mu} & . & \sigma_2^2 \end{bmatrix}$$

Where $\sigma_{11}^2 = var(\mu_i)$, $\sigma_1^2 = \text{var}(\varepsilon_1)$, $\sigma_2^2 = (\varepsilon_2)$, $\sigma_{1\mu} = cov(\mu_i, \varepsilon_1)$, $\sigma_{2\mu} = cov(\mu_i, \varepsilon_2)$ Furthermore, σ_u^2 = is estimable up to a scale factor and can be assumed to be equal to 1 (Maddalla, 1983) and cov(ε_1, ε_2) is not defined as Y_1 and Y_2 cannot be observed simultaneously. Moreover, the correlation between the error term of the selection equation and the outcome equation is not zero (i.e., corr(μ_1, ε_1) $\neq 0$ and corr(μ_1, ε_2) $\neq 0$) which creates selection bias. ESR addresses this selection bias by estimating the inverse mills ratios (λ_{1i} and λ_{2i}) and the covariance terms ($\sigma_{1\mu}$ and $\sigma_{2\mu}$) and including them as auxiliary regressors in Eqs. (28) and (29). If $\sigma_{1\mu}$ and $\sigma_{2\mu}$ are significant, we reject the absence of selection bias. In addition, $\sigma_{1\mu} < 0$ represents positive selection bias (i.e., households with above-average food security are more likely to choose to be in the treatment). The ESR model estimates can then be used to estimate ATT (Average treatment effect on untreated households) as follows:

$E(Y_{1i}|T_i = 1) = \gamma_1 x_{1i} + \lambda_{1i}\sigma_{1\mu}$ 30

$E(Y_{2i}|T_i = 0) = \gamma_2 x_{2i} + \lambda_{2i}\sigma_{2\mu}$ 31

$E(Y_{2i}|T_i = 1) = \gamma_2 x_{1i} + \lambda_{1i}\sigma_{2\mu}$ 32

$E(Y_{1i}|T_i = 0) = \gamma_1 x_{2i} + \lambda_{2i}\sigma_{1\mu}$ 33

Equations (30) and (31) along the diagonal of Table 6 represent the actual expectations observed in the sample. Equations (32) and (33) describe the counterfactual expected outcome (33). In addition, we calculate the average treatment of the treated "on beneficiaries' pupils" on the treated (ATT) as the difference between equations (30) and (32) following the Heckman et al. (2001),

$ATT = E(Y_{1i}|T_i = 1) - E(Y_{2i}|T_i = 1) = x_{1i}(\gamma_1 - \gamma_2) + (\sigma_{1\mu} - \sigma_{2\mu})\lambda_{1i}$ 34

which represents the impact of credit, linking farmers to caterers, and linking farmers to processors on household food security. Similarly, for non-beneficiaries of access to credit, linking farmers to caterers, and linking farmers to processors on household food security, we calculate the effect of treatment on the untreated (ATU) as the difference between equations (33) and (31).

$$ATU= E(Y_{1i}|T_i = 0)- E(Y_{2i}|T_i = 0) = x_{2i}(\gamma_1-\gamma_2) + (\sigma_{1\mu} - \sigma_{2\mu})\lambda_{2i} \quad \ldots\ldots\ldots\ldots 35$$

To account for the effects of heterogeneity, beneficiaries of access to credit, linking farmers to caterers, and linking farmers to processors. For example, beneficiary farmers may have a higher household food security status than non-beneficiaries, even though they benefit due to unobservable characteristics such as their skills. We chose to adapt because of the difference between (a) and (d).

$$BH_1= E(Y_{1i}|T_i = 1)- E(Y_{1i}|T_i = 0) = (x_{1i} - x_{2i})\,\lambda_{1i} + \sigma_{1\mu}\,(\lambda_{1i}- \lambda_{2i}) \quad \ldots\ldots\ldots 36$$

The difference between equations (34) and (35) is "transitional heterogeneity," or whether the effect of farmers' access to credit, linking farmers to caterers, and linking farmers to processors is larger or smaller among beneficiaries or non-beneficiaries in the counterfactual case that they did benefit (i.e., ATT and ATU).

$$BH_2= E(Y_{2i}|T_i = 1)- E(Y_{2i}|T_i = 0) = (x_{1i} - x_{2i})\,\lambda_{2i} + \sigma_{2\mu}\,(\lambda_{1i}- \lambda_{2i}) \quad \ldots\ldots\ldots\ldots 37$$

Table 6. Conditional Expectations, Treatment, and Heterogeneity Effects

	Decision stage		
Sub-samples	Beneficiaries	Non-beneficiaries	Treatment effects
Beneficiaries' farmers	(a) $E(Y_{1i}\|T_i = 1)$	(c) $E(Y_{2i}\|T_i = 1)$	ATT
Non-beneficiaries' farmers	(d) $E(Y_{1i}\|T_i = 0)$	(b) $E(Y_{2i}\|T_i = 0)$	ATU
Heterogeneity effects	BH_1	BH_2	TH

Note:(a) and (b) represent observed expected farmers' access to credit, linking farmers to caterers and linking farmers to processors ;(c) and (d) represent counterfactual expected farmers' access to credit, linking farmers to caterers and linking farmers to processors

Ti = 1if farmers beneficiaries; Ai = 0 if farmers are non-beneficiaries.

Y1i: changes in household food security status if farmers are beneficiaries.

Y2i: changes in household food security status if farmers are non-beneficiaries.

ATT: Average effect of the treatment (i.e., beneficiaries) on the treated (i.e., beneficiaries' farmers of access to credit, linking farmers to caterers and linking farmers to processors);

ATU: the effect of the treatment (i.e., SFP) on the untreated (i.e., non-beneficiaries' farmers of access to credit, linking farmers to caterers and linking farmers to processors);
BHi: effect of base heterogeneity for beneficiaries' farmers (i = 1), and non-beneficiaries' farmers (i = 2);
TH = (ATT - ATU), i.e., transitional heterogeneity

3.3.2.1. Sample description for smallholder farmers

The Food Consumption Score

The World Food Programme developed the FCS as a frequency-weighted dietary diversity score (Leroy et al., 2015). The FCS is the sum of the number of times a food group from the household dietary score was eaten in the previous seven-day period. Information on the frequency of consumption in the week prior of cereals, tubers, pulses, vegetables, fruits, meats and fish, milk, sugar and oil, multiplied by the weight (importance in the diet) assigned to each group by the World Food Program (WFP, 2006). The scores are then classified into three categories: poor (<21.5), borderline (21.5–35), and acceptable (>35) categories. The model used is as follows:

$$FCS = a_1b_1 + a_2b_2 + a_3b \ldots\ldots\ldots\ldots a_8b_8 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (1)$$

where a = weight of each food, 1-8 = Food group, and b = frequency of food consumption (number of days for which each food group was consumed during the past 7 days).

Table 7 furthermore, displays the variables that were imported into the probit regression models, with the food consumption score of smallholder farmers used as the dependent variable. A majority (67.1%) of the respondents were male with a mean age of 42.09, with 88.8% of the respondents married and having on average 17.67 years of farming experience. The result indicated that 35% of the smallholder farmers obtained a secondary education and about 31% of the farmers did not have formal education. The results, furthermore, revealed that 45.4 % of the farmers' access funding under the school feeding program for farmers to production, 36 (15%) of the farmers are linked to caterers, implying that they have been selling the product to caterers, and 12 (5.0 %) of the farmers are linked to processors, suggesting that they have been selling some of their produce direct to processors. Furthermore, the results revealed that 43 (17.9%) had access to extension service delivery, 84 (35.0%) had access to input subsidy, 102

(42.5%) had access to market information, and 52 (22.5%) were members of a cooperative group.

Table 7. Description of variables in probit regression model (n = 240)

Variables	Description and measurement	Frequency (Yes)	(%)
	Dependent variable		
Food security indicators			
Food consumption score	0 = poor and borderline (up to 35), 1 = acceptable (>35)	NA	NA
Independent Variables			
	Household head characteristics		
Age	Age of household head (years)	Mean = 42.09	(8.48)
Gender	Male= 1, Female = 0	161	67.1
Marital status	Married = 1, unmarried = 0	213	88.8
Years of Farming experience	Farming experience in years	Mean = 17.67	(8.91)
Educational qualification	Quranic Edu. = 1, primary = 2, secondary = 3, NCE = 4, graduate = 5, postgraduate = 6	Mean = 2.83	
	Household characteristics		
Household size	The household size in numbers	Mean = 7.94	(3.88)
	Homegrown school feeding program instruments		
Access to HGSF credit (Fund)	Yes = 1 No = 0	109	45.4
Farmers linked to caterers	Yes = 1 No = 0	36	15.0
Farmers linked to processor	Yes = 1 No = 0	12	5.0
Households with children benefiting from HGSF	Yes = 1 No = 0	146	60.8
	Institutional variables		
Access to extension services	Yes = 1 No = 0	43	17.9
Access to input subsidy	Yes = 1 No = 0	84	35.0
Access to market information	Yes = 1 No = 0	102	42.5
Member of cooperative society	Yes = 1 No = 0	52	22.5

NCE: National Certificate of Education
SFP: School Feeding Program

3.3.3. Sampling technique and data collection for food vendors

A multi-stage sampling procedure was used to choose the food vendors. In the first stage, three states from six in north-eastern Nigeria were selected purposively: Adamawa, Bauchi, and Gombe due to their less vulnerability to Boko Haram terrorist attacks. Stage two involved a purposive selection of four local government areas from

each of the selected three states to avoid local government areas where kidnappings and banditry attacks were rampant. In the third stage, five wards were selected randomly from the initial list of local government areas. The fourth stage entails selecting four food vendors randomly from each of the wards to create 240 respondents.

The researcher and trained enumerators conducted face-to-face pen and paper interviews to collect data. Most of the interviews were conducted in Hausa (the study area's native language) and were translated into English on the spot. Data were collected from December 2020 to February 2021 with a 100% response rate. A pilot survey was conducted with 24 food vendors in the study sites before the survey, as 10% of the study sample size is recommended (Hertzog, 2008). The questionnaire was adapted accordingly.

The questionnaire for the study was developed based on the KAP model (knowledge, attitudes, and practices). The food safety KAP questionnaire was based on the World Health Organization's "Five keys to safer food" (Luo et al., 2019; Baser, F. et al., 2017; Madaki and Bavorova, 2021; Dehghan, P. et al., 2017; Ferk et al. 2016; Osailiet al., 2018; Green & Knechtges, 2015) combined with the socio-demographic characteristics of food vendors such as gender, age, school education level, household size, years of experience, and income.

Twelve items were used to assess food safety knowledge. Each item was scored 1 if the answer was correct and 0 if the answer was incorrect or "I don't know." The total score ranged from 0 to 12, with a high score indicating a high level of knowledge on the topic. Questions were adapted from previous studies (Luo et al., 2019; Baser et al., 2017; Madaki and Bavorova, 2021; Osailiet al., 2018).

Eight items were used to assess food handlers' attitudes toward food safety. Each item had five levels, with a score ranging from 1 to 5, indicating "Strongly disagree" to "Strongly agree," respectively. The total score ranged from 8 to 40, with a higher score indicating greater concern about food safety. Questions were adapted from previous studies (Osailiet et al., 2018; Madaki and Bavorova, 2021; Luo et al., 2019).

Nine items were used to evaluate food safety practices. Participants were asked to rate the frequency of use of these practices as follows: 1 = never, 2 = rarely, 3 = sometimes, 4 = often, and 5 = always. These items' total scores ranged from 9 to 45,

with a high score indicating good food safety practices. Questions were adapted from previous studies (Osailiet al., 2018; Madaki and Bavorova, 2021; Luo et al., 2019).

3.3.2.3 Analytical tools for assessing factors influencing food safety knowledge, attitude and practices of food vendors

This subsection descriptive statistics were used to summarize respondent biodata and their knowledge, attitudes, and practices scores (percentages, mean, mode and standard deviation). Linear regression models were used to analyse factors influencing vendors' knowledge, attitudes, and practices in food safety. Description of variables selected for the model as expected to influence the food safety knowledge, attitude and practices are presented in Table 9. The association between the respondents' knowledge, attitudes, and practices was tested using Spearman's correlation coefficient. STATA 14 was used to analyse the data.

Linear Regression

Models specification:

$Y=b_0+b_1X_1+b_2X_2+ \ldots +b_nX_n+e \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots$ (39)

Y=Dependent variables (food safety knowledge (model 1), food safety attitude (model 2), and food handling practice (model 3)

b_0-bn= Regression coefficients

X_1-X_n= Independent variables (Age, gender, marital status, household size, years of experience, and level of education and food safety knowledge information source)

4 e=Error term

The model was tested for multi-collinearity using correlation, coefficients of tolerance, and a variance inflation factor (VIF), which indicated that the variables were independent. The Durbin-Wu-Hausman test did not reveal any effect of potential endogeneity.

3.3.3.1. Sample description for food vendors

Table 8 reveals that the majority (88.75%) of the vendors preparing food within the SFP are female in the study area. Furthermore, the results revealed that most (75.4

%) vendors are under 40 years old. About 70% of the vendors are married and a majority (70.41%) of the vendors have 5-10 persons in their household. The result revealed that 25.42% of the vendors had qur'anic education, 25% had primary education and 38.75% had secondary school education. Our study findings revealed that 38.33% of the food vendors have 5-10 years of vending experience. The findings revealed that the majority (75.42%) of the vendors earn 5000-10000, equivalent to ($13-25) food vending income. About 70% of the vendors do not have food handling training. This is consistent with Madaki and Bavorova (2019) study conducted in Nigeria, which reported that the majority of food vendors lack food handling training. Poor food handling training implies that vendors will lack modern and advanced skills in food safety practices. A majority (78.75%) had no medical certificate before engaging in the food vendor business. This implies that the majority of the vendors do not understand the need for a medical certificate before establishing a food vendor business. This is in line with Abeokuta (2021) reporting that most food vendors in Nigeria do not have a medical certificate and that it should be required to help improve food hygiene.

