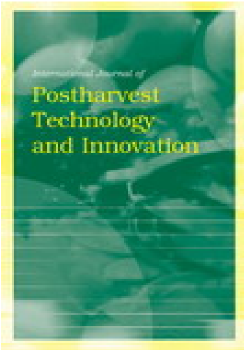

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Carren A. Okumu, John Mburu, Esther Mujuka, Jane Ambuko, Israel Leoname Frohlich Klug

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Knowledge, attitude and practices relevant to food loss reduction along the bean supply chain of the home-grown school meal program in Kajiado and Kitui counties, Kenya

Carren A. Okumu*

Department of Agricultural Economics,
University of Nairobi,
P.O. Box 29053, Nairobi, Kenya
Email: okumuca@gmail.com
*Corresponding author

John Mburu

Department of Agricultural Economics,
University of Nairobi,
P.O. Box 29053, Nairobi, Kenya
Email: john.mburu@uonbi.ac.ke

Esther Mujuka

Department of Agricultural Economics,
University of Nairobi,
P.O. Box 29053, Nairobi, Kenya
Email: esthermujuka@gmail.com

Jane Ambuko

Department of Plant Science and Crop Protection,
University of Nairobi,
P.O. Box 29053, Nairobi
Email: jane.ambuko@uonbi.ac.ke

Israel Leoname Frohlich Klug

Food and Agriculture Organization of the United Nations (FAO),
Viale delle Terme di Caracalla, 00153 – Rome, Italy
Email: Israel.Klug@fao.org

Abstract: Adoption of food loss-reduction measures greatly depends on the knowledge, attitude and practices (KAPs) of the actors. This paper analyses KAPs relevance to food loss reduction among supply chain actors. Focusing on Kajiado and Kitui counties and supply chains to the Kenya home grown school meals programme (HGSMP), face-to-face interviews using structured questionnaires gathered insights from a total of 108 farmers and 90 traders.

Descriptive analysis, factor analysis and multivariate regressions were conducted. The results reveal that farmers in both counties have very different KAPs due to their different socio-cultural and agro-ecological conditions. Further analysis revealed that actors' knowledge, positive attitudes and practices are specific, distinct and crucial to reducing postharvest losses. Therefore, tailored capacity-development efforts and incentives that encourage behavioural shifts and adoption of appropriate postharvest practices and technologies are recommended to addressing food loss effectively.

Keywords: food loss; HGSMP; home-grown school meals program; multi-variate regression; KAPs; knowledge attitude practices; Kenya.

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Biographical notes: Carren A. Okumu is a student researcher at the University of Nairobi, at the final stages of completing her Master's in Agricultural and Applied Economics. She holds a Diploma in Horticulture (Jomo Kenyatta University of Agriculture and technology; Bachelor in Business Management (Kenya Methodist University). Her research interests focus on postharvest loss reduction, commodity value chains, pre-and post-harvest management and food systems development. She is a Post harvester, a marketer, a value-chain specialist and a certified GLOBALGAP farm auditor with over 15 years' experience in marketing and pack house management, design and implementation of quality management systems; market specification conformance and farm audits.

John Mburu is an Associate Professor in the department of Agricultural and Resource Economist and holds a PhD in Agricultural Economics (2002) from the University of Goettingen, Germany with a focus on Environment and Resource Economics, as well as the socio-economics of rural development and forest policy. His research interests include environmental and resource economics and value chain analysis, contributing significantly to the academic field with numerous citations. He has worked extensively, for over 20 years, on crop genetic resources, animal (livestock) genetic resources, economics of livestock breeding, Economic valuation of forests and wildlife; analysis of the efficient and sustainable approaches of conservation of natural resources; cost-benefit analysis; Incentives for conservation of biodiversity and natural resources, irrigation, market chain analysis, climate change, cross border trade, microfinance, poverty and horticulture commodity value chain analysis. He has widely published in these areas.

Esther Mujuka graduated with a PhD in Agricultural Economics at the University of Nairobi, Kenya in 2023. She specialises on food and waste loss (FWL) estimation and economic evaluation of FLW. He has considerable experience in economic analysis of development projects targeting rural households. She just concluded an assessment of food losses in two supply chains (grain and vegetable) in the homegrown school meals program for the food and agricultural organisation (FAO). She has also worked for the Ministry of Agriculture. She has published on the returns to investment in postharvest loss reduction technologies, consumer awareness and willingness to pay for naturally preserved solar-dried mangoes and on the potential economic impact of integrated pest management in Kenya.

