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Effects of post-harvest losses on food security among cowpea farming households in Oyo state, Nigeria

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Abstract

The study examined how post-harvest losses affected food security among cowpea farming households in Oyo state, Nigeria. Multistage sampling method was used to choose the study's samples. For the research, data was gathered from the farmers, utilizing a well-organized questionnaire and interview schedule. Descriptive statistics including (frequency, percentage, and mean), 3-point Likert-type rating scale, Household food expenditure, FGT food insecurity measure, and Probit regression were used to analyze the gathered data. Results indicated that middle-aged, male persons who grew an average cowpea farm of 1.37 hectares dominated cowpea production in the study area. Moreover, among cowpea farming households in the study region, average post-harvest losses observed was 21.9%, and food insecurity prevalence was 52.5%. Furthermore, variables including access to credit, years of formal education and farm size positively and significantly influenced food security whereas post-harvest losses, planting of local cowpea varieties, and household size negatively and significantly affected food security. According to the research, resolving the main causes found—that is, planting local cowpea seed varieties, large household size, and post-harvest loss occurrences—is absolutely necessary to help to alleviate food insecurity among cowpea growers in the study area.

Keywords: Food security; Post-harvest loss; Cowpea; FGT; Probit model; Nigeria

1. Introduction

Among the many crops grown in Nigeria, cowpea (Vigna unguiculata), ranks particularly prominent because of its adaptability, nutritional value, and economic importance [1]. Originating from Africa, where the main cowpea producing nations are located [2], about 95% of its global production is traceable to West Africa, and Nigeria doubles as its leading producer and consumer in the world [3; 4; 2]. Cowpea, known locally in southwest Nigeria as 'ewa', is a staple food and a key source of protein, especially in low-income households that cannot regularly afford meat [5]. Boiled beans, 'moinmoin' (bean pudding), 'akara' (bean cake), and bean porridge are among the many ways the crop is consumed all across Nigeria, so making it an essential component of local food culture and diets [6; 7]. Many smallholder farmers, who depend on cowpea production and sale to support their livelihoods also consider it a significant cash crop [8], In the savanna agro-ecological regions, where climate conditions—especially during the dry season—supports its short growth cycle [9], cowpea helps farmers in these regions to cover fundamental household needs like medical costs, farm expenses and school fees [10]. Moreover, as a legume, cowpea increases soil fertility by fixing nitrogen, hence supporting sustainable farming practices in the area. Although there are advantages associated with cowpea cultivation, large post-harvest losses—which threaten household income and food security—restrict cowpea production [11]. Post-harvest losses have hampered the food security level of farmers and their families in low income countries around the world owing to obstacles to the acquisition of better storage technologies [12]. Post-harvest losses have been associated

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with around one-third of the world's food production service consumption or market sales [50]. While nearly 29.8% of the hungry population would be severely food insecure [50], Sub-Saharan Africa was predicted to have 233 million people starving and undernourished, similarly, Nigeria that earns a significant foreign exchange revenues from crude oil and considerable agricultural income, still has around 48.3% of her rural residents being food insecure [12; 13].

Measurable quantitative and qualitative losses of agricultural products between harvest and final consumption are known as post-harvest losses [14]. Because of poor storage infrastructure, pest infestation, high humidity, and inadequate handling techniques, cowpea farmers in Nigeria have great difficulty saving their crops [11], Particularly problematic is the cowpea bruchid (*Callosobruchus maculatus*), a ubiquitous storage pest that can destroy large quantities of kept cowpea grains in a matter of weeks if not properly controlled [15]. Post-harvest losses in cowpea can reach 30–40%, especially in regions where modern storage technologies are not extensively used, according to [16; 17] and such losses for small profit margin farmers can be catastrophic.

Traditional methods of storage—namely the use of jute bags, mud silos, or open-air storage—provide little defence against pests and environmental damage [18]. Moreover, either because of cost or limited awareness, many farmers lack access to hermatic storage solutions such as the Purdue Improved Cowpea Storage (PICS) bags [19]. Consequently, a lot of the harvested cowpea spoils before it can be eaten or sold, causing significant labour, land, and input waste with the related serious economic consequences: mean lower incomes for farming households, exorbitant market costs for consumers restricting affordability [20; 21].