Table 8. Socio-economic characteristics of food vendors (N = 240)

Variables	Items	Frequency	Percentages
Gender	Male	27	11.25
	Female	213	88.75
Age (in years)	< 30	77	32.09
	30-40	104	43.31
	41-50	40	18.34
	> 50	15	6.26
Marital status	Single	52	21.67
	Married	167	69.58
	Divorced	19	7.92
	Widow	2	0.83
Household size	< 5	28	11.67
	5-10	169	70.41
	>10	43	17.92
Educational level	Quranic education	61	25.42
	Primary school	60	25.00
	Secondary school	93	38.75
	Diploma	26	10.83
Years of experience	<5	48	20.00
	5-10	92	38.33
	11-15	38	15.84
	16-20	34	14.16
	>20	28	11.67
Food vending profit/month (Naira)	<5000	21	8.75
	5000-10000	181	75.42
	11000-15000	30	12.5
	>15000	8	3.33
Food handling training	Yes	73	30.42
	No	167	69.58
Medical certificate	Yes	51	21.25
	No	189	78.75

1 USD = 411 Naira (Nigerian currency)

Table 9. Description imported into the multiple linear regression model (N = 240)

Variables	Description	Mean	Std. Dev.	Min	Max
Dependent variables					
Food safety knowledge	Food safety knowledge score	8.82	1.96	2	12
Food safety attitude	Food safety attitude score	34.51	7.21	8	40
Food safety practice	Food safety practice score	33.04	7.37	9	45
Socio-demographic characteristics					
Age	Number of years	35.20	8.68	20	58
Gender	0 = Female and 1 = Male	0.04	0.20	0	1
Household size	Number of people in the house	7.60	3.48	1	27
Food vending experience	Years in food vending business	10.90	7.29	1	30
Education qualification	Years of education	7.70	5.27	0	15
Food vending profit	Amount of profit made (Naira) [a]	8031.25	3378.20	2000	20000
Food handling training	Yes =1 No = 0	0.30	0.46	0	1
Food safety information sources					
Radio source	Yes =1 No = 0	0.78	0.42	0	1
Television source	Yes =1 No = 0	0.61	0.50	0	2
Food inspection institution	Yes =1 No = 0	0.32	0.47	0	1
Social media	Yes =1 No = 0	0.10	0.31	0	1
Friend & colleagues	Yes =1 No = 0	0.10	0.31	0	1
Internet	Yes =1 No = 0	0.21	0.41	0	1

[a] NB: 1 USD = 410 Naira (Nigerian currency) on 22/01/2021

4. Results and Discussions

4.1. Introduction

Chapter four presents the results of the econometric models described in the methodology, as well as the characteristics of the teachers, pupils' households, smallholder farmers, and food vendors. Each respondent's results are presented separately.

4.2. Results on effect of SFP on pupils' academic performance

4.2.1 Teachers' perceived effect of SFP pupils school enrolment, attendance and performance

The results of the perceived effect of school feeding program on pupils' enrolment, attendance and performance by class teachers are presented in Figure 10. According to the study's findings, most teachers (88.3%) perceived that the school feeding program increased pupil enrolment. This is in line with the results of Zenebe et al., 2018; Alderman and Bundy, 2012; Kristjansson et al., 2007; Snilstveit et al. (2018); Mwendwa & Gori, 2019, who reported that a school feeding program increased pupil enrolment. Furthermore, this study's findings revealed that most teachers (88.3%) believe the school feeding program had reduced absenteeism, increasing pupil school attendance in the study area. This finding is consistent with previous research conducted by Gelli et al., (2016); Zenebe et al., (2018); Snilstveit et al., (2018) and Mwendwa & Gori, (2019), which found that school feeding programs increased pupil attendance. Class teachers were also asked if school feeding impacts students' academic performance. According to the findings, the majority of teachers (70.6%) believe that the school feeding program improves students' academic performance.

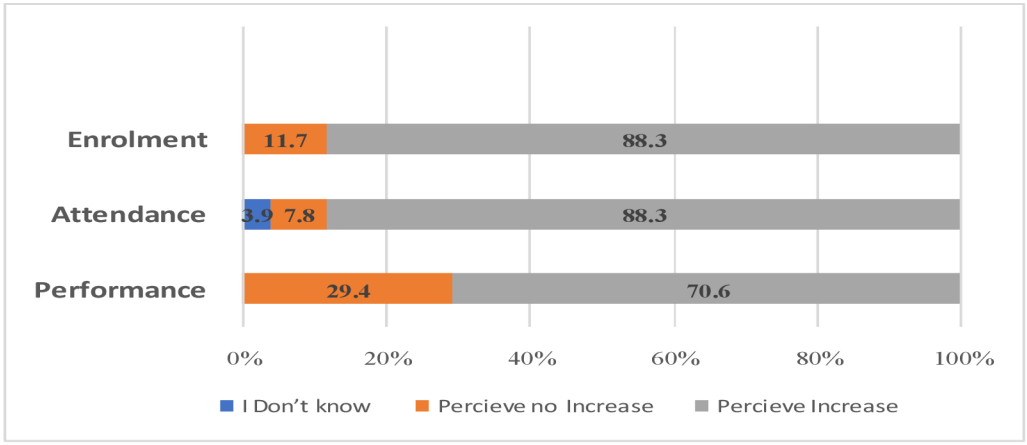


Figure 11: Teachers' perceived effect of school feeding on pupils' school enrolment, attendance and performance

4.2.1. Perceived pupils' class participation

Figure 11 shows that 68.3 % of the teachers perceived a moderate and large improvement in pupils taking learning seriously, 55.6% in heeding instructions and 59.4% in staying active all day in school. The perception of the teachers on the effect of school meals on pupils' class participation showed that 48.9 % of the teachers perceived a moderate or large improvement in listening attentively, 42.7 % in working independently and 45.0 % in better concentration.

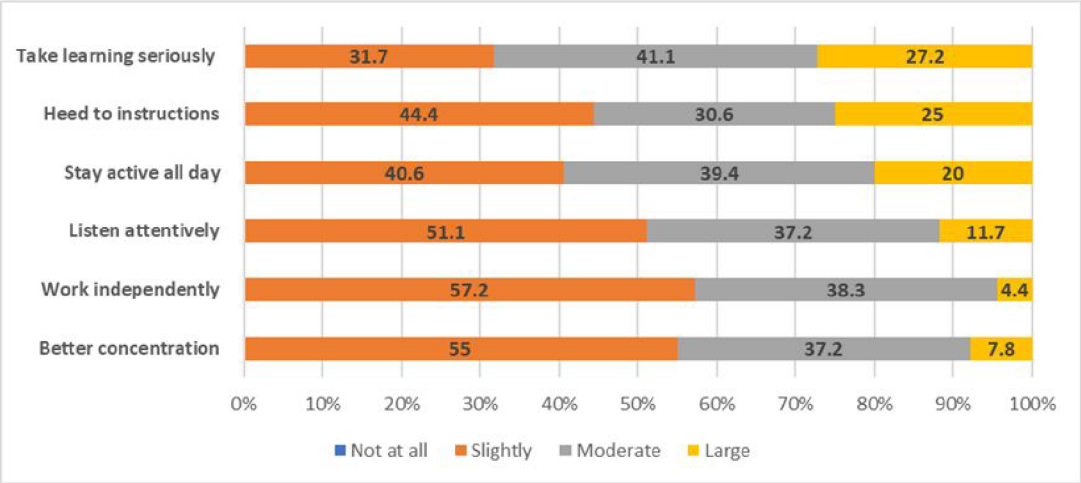


Figure 12: Teachers perceived no effect, small, moderate and large effect of SFP on pupils' class participation

4.2.2. Results of effect of SFP on pupils' enrolment, attendance and performance (school record evidence)

Table 10 displays the comparison of means of pupil enrolment, attendance and performance in Math and English before and during the SFP. The results indicate that there is a significant difference between pupils' enrolment before and during the intervention (73.38 % before and 93.59 % net enrolments after). The finding agrees with studies conducted in Peru, Mali, Sri Lanka, Egypt, Ghana, Bangladesh and Ethiopia on the effects of the school feed program on children's school enrolment, that provide evidence of an increase in the number of children enrolled (Taylor and Ogbogu, 2016; Tijjani et al., 2017; Masset and Gelli, 2013; He, 2009; Aurino et al., 2018; Metwally et al., 2020; Sulemana et al., 2013; Ahmed, 2004; Zenebe et al., 2018; Alderman and Bundy, 2012; Hinrichs, 2010).

There is a difference between pupils' school attendance rates that increased from 70.58% to 90.86% net attendance during the SFP. This finding agrees with studies conducted in the United Kingdom, Ghana, Ethiopia and Laos, who reported that there is a positive relationship between the school feeding program and the child school attendance rate (McEwan, 2013; Belot and James 2011; Aurino et al., 2018; Metwally et al., 2020; Gelli et al., 2016; Zenebe et al., 2018; Alderman and Bundy, 2012).

Regarding the performance, both the mean scores in Math and English increased during the program. Performance in Math increased from 46.98 to 48.78 points on a scale of 1-100 and performance in English rose from 46.53 to 48.21 points. This result agrees with several studies conducted in Nigeria, UK, Ethiopia, Ghana, Burkina Faso, Kenya, India and Bangladesh who reported that the school feeding program significantly improved child academic performance (Tijjani et al., 2017; Belot and James, 2011; Zenebe et al., 2018; Metwally et al., 2020; Gelli et al., 2016; Kazianga et al., 2013; Lawson 2012; Kristjansson et al., 2007; Bundy et al., 2009; Chepkwony et al., 2013).

Table 10. Effect of School Feeding Program on Educational Performance (n=180)

Variables	Items	Mean (SD)	t-value	p-value
Net school enrollment rate (%)	Before	73.38 (18.53)	-19.75	0.000**
	After	93.59 (23.07)		
Total net attendance rate (%)	Before	70.58 (17.59)	-15.75	0.000**
	After	90.86 (21.91)		
Math score[1]	Before	46.98 (8.42)	-3.82	0.000**
	After	48.78 (9.36)		
English score[1]	Before	46.53 (8.19)	-4.05	0.000**
	After	48.21 (8.53)		

** Significant at 0.05; Paired-sample t-tests; [1]measured on a scale 0-100 points.

[2]The net enrollment rate = students enrolled who are of the official age group for a given level of education / the population for the same age group (UIS, 2011). [3]Total net attendance rate = the total number of students in the official school-age range for the given level of education attending school at any level of education/population of the same age group (UIS, 2011).

[4]Grade 1-3 means from primary one to three participating classes. [5]The performance in Math and English were measured by points on a scale 0-100.

4.2.3. Results of effect of duration of SFP on academic performance

The results from Table 11 display the effect of the duration of the feeding program on pupils' performance. The independent control variables inserted into the model included the age of the teacher, gender, educational qualification, staff-student ratio, number of pupils in class, and average school attendance rate for pupils.

The results of the linear regression on the effect of duration of the feeding program revealed a statistically positive significant impact on pupils' English and Math score, implying that a one-month increase in the duration of the feeding program is likely to increase performance in English and Math by 0.86 and 0.68 scores, respectively. The findings are consistent with previous research conducted in India and Zambia, which found that prolonged exposure to midday meals has a robust positive effect on learning achievement (Chakraborty and Jayaraman, 2019; Singh et al., 2014).

Table 11. Linear regression on factors affecting pupil's educational performance

Variables	Performance English*		Performance Math*	
	Coefficient	p-value	Coefficient	p-value
Teachers' characteristics				
Age of the teacher	-0.022	0.810	0.173	0.076
Gender of the teacher	-4.034	0.004	-3.688	0.014
Graduate	7.091	0.001	8.277	0.000
Postgraduate	1.599	0.610	2.623	0.441
School characteristics				
Teacher pupil's ratio	0.039	0.400	0.019	0.704
Duration of the feeding program	**0.863**	**0.001**	**0.682**	**0.013**
Number of pupils in a class	-0.127	0.003	-0.108	0.018
Average school attendance boys	-0.398	0.000	-0.331	0.000
Average school attendance girls	0.362	0.001	0.302	0.007
(constant)	44.958	0.000	38.951	0.000
F-value		4.412		4.897
R^2		0.189		0.206
Adjusted R^2		0.146		0.164

Source: Own Survey *Performance in English and Math for grades 1-3, measured on a scale 0-100 points.

4.3. Results of the effect of SFP on pupils' nutritional status

4.3.1. Socio-demographic characteristics of the pupils

Table 12 compares the socio-demographic characteristics of the beneficiaries (treated) and non-beneficiary pupils (control). The findings revealed that the mean age difference between the beneficiary and non-beneficiary pupils is about 16 months and is significant at a 1% level. This implies a significant difference between the age of the beneficiary and non-beneficiary pupils. It also means beneficiary pupils are older than non-beneficiary pupils. However, there is no statistically significant difference in terms of gender and household size.

The mean difference in dietary diversity score between the beneficiary and non-beneficiary pupils is about 2.1 additional food classes at a 1% significance level. This implies beneficiary pupils have additional/more food classes than those not benefiting from the school feeding programme. The finding revealed there is no significant difference in the mean score of Height-for-age between beneficiary and non-beneficiary pupils. The BMI-for-age shows a significant difference with a mean difference of -0.48 between the beneficiary and non-

beneficiary pupils at a 1% significance level. This means that the non-beneficiary pupils are more overweight or obese, which is a sign of malnutrition (van Stralen et al., 2012; WHO, 2021). There is no significant difference in the weight of the beneficiary and non-beneficiary pupils.

Table 12. Socio-demographic characteristics between the beneficiary and non-beneficiary pupils

Variables	Beneficiary pupils (n=600) Mean ± S.D.	Non beneficiary pupils (n=180) Mean ± SD	Mean difference	t-statistics
Age in months	110.10 (21.00)	93.93 (15.31)	16.17***	9.59
Gender	0.50 (0.50)	0.50 (0.50)	0.00	0.00
Household size	8.52 (3.58)	8.20 (3.39)	0.32	1.05
Dietary diversity score	6.13 (1.76)	4.02 (1.09)	2.12***	15.31
Height-for-age	-1.21 (1.24)	-1.18 (1.07)	-0.03	0.26
BMI-for-age	-0.60 (1.100	-0.12 (1.15)	-0.48***	-5.10
Weight of pupils (kg)	24.75 (4.94)	24.54 (3.01)	0.21	0.54

Source: Own survey 2021, *** 1% level of significance; **5% level of significance; *10% level of significance, Standard deviations are reported in parentheses

Table 13 shows that there is no significant difference in mothers' educational attainment between SFP beneficiary and non-beneficiary pupils. For example, 39.50 % of beneficiary mothers have a secondary school education, which is nearly the same as 40.56 % of mothers. Similarly, there is no significant difference between the fathers of beneficiary pupils and those of non-beneficiaries. This implies that beneficiaries and non-beneficiaries share similar socioeconomic characteristics.

Table 13. Comparing socio-demographic characteristics between the beneficiary and non-beneficiary pupils

Variables	Beneficiary pupils (n=600)	Non-beneficiary pupils (n=180)	Chi-square value	Sig.
Mothers' education			30.74	0.112
Quranic/non-formal	28.83	27.22		
Primary	20.33	20.00		
Secondary	39.50	40.56		
NCE/Diploma	10.34	11.67		
Graduate	1.00	0.56		
Fathers' education			34.24	0.120
Quranic/non-formal	24.00	26.11		
Primary	12.67	11.44		
Secondary	49.00	50.22		
NCE/Diploma	8.83	7.22		
Graduate	5.50	5.01		

Source: Own Survey, 2021; Chi-square test/independent t-test

4.3.2. Distribution of pupils' nutritional categories

Table 14 shows the distribution of pupils based on the international children's nutritional status based on the WHO growth reference (Cashin and Lesley, 2018). According to the findings, 7.2 % of the beneficiary pupils were severely stunted, compared to 6.1 % of non-beneficiary pupils. Similarly, 19.7 % of beneficiary pupils were moderately stunted compared to 15.6 % of non-beneficiary pupils. Furthermore, 73.2 % of the beneficiary pupils were in normal categories, slightly lower than 78.3 % of the non-beneficiary pupils. This implies that non-beneficiary pupils fell more into the normal categories than the beneficiary pupils in statistical terms.

Furthermore, the distribution of the pupils' BMI-for-age revealed that 2.8% of the beneficiary pupils were severely thin, compared to 2.2% of non-beneficiary pupils. In addition, 84.5% of the beneficiary pupils had a normal BMI for their age, compared to 76.1% of the non-beneficiary pupils. Similarly, 5.5% of the beneficiaries were overweight, compared to 15.0% of the non-beneficiaries. This implies that the prevalence of children being overweight is higher among non-beneficiary pupils.

Table 14. Distribution of pupils according to international nutritional status cutoffs (Children 5-19 years)

Anthropometric Indicator	Condition	Z-score	Beneficiary pupils (n=600)	Non-beneficiary pupils (n=180)
Height-for-age	Severe stunting	< -3 SD	7.2	6.1
	Moderate stunting	≥ -3 to < -2 SD	19.7	15.6
	Normal	≥ -2 SD	73.2	78.3
BMI-for-age	Severe thinness	< -3	2.8	2.2
	Moderate thinness	≥ -3 to < -2	7.0	5.0
	Normal	≥ -2 to ≤ +1	84.5	76.1
	Overweight	> +1 to > +2	5.5	15.0
	Obesity	>+2 to >+3	0.2	1.7

Source: Own survey, 2021

4.3.3. Factors affecting pupils' nutritional status

The findings of the linear regressions indicated (Table 15) that the SFPs had a statistically significant positive effect on pupils' DDS, implying pupils benefiting from an SFP experience an increase of 2 additional classes of food among the pupils. This confirmed our hypothesis that an SFP improves the DDS of beneficiary pupils. This result is in line with previous studies (Zenebe et al., 2018; Chakraborty and Jayaraman, 2019) who reported that school feeding programmes improved pupils' dietary scores.

The results showed that an SFP has a statistically significant negative effect on pupils' BMI -for -age. This implies that non-beneficiary pupils are more overweight than beneficiary pupils. This is in line with the findings of (Teo et al. 2021; Chen et al. 2020; Gelli et al. 2019), who reported a significant negative effect of SFPs on the BMI-for-age of beneficiary pupils. The main reason behind this finding is that increased consumption of energy-dense foods high in fat and carbohydrate but low in proteins, vitamins, minerals, and other healthy micronutrients influences child becoming overweight and obese (Hanson and Gluckman, 2011; Mokdad et al., 2004). As opposed to this, beneficiary pupils of the SFP are exposed to a balanced diet that helps balance any nutrient deficiency, which in turn reduces body weight and the phenomena of obesity and being overweight among the beneficiary pupils (Foster et al. 2008; Gleason et al. 2009; Anderson et al. 2018; Jomaa et al. 2011; Abizari et al. 2014; Finkelstein et al. 2015).

The findings also showed that an SFP has a statistically significant positive effect on the Height-for-age index among the benefiting pupils, with a 0.521 increase in z-score. This is in line with other studies (Gelli et al., 2016; Zenebe et al., 2018; Jamie et al., 2017; Buttenheim et al., 2011), highlighting that SFP participants have a significantly higher height-for-age z-score than non-beneficiaries.

The results indicated that age has a statistically significant negative effect on pupils' BMI-for-age with a -0.004 z-score effect. This contradicts the findings of Dinku et al. (2020), who reported that an increase in the age of children had a positive impact on BMI-for-age. The negative effect can be attributed to the high number of cases of malnutrition among children in the study area before the programme implementation (WFP, 2020b; UNICEF, 2020b). Similarly, an increase in age has a statistically negative significant effect on pupils' Height-for-age index with a coefficient of -0.027 z-score. This is consistent with Dinku et al. (2020), who reported that as the age of children increases Height-for-age index decreases.

Gender has a significant negative effect on the Height-for-age index of pupils with a coefficient of -0.191 z-score effect. This implies that girl children had a better Height-for-age index than their boy counterparts. This is in line with Gelli et al. (2019), who reported that being a girl child has a significant positive effect on Height-for-age compared to their boy counterparts. One plausible argument to explain this finding rests on intra-household inequalities. It might be the case that boy children receive more food rations than girl children who are culturally and economically disadvantaged in households due to gender discrimination in Nigeria (Akerele, 2011) and as a result, girls who are subjects of SFPs may benefit disproportionally more from the free meals provided in the SFP scheme than pupils from less disadvantaged households.

As expected, household size is statistically significant and negatively associated with BMI-for-age in our study. This finding is in line with the studies (Timothy & Richard, 2010; Burke et al., 2016; Babar et al., 2010; Babatunde and Qaim, 2010; Gelli, 2019) that reported that an increase in household size has a negative effect on the BMI-for-age of a child. Thus, the lower the dependency ratio, the higher the nutrient intake of preschool children (Burke et al., 2016; Babatunde and Qaim, 2010).

The linear regression results showed that the mother's education positively affects the DDS of a pupil with a coefficient of 0.30 classes of food. This implies that it is more likely to increase DDS among children for every additional year in the mothers' education. This is consistent with the studies of (Berhane et al. 2020; Alderman and Headey, 2017; Vollmer et al., 2017; Frost et al., 2005; Kabubo-Mariara et al., 2008), who reported that the more educated a mother is, the more likely it is for her children to obtain a higher DDS. Similarly, the effect of maternal education on pupils' BMI-for-age showed a significant statistically positive effect on the BMI-for-age of pupils with a 0.239 increase in z-score. This is in line with several recent studies (Berhane et al. 2020; Vollmer et al. 2017, Micheal et al. 2016), who reported that the higher educated a mother is, the more likely her children will display a higher level of BMI-for-age.

Table 15. Factors affecting pupils' Dietary diversity scores, BMI-for-age and Height-for- age index

Variables	Dietary diversity score	BMI-for- age	Height-for-age index
National safety net programme			
SFP	2.218 (0.149)***	-0.545(0.113) ***	0.521 (0.111)***
Demographic characteristics			
Age (in months)	-0.001(0.003)	-0.004 (0.002)**	-0.027 (0.002)***
Gender	0.036 (0.115)	-0.079 (0.077)	-0.191(0.076)**
Household size	-0.012 (0.018)	-0.035 (0.012)***	-0.013 (0.012)
Mothers' education	0.300 (0.083)***	0.239 (0.056)***	-0.066 (0.055)
Fathers' education	-0.035 (0.079)	-0.155 (0.053)***	0.080 (0.053)
Constant	3.579 (0.366)	0.035 (0.260)	1.801 (0.257)
F-value	0.000	0.000	0.000
R^2	0.258	0.106	0.227
Adjusted R^2	0.252	0.098	0.220
Observation	780	780	780

SFP: School feeding programme, *** 1% level of significance; **5% level of significance; *10% level of significance Standard errors are reported in parentheses

4.3.4. Effects of SFPs on pupil's DDS, BMI-for-age and Height-for-age index

Table 16 presents the result of average treatment effect estimates of an SFP on the outcome variables DDS BMI-for-age and Height-for-age index among beneficiary and non-beneficiary school pupils. Columns 1, 2, and 3 present treatment effect results based on propensity score matching (PSM), inverse probability weighted adjusted regression (IPWRA), and endogenous switching regression (ESR) specifications. As described in section 3, these analyses are to answer the counter-factual question, "*What would have happened to the nutritional status of pupils if they did not have access to the SFP, as beneficiaries (treated) if that same pupil was a non-beneficiary (control)*?".

In general, the reported effects of SFPs on pupils' nutritional status are robust across all estimation strategies, demonstrating the importance of the programme on the outcome indicators. The treatment effect results of SFPs on DDS among beneficiary and non-beneficiary pupils using a PSM model specification indicates that beneficiary pupils experienced an additional 1.94 more classes of food than non-beneficiary pupils. When using IPWRA specifications, the DDS of the beneficiary pupils increased by 1.72 more classes of food than non-beneficiary. In our ESR model, where we accounted for both observable and unobservable sources of bias, the effect of SFPs on DDS indicates an additional level of 0.90 classes of food than their non-beneficiary counterpart (see appendix A5 & A6). The estimated impacts' direction and magnitude are also consistent across all specifications. These findings imply that an SFPs has the potential to improve pupils' DDS. This finding is consistent with the studies of (Zenebe et al. 2018; Roothaert et al., 2021; Jacoby et al.1996; Grillenberger et al. 2013; Chakraborty and Jayaraman, 2019), who reported that SFPs increased the DDS of beneficiary pupils over those of non-beneficiaries.

Furthermore, when using a PSM specification to analyse the impact of SFPs on the BMI-for-age of pupils, the finding indicates that beneficiary pupils experience a -0.72 z-score decrease in BMI-for-age compared to their non-beneficiary pupil counterparts implying that beneficiary pupils lost more weight than the non-beneficiary counterparts. The additional statistical treatments derive the same results. Using IPWRA specifications, findings reveal that SFP decreases BMI-for-age of beneficiary pupils with a -0.34 z-score compared to their non-

beneficiary counterparts. In line with these previous treatments, using the ESR model, our results demonstrate that an SFP decreases beneficiary pupils' BMI-for-age with a -1.14 z-score compared to the non-beneficiary pupils (see appendix A1 & A2). This is in line with the study (Würbach et al. 2009; Moore et al. 2007; Teo et al. 2021; Chen et al. 2020; Siega-Riz et al. 1998; Gelli et al. 2019; Buttenhein et al. 2011; Pelletier et al. 1995; Baxter et al. 2010; Gleason et al. 2009) whose authors used similar kinds of sample and reported that SFPs had a significant negative effect on BMI-for-age among beneficiary pupils. As explained in the previous subsection, pupils benefiting from an SFP can get a balanced diet which will help reduce their overweight situation (Abizari et al., 2014; Jomaa et al., 2011; Finkelstein et al., 2015).

The treatment effect of SFPs on the Height-for-age of pupils using PSM indicates that beneficiary pupils reported an increase of 0.24 z-score compared to their non-beneficiary counterparts. Similarly, when using IPWRA specifications to analyse the treatment effect of SFPs on Height-for-age revealed an increase of 0.092 z-score among beneficiary pupils more than the non-beneficiary counterpart. In our ESR model, where we account for both observable and unobservable sources of bias, the effect of SFPs on the Height-for-age index reveals an increase of a 0.146 z-score (see appendix A3 & A4). This finding is consistent with studies by (Gelli et al., 2016; Zenebe et al., 2018; Jamie et al., 2017; Buttenheim et al. 2011; Kristjansson et al. 2006), who reported an increase in the Height-for-age index among pupils benefiting from SFPs more than non-beneficiary counterparts.