Post-harvest losses is a critical issue in the Nigerian context influencing food security [22]. Food security is the condition where all people have physical, social and economic access to enough, safe and nutritious food that meets their dietary needs for an active and healthy life at all times [23]. Post-harvest losses gave way to compromised produce in terms of quality and quantity leading to reduced food available for consumption and lower revenues from sales which restrict farmers' capacity to buy other food products, thereby impacting both dietary variety and general well-being [24; 25; 26]. Rising market prices result from the reduction of these supplies owing to storage or handling problems, therefore lowering urban consumer affordability especially for low-income families depending on inexpensive plant-based protein resulting in a worsened food insecurity condition [27; 28].

Though government agencies, NGOs, and research institutes work to encourage better post-harvest techniques, however, practice rates in Nigeria remain low [29; 30]. Programs promoting the use of improved storage bags, pesticide treatments, and post-harvest training have shown some good results, yet cost barriers, limited extension services, and cultural preferences for conventional methods have limited their effect [31]. Infrastructure deficiencies such poor roads, inadequate market facilities and limited access to credit also impede the scalability of better post-harvest solutions [32].

Considering these facts, it is imperative to better grasp the dynamics of post-harvest losses in cowpea production and their impact on food security. Although some studies have investigated overall patterns of post-harvest loss in Nigeria, there is little local study that explored the link between cowpea post-harvest losses and food security. Previously, studies in this regard were conducted in northern Nigeria [12; 33] and we consider investigating the relationship between post-harvest losses and food security in the southern Nigeria worthwhile because the peculiarities of each of the regions (including socio-cultural, agro-ecological among others) necessitate gathering of localized data that would inform targeted policy intervention. Therefore, this study investigated the effects of post-harvest losses on cowpea farming households' food security in Oyo-state, Nigeria.

2. Material and methods

2.1. Study area

This research was conducted in Oyo state, Nigeria. Oyo state has a population of 6,617,20 [34] and thirty-three local government areas (LGAs) and it is one of the six states that make up Nigeria's south west geo-political zone. The state covers around 28,454 square kilometers between 2° 47' and 4° 23' east of the meridian and between 7° 3' and 9° 12' north of the equator [35; 36]. It shares borders with Kwara State to the north, Osun State to the east, Ogun State to the south, and the Republic of Benin to the west. A tropical wet and dry climate distinguishes Oyo state, with a rainy season from March to October and a dry season from November to February. Temperature fluctuates between 21°C and 39°C [35]. The environment helps raising of many crops and livestock systems. The population is involved in public service, trading, handcrafted crafts, and agriculture (rural people).

2.2. Sampling procedure

Through structured questionnaire and interview with cowpea farming household interviews in the study area, the main data for this study were gathered using a structured questionnaire. Respondents for the study were selected using a multistage sampling approach. Simple random selection of two ADP zones from the four in the state made up the first step. From each of the selected ADP zones, three local government areas (LGA) were randomly chosen in the second phase. The third stage used random sampling to choose two villages from each of the chosen LGAs. Ten farmers from each of the selected communities were identified using snowball sampling in the fourth phase. Altogether, 120 cowpea farming households from the study area were included in the sample.

2.3. Method of data analysis

To examine the gathered data, the study employed analytic approaches including descriptive statistics (frequency, percentage, and mean), Likert-type rating scale, Household food expenditure, FGT food insecurity index and probit regression model.

2.4. Household food expenditure estimation

This study assessed household food expenditure to construct a food security line following [37; 38; 39; 40]. The food security line was calculated as two-thirds of the average monthly food expenditure of all households. Using the food security line as a benchmark, households were then categorized into food secure and food insecure. As such, a food secure household was defined as one whose per-capita monthly food expenditure is equal to or above the food security line; whereas a food insecure household is that whose per-capita monthly food expenditure is below the food security line.