Table 16. Effect of School Feeding Programme on pupils' nutritional status

Variables	**Average Treatment Effect on the Treated (ATT)**		
	PSM	**IPWRA**	**ESR**
	1	**2**	**3**
Dietary Diversity Score	1.938***	1.722***	0.897***
	(0.129)	(0.264)	(0. 042)
BMI– for-Age	-0.715***	-0.339*	-1.143***
	(0.156)	(0.171)	(0.029)
Height-for-Age	0.240*	0.092*	0.146***
	(0.220)	(0.164)	(0.055)
N	780	780	780

PSM: Propensity score matching, IPWRA: Inverse Probability Weighted Adjusted Regression, ESR: Endogenous switching regression, ATT: average treatment effect on the treated: Robust standard errors are reported in parentheses, α level of significance; 0.01 = ***; 0.05 = **; 0.1 = *

Source: Authors' estimations

4.3.5. Effect of the duration of the SFPs on pupils DDS, BMI-for-age and height-for-age index

Table 17 indicates the effect of SFP duration on pupils' DDS, Height-for-age index, and BMI-for-age on the beneficiary and non-beneficiary pupils. Findings reveal a significant difference in DDS between the treated group at 16-24 months duration in the SFP against the control groups with 2.8 additional classes of food, and the magnitude of the impact increased with increasing duration of the programme. Furthermore, the result indicated a significant difference in the Height-for-age index of the beneficiary pupils at 16-24 months with those at < 8 months of intervention with 1.4 z-scores, marking a positive impact on SFP duration. Likewise, in the previous two treatments, the effect of duration on BMI-for-age indicated that the beneficiary group at 16-24 months showed a significant difference from the control with a -0.39 z-score. This is in line with (Chakraborty and Jayaraman, 2019; Essuman and Bosumtwi-Sam, 2013), who reported that prolonged exposure to SFPs has a robust positive effect on pupils' learning outcomes and nutritional status.

Table 17. ANOVA Result of the Effect of School Feeding Programme Duration

Groups A	Group B	DDS	Height-for-age	BMI-for-age
			Mean difference (A-B)	
16-24 months	Control	2.797***	0.146	-0.393***
	< 8 months	0.127	1.363***	0.418**
	8-15 months	0.376***	0.650*	0.132

Source: Own survey 2021, *** 1% level of significance; **5% level of significance; *10% level of significance, DDS: dietary diversity score

4.4. Result of the impact of homegrown SFP on Smallholders' Food Security

4.4.1. Household food security status of smallholder farmers

Table 18 result shows the food security status of smallholder farming households. Findings revealed that 2.5% of farmer households fell within the poor category, 67.1 % were in the borderline category, and 30.4 % were within acceptable levels. Inferring that the majority of

the households were food insecure. This is consistent with the World Bank Group's report (World Bank Group, 2021), which reported that up to 73% of households in northeast Nigeria are poor. Similarly, NBS (2021) stated that about 83 million people in Nigeria live below the country's poverty level of 137,430 naira ($381.75) per year, with northern Nigeria accounting for approximately 78 %.

Table 18. Food Security Status of the Farming Household

FCS	Profile	Percentages
0-21	Poor	2.5
21.5-35	Borderline	67.1
>35	Acceptable	30.4

FCS: Food Consumption Score

4.4.2. HSFP instruments' effect on smallholder farmers' household food security

The binary probit model results (Table 19) revealed that farmers' linkage to caterers positively correlates with smallholder farmers' household food security status. Implies that the more farmers are linked to caterers the more likely it will improve their household food security status. This is in line with the findings of (Montalbano et al. 2018; Mensah, 2018; Fortes et al. 2020; Zenebe et al. 2018; Masset and Gelli, 2013), who found that farmers who collaborated with caterers to sell their goods saw an improvement in their household food security status.

Linking smallholder farmers to processors showed to have a statistically positive significant relationship on their household food security status, with a marginal effect of 0.130. This implies that farmers linked to processors are more likely to experience 13 points increase in their household food security status. This result is consistent with the findings of some authors who found that farmers linked to processors have improved household food security status (Corsi et al., 2017; Devereux, 2016; Kissoly et al. 2017; Herrmann et al. 2018; Geday et al. 2016).

Contact with an extension agent has a statistically significant positive relationship with smallholder farmers' household food security, with a marginal effect of 0.115. Suggesting that extension agent contact will likely increase smallholder farmers' household food security by 11.5 points. This is in line with (Danso-Abbeam et al., 2018; Ogunniyi et al., 2021; Ragasa and Mazunda, 2018; Gebru et al., 2020; Kehinde et al. 2021), who reported that access to extension service delivery improves smallholder farmers' household food security status.

Findings indicated that access to input subsidies has a statistically significant positive effect on household food security status, with a marginal effect of 0.136. Implying access to agricultural input subsidies is likely to increase household food security by 13.6 points. This finding is in line with (Devereux 2016; Balana et al., 2020, Herrmann et al. 2018), who reported that access to agricultural input subsidies improved smallholder farmers' household food security status.

Table 19. Factors affecting level of food security – results of binary probit model

Variables	**Coefficient**	**Std. Err.**	**P-value**	**Marginal Effect**
Household Head Characteristics				
Age	-0.047	0.005	0.043	-0.010
Gender	0.185	0.049	0.443	0.038
Marital Status	0.050	0.079	0.896	0.010
Years of farming experience	0.021	0.005	0.365	0.005
Educational qualification	0.088	0.143	0.188	0.019
Household characteristic				
Household size	0.048	0.008	0.188	0.010
Homegrown School Feeding Program instruments				
Access to HGSF credit (Fund)	0.195	0.054	0.435	0.042
Farmers link to caterers	0.619	0.421	0.015	0.102
Farmers link to processor	1.061	0.379	0.001	0.130
Household with children benefiting SFP	-0.026	0.052	0.914	-0.006
Institutional characteristic				
Access to extension service delivery	0.464	0.077	0.090	0.115
Access to input subsidy	0.548	0.073	0.062	0.136
Access to market information	1.147	0.314	0.234	0.374
Membership in cooperative society	0.687	0.240	0.408	0.199
Number of observations	240			
Constant	-1.975	0.965	0.041	
LR Chi (14)	21.52		0.089	
Pseudo R^2	0.103			

HGSF: Homegrown school feeding program, SFP: school feeding program

4.4.3. Effect of access to credit, farmers link to caterers and farmers link to processors on the food security status

The result of treatment effect estimates on farmers' access to credit, farmers linked to caterers and farmers linked to the processor on their household food security using alternative estimation techniques are presented in Table 20 below. Columns 1, 2, and 3 present treatment effect results based on PSM, IPWRA, and ESR specifications. The results are robust across all estimation strategies, demonstrating the impact of HGSF on smallholder farmer household food security status indicators. Using PSM findings demonstrated that farmers with access to credit report 4.9 points increase in household food security status, and when using IPWRA specifications, the household food security status of smallholder farmers increases by 3.3 points. In the ESR model, where we accounted for both observable and unobservable bias, the effect of access to credit on smallholder farmer household food security status, the result demonstrated 5.6 points increase (see appendix A7 & A8). The estimated impacts' direction and magnitude are consistent across all specifications. This is in line with (Jimi et al. 2019; Bocher et al. 2017) who reported that smallholder farmers with access to credit can provide a variety of options for improving agricultural production, including access to inputs that can boost productivity and household food security.

Furthermore, the result demonstrated that when smallholder farmers are linked to caterers, it improves household food security status. Using the PSM model findings indicated an increase in smallholder farmers' food security status by 1.7 points even though the result was not statistically significant when using IPWRA specifications household food security status increased by 1.7 points. While using the ESR model, the result indicated that household food security status increases by 20 points (see appendix A9 & A10). This implies that when farmers are linked to selling their produce to caterers, it creates a reliable market and reduces post-harvest losses usually encountered by smallholder farmers. This tends to increase these farmers' household incomes and expenditures, improving their food security status. This is in line with the studies of (Herrmann et al. 2018; Kissoly et al. 2017), who reported that farmers with market links have a reliable market and are more commercialized, with significantly higher producer prices and household food security status than those without such linkages. Comparing the PMS, IPWRA and ESR outcomes, the results show that the ESR indicates a higher effect of farmers'

link to caterers on household food security. This implies that the ESR model accounted for the effect of the unobservable bias that affects household food security status that the PSM and the IPWRA models were not accounted for.

The effect of farmers' links to processors revealed that it is likely to improve smallholder farmers' household food security status. Using PSM, the result showed 1.2 points increase in smallholder farmers' household food security status, and when using IPWRA specifications result indicated an increase of 0.8 points. In our ESR model, where we accounted for both observable and unobservable bias, the effect of farmers' link to the processor on their household food security increases by 9.9 points (see appendix A11 & A12). When farmers are linked to selling their produce to processors, they can sell the surplus not required by caterers, effectively reducing post-harvest losses, boosting their income, and improving household food security. This is in line with the study of (Omondi et al. 2017), who reported that establishing a link between smallholder farmers and processors helps to reduce food waste and provide a market for farmers to sell their products, thereby increasing income and household food security. When the PSM, IPWRA, and ESR results are compared, the ESR indicates that farmers who link to processors have better household food security. This means that the ESR model took into account the effect of unobservable biases that affect household food security, which was not taken into account by the PSM and IPWRA models.

Table 20. Effect of access to credit, farmers link to caterers and farmers link to the processor on household food security status.

Variables	**Average treatment effect on the treated (ATT)**		
	PSM	**IPWRA**	**ESR**
	1	**2**	**3**
Access to credit	4.931**	3.258**	5.554***
	(1.997)	(1.582)	(0.476)
Farmers link to caterers	1.660	1.721 *	19.998***
	(3.000)	(1.498)	(1.232)
Farmers link to processor	1.176*	0.825 *	9.910***
	(3.693)	(1.983)	(1.502)
N	240	240	240

PSM: Propensity score matching, IPWRA: Inverse probability weighted adjusted regression, ESR: Endogenous switching regression, ATT: average treatment effect on the treated, FCS: Food consumption score, Robust standard errors are reported in parentheses, α level of significance; 0.01 = ***; 0.05 = **; 0.1 = *

Source: Authors' estimations

4.5. Result and discussion of food safety knowledge, attitude and practice of food vendors in SFP

4.5.1. Food safety knowledge of food vendors

The results presented in Table 21 revealed that the food vendors answered this question on food safety with the greatest accuracy: i. Using expired food can't cause health disorders (88.3% of respondents knew); ii. Food from unhygienic and unclean sources might harbour disease-causing organisms (83.8% of respondents knew); iii. Some foodborne disease/contamination can cause death (82.5% respondents knew); iv. Microorganisms are frequently found in hand (89.6% respondents knew); v. The taste of food should be checked with a different spoon (84.2% respondents knew); and vi. Frequently used rags and laundry should not be kept out of the kitchen (86.7% of respondents knew). Furthermore, the vendors had relatively low or average knowledge on the questions: i. Unaccredited, off-brand, and bulk products should not be purchased (42.9% of respondents knew); ii. Humans can't be infected by unhygienic stuff foodstuff (63.8% of respondents knew); iii. Leftover food should be stored in the refrigerator within two hours (62.9% of respondents knew).

Table 21. Descriptive result of food safety knowledge of food vendors (N = 240)

Questions the food handlers were asked on food safety knowledge	Yes	No	I don't know
Food can be a source of disease infection	74.17	10.83	15.00
Food from unhygienic and unclean sources might harbor the disease-causing organism	83.75	8.00	8.25
Using expired food can't cause health disorders	88.33	7.23	4.00
Some foodborne diseases/contamination can't cause death	82.50	9.60	7.90
Unaccredited, off-brand and bulk products should not be purchased	42.92	39.08	18.00
Humans can't be infected by unhygienic foodstuff	63.75	17.75	18.50
Microorganisms are not frequently found in hand	89.58	6.82	5.60
After touching raw foodstuff, touching cooked food without cleaning your hand causes the transfer of microorganisms	81.25	12.35	6.40
The internal temperature of the refrigerator should be less than 5 degrees celsius	69.17	12.00	18.83
Leftover food should be stored in the refrigerator within two hours	62.92	30.00	7.08
The taste of food should be checked with a different spoon	84.17	10.83	5.00
Frequently used rags and laundry should not be kept out of the kitchen	86.67	8.50	4.83

Answer options: Yes, No, and I don't know

4.5.2. Food safety attitude of food vendors

Results from table 22 revealed how food vendors agreed with the questions on food safety attitude, and findings revealed that 91.3% (strongly agreed, 59.6% and agreed 31.7%) of the food vendors reported that safe food handling is an important part of their job, with a mean score of 4.41. This implies food vendors understand and take responsibility for their task expected. Furthermore, 90.8% (strongly agreed, 58.8% and agreed, 32.1%) of the food vendors reported that learning more about food safety is important to me, with a mean score of 4.36.

The result further revealed that 91.3% (strongly agreed, 58.3% and agreed 32.9%) of the food vendors reported that raw food should be kept separate from cooked food, with a mean score of 4.36. The result also revealed that 69.6 % (strongly agreed 43.3% and agreed 26.3%) of the food vendors reported that using masks, protective gloves, caps and adequate clothing

reduces the risk of food contamination, with a mean score of 3.92. also, 90.8% (strongly agreed 55.4% and agreed 35.4%) of food vendors reported that improper food storage may be hazardous to health, with a mean score of 4.37. Furthermore, 88.75% (strongly agreed, 63.3% and 25.4%) of the food vendors agreed that sick staff should not be involved in food handling and food services, with a mean score of 4.40. A majority, 87.5% (strongly agreed 58.33% and agreed 29.2%) of the food vendors agreed that staff with cut or open wounds on fingers or hands should not touch unwrapped food, with a mean score of 4.34.