2.5. FGT food security index

Assessment of household food security condition can be made using an analytical tool called FGT. Either at the household or country level, FGT is useful in evaluating food insecurity occurrence, intensity, and depth following [40], FGT can be expressed as

$$F\alpha = \frac{1}{n} \sum_{i=1}^{q} \left(\frac{z-y_i}{z}\right)^{\alpha}$$

Where:

- n = total number of households
- q = number of food insecure households
- z = food security line
- y_i = per cspital food expenditure for household $_i$
- α = degree of food security aversion

2.6. Probit model

The probit model can be specified as shown below:

$$\gamma_i = F(X_i\beta) + \varepsilon_i$$

$$\gamma_i = \begin{cases} 1, if\ food\ secure \\ 0, otherwise \end{cases}$$

Where,

$\varepsilon \sim N(0,1);\ \beta = maximum\ likelihood;\ \varepsilon = error\ term; X = set\ of\ independent\ variables$ included in the model.

The independent variables in this study include:

Age (years), Amount of Credit received (₦), Formal Education (years), Extension contact (yes or no), Farming experience (years), Farmers' group (yes or no), Farm size (Hectares), Gender (1 = male, 0 = female), Household size (number), Marital status (1 = married, 0= otherwise), Post harvest loss (tons/ha), Seed variaties (1 = improved, 0 = otherwise)

3. Results

Table 1 presents the socio-economic characteristics of cowpea farmers. The results reveal that most of them were males, suggesting a male-dominated cowpea farming population possibly because of the laborious nature of cowpea cultivation. This result is consistent with [41], who found a male dominated population of cowpea cultivation in their study area. Nigeria. An average age of 49.2 years, suggests the farmers' potentialities for productivity. A similar finding is contained in [42]. Most of the respondents were married suggesting family-based farming activities where spouses pool resources together to the success of the agricultural business. [41] earlier, reported the dominance of married respondents in their cowpea study. Regarding farming experience, an average cowpea farmer had been involved in cowpea cultivation for 13.62 years, therefore highlighting a certain level of expertise in cowpea cultivation. This result supports [42] who found in their study that, an average cowpea farmer had 13.3 years of farming experience.

With 9.28 years of formal education, an average farmer had basic education which may influence technology adoption and wise farming decisions. According [43], the average cowpea farmer in their research had nine years of formal education, Regarding household size, an average farmer's household comprised around eight persons, indicating a rather large households. This indicates higher food consumption requirements but also presents a labour potential for both post-harvest operations and agriculture.This result supports [43], who found that the household size of an average cowpea farmer in their research was around eight people.

Table 1 Distribution of farmers by farmers' characteristics

Farmers' characteristics	Frequency	Percentage
Age		
≤ 30	7	6
31 – 40	18	15
41 – 50	34	28
51 – 60	36	30
> 60	25	21
Mean: 49.2years		
Farming experience (years)		
≤ 10	62	52
11 – 20	35	29
> 20	23	19
Mean: 13.62years		
Education (years of schooling)		
0	29	24
1	37	31
2	35	29
3	19	16
Mean: 9.28years		
Household size		
1 – 5	56	47
6 – 10	54	45
11 – 15	10	8
Mean: 7.8persons		

Gender		
Male	95	79
Female	25	21
Marital status		
Single	22	18
Married	65	54
Divorced	14	12
Widowed	19	16

Source: field survey, 2024

3.1. Farm characteristics

Table 2 reveals that an average cowpea farmer's farm size was 1.37 hectares, which suggests smallholder production. This may imply inability to acquire mechanization facilities and improved storage technologies. This result supports [43] who found average farm size to be 1.01ha. Also, average post harvest loss suffered by farmers was 21.9%. suggesting an adverse effect on households' food security. This result is consistent with [33], who found post-harvest losses among grain farmers was significant and influenced food insecurity. Intercropping is the dominant cropping system practised by the farmers . This reflects factors such as availability of farmland and diversification initiatives against crop failure to assure a stable farm income and ultimately food security. [44], earlier reported a similar result that more than half of cowpea farmers in his study practised intercropping.

Table 2 Distribution of farmers by farm characteristics

Farm characteristics	**Frequency**	**Percentage**
Farm size (ha)		
< 1	60	72
1 – 5	28	34
> 5	12	14
Mean: 1.37ha		
Post-harvest loss (%)		
< 20	71	59.2
21 – 30	21	17.5
> 30	28	23.3
Mean : 21.9		
Cropping system		
Sole cropping	41	34
Inter cropping	79	66

Source: field survey, 2024

3.2. Distribution of cowpea farmers by seed varieties cultivated

Table 3 results show that just 36% of farmers planted imported types including 'Ife brown' and BB white, whereas the majority (64%) cultivated local cowpea varieties mostly 'Sokoto' and 'Oloyin'. This varietal preference has significant food security and post-harvest loss consequences.. Local cowpea cultivars—though often well suited to local consumer preferences and agro-ecological conditions—usually are susceptible to diseases, field and storage pests, and negative environmental circumstances. On the other hand, better cowpea varieties like 'Ife brown' and 'BB white' have been bred to overcome these challenges. These results are consistent with those of [25], who discovered that farmers in Nigeria

preferred local varieties more than the improved ones because of their preference for traits like seed color, size, and striga resistance.

Table 3 Distribution of farmers by cowpea seeds varieties cultivated

Seed varieties	F	%
Improved		
Ife Brown	16	13.3
Ife Bimpe	9	7.5
BBT White	12	10
BBT Brown	6	5
Total (A)	43	
Local		
Oloyin	24	20
Big Brown (Drum)	13	10.8
Sokoto White	32	26.7
Igbira White	8	6.7
Total (B)	77	
Total (A) + (B)	120	100

Source: field survey, 2024

3.3. Rank of post-harvest activities by level of losses as reported by cowpea farmers

Table 4 shows how farmers ranked the level of losses associated with each of the post-harvest activities as per farmers' based on their individual experiences. The results showed varying level of losses; storage came first, followed by threshing, transportation, packaging, drying, and winnowing in that order. This result indicates how improper handling of crops after harvest and lack of good post-harvest infrastructures undermine food security efforts.

Table 4 Rank of level of losses from post-harvest activities as reported by farmers

Activities	Level of losses				
	High 3	Medium 2	Low 1	Mean	Rank
Threshing	86	18	16	2.58	2nd
Winnowing	12	18	90	1.35	6th
Drying	26	24	70	1.63	5th
Packaging	68	14	38	1.84	4th
Transportation	41	19	60	2.25	3rd
Storage	114	6	-	2.95	1st

Source: field survey, 2024

3.4. Distribution of farmers by storage technology

Table 5 shows the distribution of farmers according to storage method they used. The findings reveal that 27.5% of farmers employed metal drums combined with insecticides while 55.8% use ordinary bags laced with synthetic insecticides and 10.8% of farmers use domestic space combined with insecticides. Invariably, over 90% of storage methods involve insecticides in either a bag or metal drum or domestic space, highlighting a strong reliance on chemical post-harvest pest management technique. The implications of this approach are that the chemical leftovers present health hazards to people especially when farmers may lack education on proper use. This could threaten food security,

a key part of which is food safety. Nevertheless, very few (5.9%) farmers used botanicals as their storage methods which is an effective and safer alternative storage technique indicating either poor awareness or access probably caused by deficiencies in extension services or market accessibility.

Table 5 Storage Technologies employed by the farmers

Storage Technologies	**F**	**%**
Bags + insecticides	67	55.8
Metal drum + insecticides	33	27.5
Bags + botanicals	5	4.2
Metal drum + botanicals	2	1.7
Space in the house + insecticides	13	10.8
Total	120	100

Source: field survey, 2024

3.5. Summary of Cowpea yield and post-harvest losses (PHL)

Table 6 presents the summary of cowpea yield and post-harvest losses in the study area. The results revealed average cowpea yield as 0.87 tons/hectare indicating a rather low yield compared to the average yield of a typical improved cowpea variety), due to the dominant dominant cultivation of local vaieties of cowpea by farmers in the study area. Percapita farm size was 1.37 hectare. This reflects the practice of smallholding that characterize Nigerian agriculture. Average post-harvest loss in terms of percentage of output,tons and Naira worth were 21.9%, 0.25 tons and N337,500 respectively.. This is more than one-fifth of the output which is significant and underscore the urgent need for action to address its devastating effect on livelihood and food security.