Table 22. Responses on food safety attitude among food vendors (n=240)

Questions food handlers were asked on food safety attitude	**SD %**	**D %**	**U %**	**A %**	**SA %**	**Mean**
Safe food handling is an important part of my job	4.17	1.25	3.33	31.67	59.58	4.41
Learning more about food safety is important to me	6.25	1.25	1.67	32.08	58.75	4.36
I believe that how I handle food relates to food safety	6.25	0.83	4.17	29.17	59.58	4.35
Raw food should be kept separate from cooked food	5.83	1.67	1.25	32.92	58.33	4.36
Using masks, protective gloves, caps and adequate clothing reduces the risk of food contamination	7.50	5.83	17.08	26.25	43.33	3.92
Improper storage of food may be hazardous to health	3.33	2.92	2.92	35.42	55.42	4.37
Sick staff should not be involved in food handling and food services	4.17	3.75	3.33	25.42	63.33	4.40
Staff with cut or open wounds on fingers or hands should not touch unwrapped food	4.17	3.33	5.00	29.17	58.33	4.34

SD=Strongly disagree, D= Disagree, U= Undecided, A=Agree, SA=Strongly Agree

4.5.3. Food safety practices of food vendors

Table 23 reveals the result of the food vendors' food safety practices. Findings revealed that 72.08% of food vendors reported that they always pay concerned about the hygienic source of foodstuff they buy. 78.33% of the food vendors reported that they always avoid buying

expired foodstuff and only 15.0% of the food vendors reported always using gloves when touching or distributing of unwrapped food. The result further revealed that 22.1% of the food vendors reported they never wash their hands before using gloves and only 17.9% reported that they always wash their hands before using gloves. About 23% of the food vendors reported they never use protective clothing when touching or distributing unwrapped foods and only 16.3% reported always using protective clothing when touching or distributing unwrapped foods. Therefore, proper food safety practices prevent food product contamination from related hazards.

The result also revealed that 21.3% of the food vendors reported never using a mask when touching or distributing unwrapped food and only 16.3% of the food vendors always used a mask when touching or distributing unwrapped food. Furthermore, the result revealed that 65.8% of the food vendors always dispose of food when their taste changes. About 24.6% of the food vendors reported that they always sterilize their utensils before use, and 78.3% of the food vendors reported that they always dispose of food when it develops some odour. This indicates that the food vendors under the SFP generally had low food safety practices.

Table 23. Responses on food safety practices among food handlers (n=240)

Questions food handlers were asked on food safety practice	Never	Rarely	Sometimes	Often	Always	Mean
I pay concerned about hygienic sources of foodstuff	2.08	1.25	9.17	15.42	72.08	4.54
I frequent you avoid buying expired foodstuff	4.58	2.50	2.08	12.50	78.33	4.58
I use gloves when touching or distributing unwrapped food	22.08	15.00	32.08	15.83	15.00	2.86
I wash my hands before using gloves	22.08	14.58	30.00	15.42	17.92	2.93
I use protective clothing when touching or distributing of unwrapped foods	22.50	13.33	32.50	15.42	16.25	2.90
I use a mask when touching or distribution of unwrapped food	21.25	16.67	29.58	16.25	16.25	2.90
I do dispose food when the taste is change	4.17	5.42	7.50	17.08	65.83	4.35
I do sterilize my utensils before use	7.50	15.00	25.00	27.92	24.58	3.47
I do dispose food when it developed some odour	5.42	2.50	5.42	8.33	78.33	4.52

*Figures presented are percentages

4.5.4. Factors influencing the food safety knowledge, attitude and practice of food vendors

Table 24 displays a result of the factors influencing the food safety knowledge of the food vendors under the SFP. Regarding the effect of *socio-demographic characteristics* of the food vendors on food safety knowledge, the results show that with increasing years of education, the food safety knowledge score of vendors increases by 0.051. The possible reason is the more educated an individual is, the more likely he can read and understand written food safety information (Osaili et al., 2018; Madaki and Bavorova, 2019). This is in line with studies (Sibanyoni et al., 2017; Luo et al., 2019; Toh and Birchenough, 2000; Woh et al., 2016; Dagne et al., 2019; Moreb et al., 2017; Siddiky et al., 2022; Low et al., 2016) who reported that education influence food safety knowledge of food vendors positively.

Regarding the *food safety information sources*, findings revealed that the use of radio by food vendors as a source of food safety information revealed that the food safety knowledge score of vendors using radio means of information is expected to be 0.578 higher compared to non-radio vendor users. This is in line with the studies (Liu and Ma, 2016; Koç and Ceylan, 2009) that reported that media (Radio) significantly positively affect food safety knowledge. The plausible reason is radio is easily assessable and affordable for food safety information (Tiozzo et al., 2019). The use of television by food vendors as a source of food safety information revealed that a vendor who uses television as a source of information is expected to have a 0.676 higher food safety knowledge score than a non-television vendor user. The plausible reason is that television provides an audio and visual demonstration and teaching (Koç and Ceylan, 2009). This is in line with the studies (Liu and Ma, 2016; Redmond and Griffith, 2005; Tiozzo et al., 2019). who reported that media (Television) significantly positively affects food safety knowledge. The food safety attitude score of vendors who use food inspection institutions is expected to be 1.540 higher than that of vendors who do not use food inspection institutions as a source of information. This could be because SFP food vendors are likely to gain safety food handling knowledge and skill over time through in-house training by food institutions (Roberts et al., 2008; Sibanyoni et al., 2017). This is in line with previous studies (Azanaw et al., 2019; Redmond and Griffith, 2005; Woh et al., 2016), who reported that food safety knowledge

increase with access to information from food inspection institution. In general, this confirms a less influence on socio-economic characteristics of food vendors working under the school feeding program except for education, while sources of food safety information show a greater effect on their food safety knowledge.

Food safety attitude model

The results (Table 24) also display the factors that influence the food safety attitude of the food vendors under SFP. Regarding *Socio-demographic characteristics*, findings reveal that with the increasing age of a vendor, so does the vendor's food safety knowledge attitude score increase by 0.240. This is consistent with (Luo et al., 2019; Sterniša et al., 2018; Siddiky et al., 2022; Liu and Ma, 2016), who reported that as age increases, so does the food safety attitude of the food vendors. The plausible reason is that as age increases, so does maturity and good decisions to take responsibility. The linear regression results revealed that a male vendor's food safety attitude score is expected to be 4.388 higher than that of a female vendor. The possible reason is that women are far more likely than men to care for children daily, grocery shop, and wash dishes. This is in line with (Luo et al., 2019), who reported that male food vendors have better food safety attitudes than their female counterparts.

The findings also indicated that as household size increases, so does it affect vendors' food safety attitude negatively by -0.284. One possible explanation is that as family sizes increase, household responsibilities grow, competing with time devoted to compliance with food safety recommendations. Griffth et al. (2017) and Pang and Toh (2008) reported that time consumption was one of the factors influencing food safety standard compliance among the staff of a large food service complex. Findings revealed that an increase in vendors' years of vending experience positively increases food safety attitude scores of the vendor by 0.165. The plausible reason is that vendors have added more value to food safety attitudes over time. This is in line with (Laura et al., 2009; Nigusse & Kumie, 2012; Teffo and Tabit, 2020; Siddiky et al., 2022; Al Banna et al., 2021) who reported that food safety practice increases with an increase in years of vending experience.

Table 24. Multiple Linear Regression of the food safety KAP scores of food vendors in Northeastern Nigeria (n=240)

Variables	Food safety knowledge		Food safety attitude		Food safety practice	
	Coefficient	Std. Err.	Coefficient	Std. Err.	Coefficient	Std. Err.
Socio-demographic characteristics						
Age	-0.027	0.023	0.240	0.079***	-0.057	0.085
Gender	0.727	0.644	4.388	2.173**	3.774	2.337
Household size	0.030	0.038	-0.284	0.129**	-0.132	0.139
Food vending experience (years)	-0.001	0.027	0.165	0.091*	0.243	0.098**
Education qualification	0.051	0.026**	-0.017	0.087	-0.096	0.094
Food vending profit	0.000	0.000	0.000	0.000	0.000	0.000
Food safety information sources						
Food handling training	0.328	0.298	-0.902	1.003	-0.036	1.079
Radio	0.578	0.318*	2.195	1.077**	1.581	1.158
Television	0.676	0.269**	-0.582	0.918	0.220	0.987
Food inspection institution	0.653	0.243***	1.540	0.831*	3.148	0.893***
Social media	-0.454	0.438	2.504	1.478*	0.448	1.589
Friend & colleagues	0.117	0.448	-2.823	1.505*	-2.201	1.619
Internet	0.501	0.324	2.530	1.094**	3.057	1.176**
Food safety knowledge			0.181	0.224	0.168	0.241
Constant	8.189	0.787	23.426	3.219	28.291	3.462
F-value	0.050		0.000		0.000	
R-square	0.092		0.244		0.165	

*** 1% level of significance; **5% level of significance; *10% level of significance

Concerning *food safety information sources,* the finding revealed that vendors who use radio for food safety information are expected to have a 2.195 higher food safety attitude score than vendors not using the radio source information for food safety. The possible reason is that radio is the predominant means of information dissemination in Nigeria (BBG, 2014). This is consistent with those (USDA, 2001; CFIA, 1998; Tiozzo et al., 2019) who reported that food vendors with information sources on the radio positively affect their food safety attitude. Furthermore, the food safety attitude score of vendors who uses food inspection institutions as the information source is expected to be 1.540 higher than that of vendors who do not use food inspection institutions as a source of information. The plausible reason is that food inspection institutions are the most trusted, precise, and dependable source of information for food vendors. This is in line with (Kornelis et al., 2007; Azanaw et al., 2019; Redmond and Griffith, 2005; Woh et al., 2016), who reported that vendors have positive food safety attitude when food inspection institution is an information source for food safety information.

Furthermore, food vendors using social media as a source of food safety information are expected to have 2.504 higher food safety attitude scores than vendors not exploring social media as a source of information. This is probably due to the rise of social media usage across the country, plus its capacity for written, audio and video demonstration platforms. This is in line with (Gan and Wang, 2015; Li and Wei, 2017; Kang et al., 2019), who reported that food vendors who assess food safety information on social media have a more positive attitude toward food safety. Findings revealed that vendors who consult friends and colleagues for food safety information have a negative effect on food safety attitudes with -2.823. This is probably due to misleading information and inappropriate food safety information. Food vendors using the internet as a source of food safety information are expected to have 2.530 higher food safety attitude scores than vendors not exploring the internet as a source of information. The possible reason is that the internet provides access to a respective source of food safety and handling information. This is in line with (Liu and Ma, 2016; Chi et al., 2017; Burke et al., 2016; Kang et al., 2019), who reported that food vendors find the internet a significant means of food safety and attitude molding. In broad, this highlighted the substantial role in socio-demographic characteristics and food safety information sources on the food safety attitude of food vendors under the SFP.

Food safety practice model

Furthermore, the result from Table 24 displays the result of the factors affecting the food safety practices of food vendors under the SFP. Regarding *socio-demographic characteristics,* the result revealed that as years of food vending experience increase, so does their food safety practice score by 0.243. This is probably since practice makes perfect and increases in years of experience provide value to food safety practice. This is in line with studies (Siddiky et al., 2022; Teffo and Tabit, 2020; Nigusse & Kumie, 2012; Al Mamun et al., 2019; Al Banna et al., 2021) who reported that food safety practices increase with the increase in years of vending experience.

Regarding *food safety information sources*, findings revealed that vendors using food inspection institutions as a source of food safety information are expected to have 3.148 scores higher than vendors not accessing information from the food inspection institution. This is because the food inspection institution has developed a culture of quality information and continuous improvement, which has instilled trust in food vendors. This is in line with the literature (Kornelis et al., 2007; Azanaw et al., 2019; Woh et al., 2016; Redmond and Griffith, 2005), who reported that vendors receive food safety information from food inspection institutions have better food safety practices. Furthermore, vendors using the internet as a source of information are expected to have a 3.057 higher food safety practice score than food vendors who do not use the internet as a source of information on food safety practices. This may be attributed to increased internet services and food safety teaching platforms. This is in line with (Burke et al., 2016; Chi et al., 2017; Kang et al., 2019), who reported that food vendors perceived the internet as a significant means of food safety practice information dissemination.

4.5.5. Correlation results between food safety knowledge, attitude and practice

The result (Table 25) shows a relationship between food safety knowledge, attitude and practice. The findings revealed that the association between food safety knowledge and food safety attitude is weak and non-significant. However, a significant positive correlation was found between food safety attitudes and food safety practices at $P< 0.01$ with a medium correlation coefficient (45%). This suggests that food handlers' food vendor practices are associated with food safety attitudes. In another way, food vendors' attitudes toward food safety can accurately

predict their actual food safety practices. This is in line with (Parry-Hanson Kunadu et al. 2016; Kwol et al. 2020; Azanaw et al., 2020; Odeyemi et al., 2018; Naeem et al. 2018), who reported a positive correlation between food safety attitudes and food safety practice.

Table 25. Relationship between food safety knowledge, attitudes and practices.

Variables	Mean	Std Err.	FSK	FSA	FSP
Food safety knowledge (FSK)	8.816	1.960	1.000		
Food safety attitude (FSA)	34.513	7.205	0.064	1.000	
Food safety practice (FSP)	33.04	7.374	0.090	0.450***	1.000

Correlation *** 1% level of significance, FSK: Food Safety Knowledge, FSA: Food Safety Attitude, FSP: Food Safety Practice

5 Conclusions and Recommendations

5.1 Introduction

This study examines the effect of a home-grown school feeding programme on school enrolment, attendance, performance, and nutrition status of Nigerian public elementary schools. To examine the effect of school SFP on pupils' academic performance, we used pupils' school enrolment, class attendance and Math and English test scores as indicators. The pupil's nutritional status indicators evaluated were their BMI-for-age, height-for-age, and dietary diversity scores. The food consumption score index was used to determine the smallholder farmers' household food security status. Furthermore, we evaluated the impact of SFP on farmers' household food security. Finally, we determine vendors' food safety knowledge, attitude and practice and we also analyse factors affecting food vendors' food safety knowledge, attitude and practice.