Table 6 Summary of Cowpea yield and post-harvest losses.(PHL)

Variable	**Value**
Average yield	0.87 tons/ha
Average farm size	1.37 ha
Percapita output	1.19 tons
Average post-harvest loss (%)	21.9 %
Average post-harvest loss (tons)	0.25 tons
*Naira worth of cowpea PHL	N337,500

Source: field survey, 2024

3.6. Key food security metrics among cowpea farming households

Table 7 displays the main food security indicators for cowpea farming households. The results show that 47% of the 120 farmers were food secure whereas 64 households (53%) were food insecure. This food insecurity incidence suggests that around 58% of cowpea producing households are unable to satisfy food expenditure up to the food security line (₦1,740.16 per day), which is somewhat higher than 1 USD based on the prevailing exchange rate at the time of data gathering in 2024. This result is comparable to [40], who found a food security line of ₦905.24, a figure somewhat over 1 USD in 2023 based on the 2023 exchange rate, among yam farmers in their study. The depth of food insecurity (0.108, or 10.8%) shows the average deficit in food spending among the food insecure, implying a rather modest difference between their food expenditure and food security threshold. This suggests the possible rapid improvements in food security from small increases in income or decreasing food losses. But the severity of food insecurity at 0.029 highlights that although inequalities among the food insecure housholds exist, they are not significant. This means that most households without enough food suffer comparable degrees of need rather than an extreme deprivation.

Table 7 Key Food Security Metrics among Cowpea Farming Households

Variable	Values
Food secure	47%
Food insecure	53%
Total	*120*
MPCapHFEXP	₦2,610.24/day
Food line	₦ 1,740.16/day
Food insecurity incidence	0.525
Food insecurity depth	0.108
Food insecurity severity	0.029

Source: field survey, 2024

3.7. Constraints to Adoption of Improved Cowpea Storage Technologies among Cowpea Farmers

Table 8 indicated Constraints to Adoption of Improved Cowpea Storage Technologies among Cowpea farmers. Majority (93.3%) of farmers indicated high cost of storage facilities, lastorage methods (81.6%), and lack of access to credit to purchase the technologies (59.2%) as the most notable limitation. This implies that economic affordability is a significant obstacle for better storage technologies like hermatic bags, metal silos, etc. The other constraints cited in the table are crucial to the awareness and technical-know-how of improved storage technologies. [46 and 47] reported similar results.

Table 8 Constraints to adoption of improved cowpea storage technologies among farmers

Constraints	F	%
1) High cost of storage facilities	112	93.3
2) Lack of access to improved storage methods	98	81.6
3) Lack of access to credit to purchase the technologies	71	59.2
4) Inadequate extension services	58	48.0
5) Limited access to information on improved storage practices	46	38

*Multiple responses Source: field survey, 2024

3.8. Probit regression results of the effects of post harvest losses on food security among cowpea farming households

Table 8 shows how postharvest loss affects food security among cowpea-growing households. The results showed a log-likelihood of -38.119014, prob>chi square at 1% level of significance as well as pseudo R^2 of 0.5338 indicating a good fit of the model.

Post-harvest loss had a bad and major impact on food security at 5%. This means that lower likelihood of food security of the household would result from more post-harvest losses suffered by them. This might be related to how post-harvest losses affect the amount and quality of the product available for consumption and sale, therefore influencing the market and nutritional values of the cowpea and finally food security. This conclusion fits [40]. On the other hand, farm size positively and significantly impacted by food security at 10%. This means that cowpea farming households with more farm size are likely to be more food secure than their counterparts with less size of farm. One potential reason for this result is that a farmer is more likely to get a higher level of output from a larger farm size than from a lesser farm size. The findings of [40] contradicts this result as they found that farm size of yam producers have no direct relationship with food security.

Moreover, at 1%, household size had a negative and significant influence on food security. This means that a cowpea farming household with a large size is probably going to be less food secure than his counterpart with a small household size. One could explain this result by the need for a large household size to acquire more food and more resources which

may be challenging to fulfill due its higher per capita food requirement compared to a farmer that has a small household size. This result corroborated [39] finding that big household size reduced likelihood of food security.

Years of formal schooling also had a positive and significant effect on food security at 5%. This means that food security is more likely to be acieved among cowpea farmers with more years of formal education than among those with less years of formal education. This result is possible since educated farmers are more prone to embrace new farming techniques and make wise choices that lead to a favorable welfare outcome. This finding matches [33], who found a higher likelihood of food security as the number of years of formal education of cowpea grower increased.