5.2 *Conclusion on effect school SFP on pupils' academic performance*

This study assessed the effect of the school feeding program on pupils' school enrolment, class attendance, educational performance and class participation in north-eastern Nigeria. Further, it investigated the effect of the duration of the program of pupils' performance. The study used data triangulation and combined primary survey data on teacher perceptions regarding the program's impact and secondary data based on school records from the pre-intervention period and during the SFP.

The perception of 180 teachers from the beneficiary schools having experience with the program supports the expectation that SFP increases school attendance, enrolment, performance as well as the active participation of the pupils in the class. Similarly, the analysis of school records approved the finding and revealed a significant positive effect of SFP on pupils' school enrolment, class attendance, and academic performance in English and Mathematics.

The study results allow us to recommend the expansion of the program to non-beneficiary schools in the investigated study site to extend the positive effects the program has in the area with a high prevalence of child undernourishment.

The duration of the feeding programme was found to have a positive effect on the academic performance of the pupils in English and Mathematics, which revealed school SFP improved academic performance. It can be thus expected that prolonging

the school feeding programme will further improve the academic performance of pupils. The program, which was originally intended to last four years, was extended indefinitely. Unfortunately, the past experience shows a high level of disturbances in the program sustenance and implementation in the particular due to rapidly changing political interests and goals (change of administration). We encourage any future administration to continue the program's long-term benefits rather than just terminate for another.

Limitations of the study

The lack of baseline and recall data on pupils' household demographic information was a limitation of the study. As a result, further research needs to incorporate pupil's household demographic information which will provide more robust and reliable data in the impact assessment of the SFP, given the fact that parental educational qualification, household income, and food security status have a significant effect on determining pupils' school enrolment, attendance, and performance.

5.3 Conclusion on effect school SFP on pupils' nutritional status

The study assesses the effect of an SFP on pupils' nutritional status in north-eastern Nigeria. The research analysed the role of the SFP from an empirical standpoint, focusing on the effect of the meals received in school on dietary diversity score, BMI-for-age index, and Height-for-age index as proxies for pupils' nutritional status.

A linear regression analysis was performed to investigate factors influencing pupils' nutritional status, using DDS, BMI-for-age, and Height-for-age index as proxies for measuring nutritional status among pupils. In addition, a robust check analysis on the effects of the SFP on pupils' nutritional status was conducted by analysing the average treatment effect on the treated (ATT) pupils using propensity score matching (PSM), inverse probability weighted adjusted regression (IPWRA) and endogenous switching regression (ESR). The analyses adopted demonstrated that SFP had a significant positive effect on DDS and Height-for-age index, implying that the SFP improved pupil nutritional status. However, the SFP has a negative effect on pupils' BMI-for-age due to the SFP contribution in attaining a balanced diet, which helps reduce the propensity to become overweight among programme beneficiaries.

The duration of the SFP has a positive effect on the DDS and the Height-for-age index of the pupils, while the effect of SFP duration on BMI-for-age revealed a significant negative impact. This result serves as a validation/additional proof of the impact of SFPs (not only comparing beneficiaries with non-beneficiaries but also highlighting the differences between beneficiaries and non-beneficiaries over time). The results clearly show that prolonged exposure to an SFP impacts pupils' nutritional status – the longer the participation in the SFP, the higher the impact. As a result, continuing the programme for a longer time will significantly increase the desired effects. The effects of COVID 19, climate change, and recently the global political crisis, on food security are expected to exacerbate food insecurity in Northeast Nigeria (FAO, 2021; WFP, 2020a; UNICEP, 2020a), making SFPs an essential safety net for young cohorts.

These results call for increased support for expanding the school food programmes in areas where communities suffer the consequences of civil conflict and where they are prone to various forms of oppression emerging from displacement and remote access to the means of subsistence.

Finally, it is critical to emphasize the need for a follow-up longitudinal study that considers the programme's long-term viability and potential long-term impacts to improve policy fine-tuning. In addition, we find that programmes should consider collecting data on households and their access to resources (farm production, land availability, housing, etc.) to detect inequalities and construct premium criteria for beneficiaries. Considering the influence of the education of parents, especially the mothers' education, closer observation of this effect may be explored, looking at food security figures at the household level.

Limitation of the study

The study's limitation is the lack of baseline and recall data, which is especially problematic when conducting surveys in conflict zones. Nevertheless, the applied techniques of treatment effect (ATT) provided a reasonable means to analyse the data, reducing any form of bias. Future studies should include baseline data to obtain more robust and reliable information. Such baseline data may help researchers better understand the nutritional status of children in rural areas before the intervention and thus replicate the intervention in other rural areas or conduct additional research in the study area.

5.4 Conclusion on the impact of HGSF on smallholder household food security

The study examined the impact of HGSF instruments on smallholder farmer household food security status in Northeastern Nigeria**.** The programme instruments include i.) farmers link to caterers, ii.) farmers link to processors, iii.) farmers' access to credit and iv.) children benefiting from HGSF. Not all farmers involved in the programme have access to all instruments, which makes it possible to study the effect of the use of single instruments on household food security.

The study assessed the effect of HGSF instruments on smallholder farmer household food security and revealed that farmers linked to caterers and those linked to processors as well as access to credit positively affected their food security status positively. Thus, emphasis should be given to the improved linkages and access to funds for the better outcome of the program.

As only 15% of farmers are linked to caterers and 5% to processors, there is a potential to encourage other farmers to use these instruments. Anecdotal evidence revealed poor coordination between registered smallholder farmers and caterers for smooth patronage and processor findings indicated that most of the agro-allied industries in the area were previously attacked by Boko Haram terrorist group, so they are not operational (Adelaja and Georg, 2019). Thus, improved security and further studies to identify robust factors affecting the linkages are needed for a better recommendation.

We found a positive impact of the three selected instruments of HGSF (credit access, link to caterers and link to processors) on smallholder farmers' household food security across all three models using PSM, IPWRA and ESR. The estimated impacts have the same direction and magnitude across all specifications. Thus, to make better policy recommendations, it is critical to emphasize the need for a follow-up longitudinal study that considers the program's long-term viability and potential long-term impacts.

Limitation of the study

The lack of baseline data, lack of farmers' previous food security status and lack of other food security indicators such as household income food security indicators were our limitations in this study. To obtain more robust and reliable information, baseline data should be included in future studies. Baseline data may assist in better understanding the farmers' households' food security status in the areas before different programs are implemented in the future.

5.5 Conclusion on food safety knowledge, attitude and practice of food vendors in SFP

This study investigated the food safety knowledge, attitudes and practices of food vendors involved in SFP in Nigeria. Multiple linear regression was used to test the influence of socio-economic characteristics and sources of food safety information on food safety knowledge.

The regression results revealed that education qualification, radio and television, and food inspection institutions' information sources positively increase the food safety knowledge of food vendors involved in the SFP. Thus, food vendors' education should be considered a criterion in selecting food vendors. These may help reduce the incidence of prevailing food poisoning and cross-contamination during food handling across schools in Nigeria. Regarding food safety attitude, both socio-demographic characteristics and food safety information sources revealed a significant impact on the food safety attitude of food vendors under the SFP. The findings on food safety attitude revealed that an increase in age, being a male food vendor, increasing years of vending experience, radio source of information, food inspection institutions, social media, and the internet all positively affect food safety attitude. These highlighted the need for utilizing the radio, social media and food inspection institutions to disseminate food safety information to the food vendors. In contrast, the increased household size and access to information from friends and colleagues had a negative impact on food safety attitudes.

Regarding food safety practices, findings revealed that years of vending experience, internet and food inspection institutions' information sources positively influence food safety practices among food handlers participating in school feeding programs. Thus, years of vending experience should be considered when selecting vendors for the programs because more experience in a particular field gives the person more value and provide means from which antecedent or previous record can be used to assess the level of food safety practices.

Findings from the study revealed that vendors have poor food safety knowledge in the study area. Thus, we recommend that Federal Food Regulatory Agencies (Federal Ministry of Health "FMoH" and National Agency for Food & Drug Administration & Control "NAFDAC") should make training mandatory for all vendors participating in

the school feeding program using the Nigeria *Unified Food Safety Training Manual*. Especially the manual of the National Policy for Food System and Implementation Strategy's (NPFSIS) objectives (3.1) (WHO, 2021).

5.6 Policy implications of the study

The study's findings have significant policy implications. There is need to make sure that policy makers explore ways to diversify the food basket and consider address nutritional issues, such as micronutrient deficiencies, obesity and overweight among children, during data collection teachers wanted researcher to take measurement of overweight and obese children thinking is a sign of healthy living. As such special educational and training on food nutrition and hygiene should be introduced.

Poor number of farmers links to caterers, farmers links to processors, and access to credit indicated the imperative the need for strong collaboration and cross-sector. Coordination Partnerships should be strengthened for complementary actions in social protection, education, school health and nutrition, and agriculture.

As the finding from our studies revealed that prolonging the duration of the school feeding programme has a positive significant effect on pupils' educational performance and nutritional status. Therefore, policy that provide a long-term stable funding and budgeting will improve the outcome capacity of the programme.

5.7 Suggestions for further studies

Further research is needed to address the study's limitations and to verify and extend the empirical findings in this study and other developing countries.

Future research should consider household income, wealth, and other indices that assess household wealth status, as this has an impact on pupils' education and nutritional status.

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7 List of Author's Scientific Contributions

7.1 Conference

Barnabas, B., Bavorova, M. and Madaki, M.Y. (2021). Examining the Impact of Linking School Feeding Program on Smallholder Farmer Income and Household Food Security Status. Tropentag, September 15-17, 2021, hybrid conference. *Towards shifting paradigms in agriculture for a healthy and sustainable future*

Mbouwe Irene Franceline, Jiofack Tafokou René Bernadin, Miroslava Bavorova, Mustapha Yakubu Madaki, **Bulus Barnabas** (2020). Stakeholders and Marketing Analysis of African Nutmeg (*Monodora myristica*) in Cameroon. Tropentag 2020, September 9 - 11, *virtual conference, Germany "Food and nutrition security and its resilience to global crises.*

8 Appendices:

8.1 List of appendixes:

Table A1. Endogenous switching regression results of the effect of SFP participation on pupils' BMI-for-age

	Effect of SFP on Pupils BMI-for-age					
	SFP Status		SFP beneficiaries		SFP non-beneficiaries	
Variables	Coef.	Std. Err.	Coef.	Std. Err.	Coef.	Std. Err.
Age in months	0.022	0.004***	-0.011	0.002***	-0.011	0.006*
Gender	-0.053	0.121	-0.021	0.089	-0.217	0.173
Mothers' education	-0.713	0.105***	0.363	0.060***	0.377	0.253
Fathers' education	0.602	0.100***	-0.236	0.060***	-0.308	0.235
DDS	0.511	0.046***				
Constant	-3.984	0.481***	0.594	0.305*	0.708	0.603
/lns1	0.116	0.033***				
/lns2	0.132	0.055*				
/r1	-0.936	0.168***				
/r2	-0.182	0.176				
sigma_1	1.123	0.036				
sigma_2	1.141	0.063				
rho_1	-0.733	0.078				
rho_2	-0.180	0.171				
Log likelihood	-1404.50					
Wald test χ 2 (4)	55.92					
LR test of independent equations χ 2 (1) 31.74 ***						

*** 1% level of significance; **5% level of significance; *10% level of significance; DDS: dietary diversity score

Table A2. Average Expected Effect of SFP on Pupils BMI-for-age; Treatment and Heterogeneity Effects

	Decision stage		
Sub-samples	Beneficiaries	Non-beneficiaries	Treatment effect
SFP Beneficiaries' pupils	-0.606	0.537	TT= -1.143***
	(0.014)	(0.024)	(0.029)
SFP Non-beneficiaries' pupils	-0.670	-0.120	TU=-0.543***
	(0.015)	(0.014)	(0.029)
Heterogeneity effects	BH_1=0.064	BH_2=0.657	TH=-0.600***

BHi: the effect of base heterogeneity for beneficiaries' pupils (i = 1), and nonbeneficiaries (i = 0)

Table A3. Endogenous switching regression results of the effect of SFP participation on pupils' height-for-age

			Effect of SFP on Pupils' height-for-age			
	SFP Status		SFP beneficiaries		SFP non-beneficiaries	
Variables	Coefficient	Std. Err.	Coef.	Std. Err.	Coef.	Std. Err.
Age in months	0.024	0.004***	-0.028	0.002***	-0.006	0.006
Gender	-0.052	0.125	-0.169	0.087*	-0.191	0.160
Mothers' education	-0.761	0.109***	-0.140	0.059**	-0.065	0.239
Fathers' education	0.668	0.103***	0.156	0.059***	0.099	0.224
DDS	0.510	0.047***				
Constant	-4.222	0.457***	1.659	0.306***	-0.441	0.567
/lns1	0.071	0.032				
/lns2	0.056	0.056				
/r1	0.523	0.165				
/r2	0.194	0.181				
sigma_1	1.074	0.034				
sigma_2	1.057	0.059				
rho_1	0.480	0.126				
rho_2	0.192	0.174				
Log-likelihood	-1389.38					
Wald test χ 2 (4)	173.09					
LR test of independent equations χ 2 (1) 11.23 ***						

*** 1% level of significance; **5% level of significance; *10% level of significance; DDS: dietary diversity score

Table A4. Average Expected Effect of SFP on Pupils height-for-age; Treatment and Heterogeneity Effects

	Decision stage		
Sub-samples	Beneficiaries	Non-beneficiaries	Treatment effects
SFP Beneficiary pupils	-1.204	-1.350	T=0.146***
	(0.027)	(0.044)	(0.055)
SFP Non-beneficiary pupils	-1.034	-1.179	TU=0.145***
	(0.008)	(0.014)	(0.016)
Heterogeneity effects	BH_1= -0.170	BH_2= -0.171	TH=0.001***

BHi: the effect of base heterogeneity for beneficiary pupils (i = 1), and non-beneficiaries (i = 0)

Table A5. Endogenous switching regression results of the effect of SFP participation on pupils' DDS

	Effect of SFP on Pupils DDS					
	SFP Status		SFP beneficiaries		SFP non-beneficiaries	
Variables	Coefficient	Std. Err.	Coef.	Std. Err.	Coef.	Std. Err.
Age in months	0.027	0.004***	0.003	0.004	0.010*	0.006
Gender	-0.139	0.125	0.047	0.140	0.178	0.156
Mothers' education	-0.610	0.115***	0.256	0.101**	-0.283	0.221
Fathers' education	0.556	0.107**	0.005	0.096 *	0.167	0.212
Distance to school	0.001	0.002***				
Constant	-11.907	1.079***	4.119	1.746	4.209	1.674
/lns1	0.544	0.034				
/lns2	0.013	0.053				
/r1	0.431	0.192				
/r2	-0.026	0.232				
sigma_1	1.723	0.058				
sigma_2	1.013	0.054				
rho_1	0.406	0.161				
rho_2	-0.026	0.232				
Log likelihood	-323.26					
Wald test χ 2 (4)	45.03					
LR test of independent equations χ 2 (1) 31.74 ***						

*** 1% level of significance; **5% level of significance; *10% level of significance; DDS: dietary diversity score

Table A6. Average Expected Effect of SFPs on Pupils DDS; Treatment and Heterogeneity Effects

	Decision stage		
Sub-samples	Beneficiaries	Non-beneficiaries	Treatment effects
SFP Beneficiary pupils	6.135	5.238	T=0.897***
	(0.020)	(0.037)	(0.042)
SFP Non-beneficiary pupils	4.342	4.017	TU=0.325***
	(0.019)	(0.028)	(0.038)
Heterogeneity effects	BH_1= 1.793	BH_2= 1.221	TH=0.572***

BHi: the effect of base heterogeneity for beneficiary pupils (i = 1), and non-beneficiaries (i = 0)

Table A7. Endogenous switching regression results in the effect of access to credit on the household food security status

			Effect of credit access on household food security			
	Credit Status		Access to credit		No-access to credit	
Variables	Coef.	Std. Err.	Coef.	Std. Err.	Coef.	Std. Err.
Age	0.022	0.022	-0.386	0.196**	-0.156	0 .218
Gender	-0.116	0.211	2.811	2.173	-1.128	2.003
Household size	0.015	0.037	0.893	0.302***	-0.591	0.389
Years of experience	-0.015	0.022	-0.085	0.191	0.210	0.220
Education qualification	0.619	0.079***				
Access to input subsidy	-0.771	0.268***				
Farmers link to processors	0.688	0.418*				
Constant	-3.127	0.852***	41.064	6.132***	45.647	5.997***
/lns1	2.275	0.082***				
/lns2	2.354	0.062***				
/r1	-0.695	0.223***				
/r2	0.032	0.266				
sigma_1	9.726	0. 805				
sigma_2	10.531	0. 651				
rho_1	-0.601	0.142				
rho_2	0. 032	0.265				
Log-likelihood	-1000.408					
Wald test χ 2 (4)	4.67					
LR test of independent equations χ 2 (1) 8.64***						

*** 1% level of significance; **5% level of significance; *10% level of significance

Table A8. Average expected effect of access to credit on smallholder farmer household food security status, treatment and heterogeneity effects

	Decision stage		
Sub-samples	Credit access	No-credit access	Treatment effect
Farmers with credit access	39.853	34.299	TT= 5.554***
	(0.344)	(0.319)	(0.476)
Farmers with no credit access	32.706	31.741	TU=0.965***
	(0.340)	(0.292)	(0.964)
Heterogeneity effects	BH_2=7.147	BH_1=2.558	TH=4.589***

BHi: the effect of base heterogeneity for credit accesss (i = 1), and no-credit access (i = 0)

Table A9. Endogenous switching regression results in the effect of linking farmers to caterers on smallholder farmer household food security status

			Effect of farmers' link to caterers on household food security			
	Famers status		Farmers link to caterers		Farmers not linked to caterers	
Variables	Coef.	Std. Err.	Coef.	Std. Err.	Coef.	Std. Err.
Age	-0.011	0.010	-0.398	0.212*	-0.231	0.116*
Gender	-0.256	0.148*	-1.479	3.168	1.856	1.788
Household size	0.062	0.021***	0.850	0.498*	0.055	0.251
Access to extension service	0.246	0.172	-3.160	3.569	1.775	2.085
Education qualification	0.008	0.001***				
Market information	-1.452	0.069***				
Constant	0.937	0.341***	38.447	4.132***	46.149	7.782***
/lns1	2.496	0.047***				
/lns2	2.133	0.130***				
/r1	16.874	16.873***				
/r2	0.186	0.412				
sigma_1	12.132	0.573				
sigma_2	8.436	1.094				
rho_1	1.000	1.120				
rho_2	0.184	0.398				
Log-likelihood	-960.573					
Wald test χ 2 (3)	15.57					
LR test of independent equations χ 2 (1) 57.49 ***						

*** 1% level of significance; **5% level of significance; *10% level of significance

Table A10. Average expected effect of linking farmers to caterers on smallholder farmer household food security; treatment and heterogeneity effects

Sub-samples	Decision stage		Treatment effect
	Linked to caterers	Not linked to caterers	
Farmers linked to caterers	35.060	15.061	TT=19.998***
	(0.160)	(0.920)	(0.541)
Farmers not linked to caterers	15.061	35.059	TU=-19.998***
	(0.907)	(0.160)	(0.537)
Heterogeneity effects	BH_2=19.999	BH_1=-19.999	TH=39.998***

BHi: the effect of base heterogeneity for farmers linked to caterers (i = 1), and farmers not linked to caterers (i = 0)

Table A11. Endogenous switching regression results in the effect of farmers linked processors on smallholder farmer household food security status

			Effect of farmers' link to caterers on household food security			
	Famers status		Farmers link to processors		Farmers not linked to professors	
Variables	Coef.	Std. Err.	Coef.	Std. Err.	Coef.	Std. Err.
Age	-0.016	0.010*	0.305	0.246	-0.358	0.117***
Gender	0.070	0.148	0.506	4.454	1.080	1.797
Household size	-0.036	0.023	1.632	0.856*	0.476	0.276*
Education qualification	-0.386	0.054***	-0.429	1.763	0.901	0.620
Market information	-2.991	0.625***	13.985	14.308	40.381	7.533***
Access to credit	1.166	0.056***				
Constant	3.913	0.428***	-0.390	18.810	42.980	4.644***
/lns1	2.499	0.048***				
/lns2	1.936	0.344***				
/r1	-17.956	465.380				
/r2	-0.561	0.860				
sigma_1	12.164	0.588				
sigma_2	6.930	2.384				
rho_1	-1.000	4.130				
rho_2	-0.509	0.637				
Log-likelihood	-947.780					
Wald test χ 2 (5)	41.37					
LR test of independent equations χ 2 (1) -32.78***						

*** 1% level of significance; **5% level of significance; *10% level of significance

Table A12. Average expected effect of linking farmers to processors on smallholder farmer household food security; treatment and heterogeneity effects

Sub-samples	Decision stage		Treatment effect
	Linked to processors	Not linked to processors	
Farmers linked to processors	34.398	24.488	TT=9.910***
	(1.350)	(0.569)	(1.502)
Farmers not linked to processors	22.324	30.332	TU=-8.008***
	(0.199)	(1.472)	(0.770)
Heterogeneity effects	BH_2=12.074	BH_1=-5.844	TH=17.918***

BHi: the effect of base heterogeneity for farmers linked to processors (i=1), and farmers not linked to processors (i = 0)

Appendix B: Questionnaire for the studies

Assessment of the Home-Grown School Feeding Program on Educational Performance and Nutrition Status of Public Elementary School Students in Northeastern Nigeria

Dear Sir/Madam,

I am a student at the Czech University of Life Science Prague, Czech Republic, and I am conducting research on "**Assessment of the Home-Grown School Feeding Program on Educational Performance and Nutrition Status of Public Elementary School Students in Northeastern Nigeria**". I invite you to take part in this research study by completing the attached surveys. The following questionnaire will take just a few minutes to complete. Please do not include your name to ensure that all details stay confidential. I would appreciate it if you could fill in and help me do this research. Thank you.

Identification

Name of School ……

Ward ……
Local government area ……

State ……
Date of the interview ……

QUESTIONNAIRE FOR HEADTEACHERS

Section A: School and Demographic Information of the Teacher

Please tick (√) to indicate your answer

1. What is your designation……

2. What is your gender: (a) Male [ ] (b) Female [ ]

3. What is the level of your professional qualification?

(a) Untrained [ ] (b) grade II teacher [ ] (c) NCE/Diploma [ ] (d) Graduate [ ]

4. What is your age in years? _____

5. Years of teaching experience? _____

6. Indicate the type of school you represent (a) beneficiaries school [] (b) Non-beneficiaries school [ ]

7. Average number of pupils in a class _____

8. Total number of pupils in the school _____

9. Total number of staffs _____

10. How long has the feeding programme been operational here (months)_____

Influence of school feeding programme on pupils' enrollment

11. Does the school feeding program encourage pupils to join the school? (a) Yes [ ] (b) No [ ]

12. Indicate the enrolment by gender

Fill in the table below on enrolment pre-intervention

Term	**Primary one**		**Primary two**		**Primary three**	
Gender	Boys	Girls	Boys	Girls	Boys	Girls
First term						
Second term						
Third term						
Total						

Fill in the table below on enrolment post-intervention

Term	**Primary one**		**Primary two**		**Primary three**	
Gender	Boys	Girls	Boys	Girls	Boys	Girls
First term						
Second term						
Third term						
Total						

13. What mostly influences the school increased enrollment?

(a) School feeding program meals [ ] (b) Free Primary Educations [ ]

(c) Past School Performance [ ] (d) Others (Specify) ……

Section B: Influence of school feeding programme on pupils' attendance

14. With school meals, are the children ready to attend classes in the morning session and afternoon session? (a) Yes [ ] (b) No [ ]

15. Indicate the attendance by gender

Fill in the table below on attendance pre-intervention

Term	**Primary one**		**Primary two**		**Primary three**	
Gender	Boys	Girls	Boys	Girls	Boys	Girls
First term						
Second term						
Third term						
Total						

Fill in the table below on enrolment post-intervention

Term	**Primary one**		**Primary two**		**Primary three**	
Gender	Boys	Girls	Boys	Girls	Boys	Girls
First term						
Second term						
Third term						
Total						

16. What mostly influences the school increased attendance?

(a) School feeding program meals [ ] (b) parents effort to send their kids [ ]

(c) Conducive learning environment [ ] (d) Pupils/teachers relation [ ]

(e) Others (Specify) ……

Influence of school feeding programme on pupils' class participation

17. Fill in the table below on participation for the last one year

Observation	**Not at all**	**Just a little**	**Pretty much**	**Very much**
Pupils take part in learning sessions when there are school meals?	1	2	3	4
Does the child have a short attention span?	4	3	2	1
Does the child accurately heed directions?	1	2	3	4
Does the child have trouble concentrating?	4	3	2	1
Does the child stay with one activity long enough to complete it?	1	2	3	4
Does the child listen attentively?	1	2	3	4
Does the child work independently?	1	2	3	4
Is the child able to concentrate on a task until completed?	1	2	3	4

Section C: Effects of school feeding programme on pupils' performance

18. Do the school meals assist the pupils to improve their class performance?

(a) Yes [ ] (b) No [ ]

19. Indicate the academic performance by gender

Fill in the table below on academic performance pre-intervention

Term	**Primary one**		**Primary two**		**Primary three**	
Gender	Boys	Girls	Boys	Girls	Boys	Girls
Math						
English						
Total						

Fill in the table below on academic performance post-intervention

Term	**Primary one**		**Primary two**		**Primary three**	
Gender	Boys	Girls	Boys	Girls	Boys	Girls
Maths						
English						
Total						

Challenges and supervision of school feeding program

20. Who has the responsibility to supervise the quality of the meal presented to the children on daily bases?

(a) School Headteacher [ ] (b) Ministry of Education [ ] (c) Nutritionist [ ]

(d) Political Holders [ ] (e) Special Stakeholders [ ] (f) Others (Specify) ……

21. How often does meal supervision happened weekly? _____

22. Any case of food contamination or poisoning within the month?

(a) Never [ ] (b) once [ ] (c) twice [ ] (d) often [ ]

23. How do you rate the food hygiene given to children

(a) poor [ ] (b) bad [ ] (c) good [ ] (d) very good [ ] (e) excellent [ ]

QUESTIONNAIRE FOR CHILDREN

Demographic Information of the children

1. Are you a beneficiary of SFP (a) yes [ ] (b) No [ ]
2. Age_____
3. Gender (a) Male [ ] (b) Female [ ]
4. Class _____
5. Household size _____
6. Mother education qualification (a) Quranic/non formal [ ] (b) primary [ ] (c) secondary [ ] (d) NCE/Diploma [ ] (e) Graduate [ ]
7. Fathers education qualification (a) Quranic/non formal [ ] (b) primary [ ] (c) secondary [ ] (d) NCE/Diploma [ ] (e) Graduate [ ]
8. what time do you come to school_____
9. How do you come to school? (a) Public means ( ) b) Private means ( ) c) By foot ( )
10. Distance of home from school in meters _____
11. Are you involving in child labour activities at home? (a) yes [ ] (b) [ ]
12. Are you engaging in any form of labour work in school? (a) yes [ ] (b) [ ]
13. Are you afraid of being abducted by kidnappers or Boko Haram? (a) yes [] (b) [ ]