Likewise at 10%, seed varieties showed a negative and significant impact on food security. This implies that farmers cultivating local cowpea variety are less likely to be food secure compared to their counterparts who cultivated improved cowpea varieties. The lower yield and poorer resistance to insects and pests attack associated with local cowpea varietiess could be linked to this finding compared with the improved cowpea varieties. The results corroborate [48] and [25], which suggest that local seed variety cultivation reduces the chance of food security among farmers.

Credit received had a positive and significant impact on food security at 1%. This implies that cowpea farming households that obtained credit are more likely to be food secure than their counterparts that did not obtain credit. A possible explanation for this finding is that credit obtained may afford the recepeints an opportunity to adopt modern/ improved farming technologies with a good pay-off. This finding backs [49], which found that food security possibility rises with the amount of credit received.

Table 9 Probit regression results of the effects of post harvest losses on food security among cowpea farming households

Food secure	**Coefficient**	**Z**	**P>|z|**
Age	0.03707 (0.0275)	1.35	0.178
Amount of Credit obtained	3.6000(1.0700)	3.37	0.001***
Formal Education	0.0689 (0.0344)	2.00	0.045**
Extension contact	-0.2540 (0.3754)	-0.68	0.499
Farming experience	0.0771 (0.0527)	1.46	0.143
Farmers' group	0.2117 (0.3494)	0.61	0.545
Farm size	0.9020 (0.4991)	1.81	0.071*
Gender	0.2058 (0.3883)	0.53	0.596
Household size	-0.6080 (0.1425)	-4.27	0.000***
Marital status	-0.0536 (0.5027)	-0.11	0.915
Post harvest loss	-22.1676 (7.9346)	-2.79	0.005**
Seed variaties	-0.8789 (0.5239)	-1.68	0.093*
Constant	0.8341 (1.0636)	0.78	0.433

Number of obs = 120; LR chi2(12) = 87.31; Prob > chi2 = 0.0000; Log likelihood = -38.119014 Pseudo R2 = 0.5338*, **, *** represent 10%, 5% and 1% level of significance respectively; standard errors are in parenthesis Source: field survey, 2024

4. Conclusion

Many families depend on cowpea, a necessary legume crop in Nigeria, for food security and income generation. But major post-harvest losses, are jeopardizing these advantage. The study presents a picture of cowpea farming households in Oyo state, Nigeria. These households grow around 1.37 hectares of land with an average of about 8 people. Usually around 49.2 years old who are mostly males (79%) have around 13.6 years of farming experience. Farmers struggle to control post-harvest losses which average 21.9% (0.25 tons) despite their level of farming experience. Some of the farmers were able to obtain credit, averaging ₦213,865, however, 52.5% of households sampled suffer food insecurity.

Although the use of metal drums, bags, and domestic spaces combined with insecticides were predominantly the storage practice in the study area, however, a handful of farmers used botanicals which is more effective and safer. The study investigated the relationship between post-harvest and food security, the results revealed that: access to credit, farm size, and education were positively and significantly influenced food security. On the other hand, post-harvest losses, planting local cowpea varieties , and large household size had negative and significant influence on food security This emphasizes how difficult it is for bigger households with limited resources to satisfy their nutritional requirements.

It is implied from the results that improving food security depends on reducing post-harvest losses. Tackling the main causes discovered—lack of access to better seed varieties, large household size, and reliance on conventional storage methods—is imperative. Thus, strategies should centre on: Increasing credit availability: Giving farmers reasonably priced loans to improve agricultural methods and install improved storage solutions. Promoting training and education: Giving farmers the information and skills required to use efficient post-harvest management approaches/technologies. • Giving access to pest-resistant, high-yielding cultivars well-suited to the local environment helps to promote adoption of improved seeds varieties. Promoting effective storage methods: Introducing and educating farmers on the use of better storage technologies, like hermetic bags or treated storage facilities, so reducing post-harvest losses. Promoting wise family planning to tackle the issue of large household size by means of intensified campaign for family planning. Examining the current land tenure system so that farmers are not constrained by land to create enough to meet both household and national food demand. Addressing these key elements will enable stakeholders to greatly minimize post-harvest losses, raise food security, and better the livelihoods of cowpea-growing families in the study area,, thereby promoting a more sustainable and food-secure future for the area.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

Statement of informed consent

Informed consent was obtained from all individual participants included in the study.

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