Children perception on the feeding program

14. What is the main factors influencing pupils academic performance?
    (a) School meals [ ] (b) School discipline [ ] (c) Culture of learning [ ] (d) Teacher – pupil competence [ ] (e) Others (specify)……
15. Do school meals motivate you to attend school regularly? (a) Yes [ ] (b) No [ ]
16. Does school food enable you to be active in school activities? (a) Yes [] (b) No []
17. Do school meals help you to study better? (a) Yes [ ] (b) No [ ]
18. Does school meal help reduce hunger while in school? (a) Yes [ ] (a) No [ ]
19. How much is the quantity of food given to you (a) very small [ ] (b) small [ ] (c) moderate [ ] (d) adequate [ ]
20. What is the quality of the meal given to you?
    (a) poor [ ] (b) bad [ ] (c) good [ ] (d) very good [ ] (e) excellent [ ]
21. Fill in the table below on participation for the last year

22. Individual Dietary Diversity Score

Question number	Food group	Examples	YES=1 NO=0
1	cereals	corn/maize, rice, wheat, sorghum, millet or any other grains or foods made from these (e.g. bread, noodles, porridge or other grain products) + insert local foods e.g. ugali, nshima, porridge or paste	
2	white roots and tubers	white potatoes, white yam, white cassava, or other foods made from roots	
3	vitamin a rich vegetables and tubers	pumpkin, carrot, squash, or sweet potato that are orange inside + other locally available vitamin A rich vegetables (e.g. red sweet pepper)	
4	dark green leafy vegetables	dark green leafy vegetables, including wild forms + locally available vitamin A rich leaves such as amaranth, cassava leaves, kale, spinach	
5	other vegetables	other vegetables (e.g. tomato, onion, eggplant) + other locally available vegetables	
6	vitamin a rich fruit	ripe mango, cantaloupe, apricot (fresh or dried), ripe papaya, dried peach, and 100% fruit juice made from these + another locally available vitamin A rich fruits	
7	other fruits	other fruits, including wild fruits and 100% fruit juice made from these	
8	organ meat	liver, kidney, heart or other organ meats or blood-based foods	
9	flesh meats	beef, pork, lamb, goat, rabbit, game, chicken, duck, other birds, insects	
10	eggs	eggs from chicken, duck, guinea fowl or any other egg	
11	fish and seafood	fresh or dried fish or shellfish	
12	legumes, nuts and seeds	dried beans, dried peas, lentils, nuts, seeds or foods made from these (eg. hummus, peanut butter)	

13	milk and milk diary	milk, cheese, yogurt or other milk products	
14	oils and fats	oil, fats or butter added to food or used for cooking	
15	Sweets, spices, condiments, beverages	sugar, honey, sweetened soda or sweetened juice drinks, sugary foods such as chocolates, candies, cookies and cakes	

SECTION D: Anthropometric measurements

Anthropometric Indicator and Condition	Result of Measurement
Height for age = height (m)/Age	
BMI=Mass (kg)/Height(m)^2	

SECTION E: Questionnaire for Smallholders' Farmers

Demographic Information of Smallholder Farmers

1. Age _____
2. Gender (a) Male [ ] (b) Female [ ]
3. Marital status (a) single [ ] (b) married [ ] (c) widow[ ] (d) separated [ ]
4. Household size _____
5. Years of farming experience _____
6. Occupation (a) Farmer [ ] (b) pastoralist [ ] (c) traders [ ] (d) caterers [ ] (e) others specify _____
7. Educational qualification (a) Quranic education (b) primary school [ ] (c) secondary school [ ] (d) Diploma [ ] (e) Degree [ ] (f) others specify _____
8. Please indicate the share of your livelihood which was covered by agricultural production: (a) 0-25% [ ] (b) 25- 50% [ ] (c) 50-75 % [ ] (d) More than 75% [ ]

Relationship between smallholders' farmers and school feeding program

	Variables	Yes	No
8	Do you have a child benefiting from school feeding program		
9	Do you have access to credit under the HGSF		
10	Do you have link with caterers under the HGSF		
11	Do you have link to processors under the HGSF		
Other institutional agricultural packages in the area			
10	Access to extension service delivery		
11	Access to agricultural input subsidies		
12	Was there any workshop organized between farmers and caterers on value chain by the government		
13	Do you receive any market information from the government		
14	Can we say the process has ensured sustainability of home-grown food		
15	Any support to form farmers group or cooperative societies		

Impact of school feeding program on farmers income and food security

17. To what extent has your income improved due to school feeding program

(a) No increase [ ] (b) 0-25% [ ] (c) 25- 50% [ ] (d) 50-75 % [ ] (e) More than 75% [ ]

18. To what extent has the school feeding program reduce the amount of household expenditure

(a) No decrease [ ] (b) 0-25% [ ] (c) 25- 50% [ ] (d) 50-75 % [ ] (e) More than 75% [ ]

Household Food Consumption Score

The frequency weighted diet diversity score is a score calculated using the frequency of consumption of different food groups consumed by a household during the 7 days

Food Group	Weight for FCS	Food Items belonging to group	Frequency	
1.Cereals and Tubers	2	Rice, pasta, bread / cake and / or donuts, sorghum, millet, maize, potato, yam, cassava, sweet potato, taro and / or other tubers		
2. Pulses	3	beans, cowpeas, peanuts, lentils, nut, soy, pigeon pea and / or other nuts		
3. Vegetables	1	carrot, red pepper, pumpkin, orange sweet potatoes, spinach, broccoli, amaranth and / or other dark green leaves, cassava leaves, onion, tomatoes, cucumber, radishes, green beans, peas, lettuce, etc.		
4. Fruit	1	mango, papaya, apricot, peach, banana, apple, lemon, tangerine		
5. Meat and fish	4	goat, beef, chicken, pork (meat in large quantities and not as a condiment) fish, including canned tuna, escargot, and / or other seafood (fish in large quantities and not as a condiment)		
6. Milk	4	fresh milk / sour, yogurt, cheese, other dairy products (Exclude margarine / butter or small amounts of milk for tea / coffee)		
7. Oil	0.5	vegetable oil, palm oil, shea butter, margarine, other fats /		
8. Sugar	0.5	sugar, honey, jam, cakes, candy, cookies, pastries, cakes and other sweet (sugary drinks)		
9. Condiments / Spices	0.5	tea, coffee / cocoa, salt, garlic, spices, yeast / baking powder, lanwin, tomato / sauce, meat or fish as a condiment, condiments		

QUESTIONNAIRE FOR CATERERS (FOOD VENDORS)

Age _____

1. Gender (a) Male [ ] (b) Female [ ]
2. Marital status (a) single [ ] (b) married [ ] (c) widow[ ] (d) separated [ ]
3. Household size _____
4. Years of farming experience _____
5. Educational qualification (a) Quranic education (b) primary school [ ] (c) secondary school [ ] (d) Diploma [ ] (e) Degree [ ] (f) others specify _____

6. Please indicate the share of your livelihood which was covered by catering job last year: (a) 0-25% [ ] (b) 25- 50% [ ] (c) 50-75 % [ ] (d) More than 75% [ ]
7. Food vending profit/month (Naira)? ……

Food handling sources of knowledge/information to the respondent

8. Did you attend training on cooking and food services (food handling)? (a) yes [ ] (b) No [ ]
9. If yes, how many times did you attend food handling training (number in life)? ……
10. From where you learnt food handling? (multiple responses are allowed)

(a) Observation [ ] (b) Home [ ] (c) Restaurant [ ] (d) Formal institution [ ]

11. from which of the following you get food handling information (multiple choice)
    (a) Radio [ ] (b) Television [ ] (c) Newspapers [ ] (d) Food inspection institution [ ] (e) Social [ ] (f) Internet [ ] (g) Friends/colleagues [ ]
12. Do you have a medical certificate? (a) yes [ ] (b) No [ ]
13. How frequent food safety inspectors visit your shop? (a) Never [ ] (b) Once in a year [ ] (c)Two times in Year[ ] (d) Three times in year [ ] (e) More than three times [ ]

Food safety knowledge of the respondent

14. Food can be source of disease infection (a) Yes [ ] (b) No [ ] (c) I don't know [ ]
15. Food from unhygienic and unclean source might harbor disease causing organism
    (a) Yes [ ] (b) No [ ] (c) I don't know [ ]
16. Using expired food can't cause health disorder (a) Yes [ ] (b) No [ ] (c) I don't know [ ]
17. Some foodborne disease/contamination can't cause death (a) Yes [ ] (b) No [ ] (c) I don't know [
18. Unaccredited, off brand and bulk product should not be purchase
    (a) Yes [] (b) No [] (c) I don't know []
19. Human can't be infected from unhygienic food stuff (a) Yes [] (b) No [] (c) I don't know []
20. Microorganism are not frequently found in hand (a) Yes [] (b) No [] (c) I don't know []
21. After touching raw food stuff, touching cooked food without cleaning hand cause transfer
    of microorganism (a) Yes [] (b) No [ ] (c) I don't know [ ]

Food Safety Attitude of the Respondent

22. Safe food handling is an important part of my job
    (a) Strongly disagree [] (b) Disagree [] (c) Uncertain (d) Agree [ ] (e) Strongly Agree []
23. Learning more about food safety is an important to me

(a) Strongly disagree [ ] (b) Disagree [ ] (c) Uncertain (d) Agree [ ] (e) Strongly Agree [ ]

24. I believed that how I handle food relates to food safety

(a) Strongly disagree [ ] (b) Disagree [ ] (c) Uncertain (d) Agree [ ] (e) Strongly Agree [ ]

25. Raw food should be kept separate from cooked food

(a) Strongly disagree [ ] (b) Disagree [ ] (c) Uncertain (d) Agree [ ] (e) Strongly Agree [ ]

26. Using masks, protective gloves, caps and adequate clothing reduces the risk of food contamination

(a) Strongly disagree [ ] (b) Disagree [ ] (c) Uncertain (d) Agree [ ] (e) Strongly Agree [ ]

27. Improper storage of food may be hazardous to health

(a) Strongly disagree [ ] (b) Disagree [ ] (c) Uncertain (d) Agree [ ] (e) Strongly Agree [ ]

28. Sick staff should not be involved in food handling and food services

(a) Strongly disagree [ ] (b) Disagree [ ] (c) Uncertain (d) Agree [ ] (e) Strongly Agree []

Food safety practice of the respondent

29. Do you concern about hygienic source of food stuff?

(a) Never [ ] (b) Rarely [ ] (c) Sometimes [ ] (d) Often [ ] (e) Always [ ]

30. How frequent you avoid buying expired food stuff?

(a) Never [ ] (b) Rarely [ ] (c) Sometimes [ ] (d) Often [ ] (e) Always [ ]

31. Do you use gloves when touching or distribution of unwrapped food?

(a) Never [ ] (b) Rarely [ ] (c) Sometimes [ ] (d) Often [ ] (e) Always [ ]

32. Do you wash your hands before using gloves?

(a) Never [ ] (b) Rarely [ ] (c) Sometimes [ ] (d) Often [ ] (e) Always [ ]

33. Do you use protective clothing when touching or distribution of unwrapped foods?

(a) Never [ ] (b) Rarely [ ] (c) Sometimes [ ] (d) Often [ ] (e) Always [ ]

34. Do you use a mask when touching or distribution of unwrapped food?

(a) Never [ ] (b) Rarely [ ] (c) Sometimes [ ] (d) Often [ ] (e) Always [ ]

35. Do you dispose food when the taste is change?

(a) Never [ ] (b) Rarely [ ] (c) Sometimes [ ] (d) Often [ ] (e) Always [ ]

36. Do you sterilize your utensils?

(a) Never [ ] (b) Rarely [ ] (c) Sometimes [ ] (d) Often [ ] (e) Always [ ]

37. Do you dispose food when it developed some odour?

(a) Never [ ] (b) Rarely [ ] (c) Sometimes [ ] (d) Often [ ] (e) Always [ ]

Economic and Control beliefs

38. Wearing gloves, caps, frequent hand washing etc. (food safety practices) is costly (money)?

(a) Surely no [ ] (b) Probably no [ ] (c) Undecided [ ] (d) Probably yes [ ] (e) Surely yes [ ]

39. Food safety practices is time consuming?

(a) Surely no [ ] (b) Probably no [ ] (c) Undecided [ ] (d) Probably yes [ ] (e) Surely yes [ ]

40. Food safety practices is against my religion/ belief?

(a) Surely no [ ] (b) Probably no [ ] (c) Undecided [ ] (d) Probably yes [ ] (e) Surely yes [ ]

41. Food safety practices is not compatible with my culture?

(a) Surely no [ ] (b) Probably no [ ] (c) Undecided [ ] (d) Probably yes [ ] (e) Surely yes [ ]

42. Compliance with food safety practices against with my peer group attitude?

(a) Surely no [ ] (b) Probably no [ ] (c) Undecided [ ] (d) Probably yes [ ] (e) Surely yes [ ]

43. Compliance with food safety practices can hot my family?

(a) Surely no [ ] (b) Probably no [ ] (c) Undecided [ ] (d) Probably yes [ ] (e) Surely yes [ ]

44. Where do prepare your meal?

(a) Home [ ] (b) school kitchen [ ] (c) personal restaurant [ ]

Picture 1. Data collection with pupils in Gombe State

Picture 2. Data collection will pupils in Adamawa State

Picture 3. Taking measurement of pupils height

Picture 4. Interviewing head teacher in Bauchi State

Picture 5. Interview with smallholder farmers in Gombe state

Picture 6. Data collection with smallholder farmers