Jane L. Ambuko is an Associate Professor and Head of Horticulture Unit at the Department of Plant Science and Crop Protection, University of Nairobi. She holds a BSc in Agriculture, MSc in Horticulture from University of Nairobi (Kenya) and a PhD in Agricultural Sciences (Pomology and Postharvest Major) from Tsukuba University (Japan). Her area of specialisation is postharvest science and technology. She has published widely in internationally refereed journals, received prestigious fellowships and is a member of several professional associations. She is a champion of Postharvest Loss Reduction aimed towards halving postharvest losses under Malabo Declaration (2014) and United Nation's SDG 1, 2, and 3.

Israel Leoname Frohlich Klug serves as a Nutrition and Food Systems Programme Officer at the Food and Agriculture Organisation of the United Nations. With an agronomic engineering degree from the University of São Paulo (2005) and a Master's in International Relations from the University of Brasilia (2010), his graduation research focused on the role of public food procurement in supporting smallholder farmers in Brazil's poorest regions, quantitative territorial rural development analysis through national datasets, and international development strategies for food security and nutrition policy. With over 20 years of experience spanning continents and various research and development institutions, his work bridge technical approaches with policy and institutional analysis and international development strategies.

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1 Introduction

1.1 Background

Common Bean (Phaseolus vulgaris L.) is a staple food that majorly provides affordable human dietary protein and iron in the diets of over 300 million people globally and over 200 million people in Sub-Saharan Africa (SSA) (Rawal and Navarro, 2019; Ferreira et al., 2021; Semba et al., 2021; Didinger et al., 2022). The crop is grown in Kenya by over 3 million small scale farmers (Wanjala et al., 2019). Therefore, it plays an important role in rural livelihoods and in strengthening food security (e.g., food availability), especially for low-income households and vulnerable individuals benefiting from food assistance (Medendorp et al., 2022; Siddiq et al., 2022).

Despite its economic importance, pre-harvest and postharvest losses in common beans remain a major concern. Although there has been a lot of public debate on food loss reduction, especially on nutrient-dense crops like common beans, losses along the supply chain have remained a persistent problem, particularly in SSA (Stathers et al, 2020; Strecker et al., 2022). Food loss reduction can contribute to improved food security (e.g., food availability) and efficiency along the supply chains, potentially translating into economic benefits for the value chain actors (FAO et al., 2021). This issue is particularly pressing in SSA, where high food loss levels coincide with under-nutrition in a rapidly growing population (Nicastro and Carillo, 2021).

Governments in the SSA region have been implementing various strategies to address food insecurity and under-nutrition, including food assistance through school meals, which is estimated to reach 53 million children out of 175 million children enrolled in primary schools, showing an increased potential for coverage growth (WFP, 2022). Increasingly, school meal programs have adopted features to purchase foods nationally, locally or from smallholder farmers. The Kenya Home-Grown School Meal Program (HGSMP) was initiated by the government of Kenya in 2009 to strengthen the market linkages between farmers and schools (WFP, 2018). Currently, the Government of Kenya has committed to gradually scaling up the national school meals programme towards universal coverage by the year 2030. This commitment aligns with the global sustainable development goals (SDGs), particularly SDG2 and Kenya's Vision 2030, which focuses on ending hunger and promoting sustainable agriculture. The increasing demand for common beans as a staple crop in these programs underscores the need to improve food quality management and reduce food losses within the supply chain (Singh and Fernandes 2018). Therefore, farmers and traders must adopt these practices that enhance and preserve quality, hence reducing food losses along the bean supply chain.

Practices leading to food loss reduction at the farmer and trader levels have been linked by empirical evidence to increased knowledge, training and positive attitudes of value chain actors (Zanin et al., 2017). Furthermore, findings by Anitha et al. (2019) revealed that actors' low knowledge and negative attitudes affected their behaviours regarding adopting food loss reduction practices. The need for enhancing postharvest management systems by integrating considerations on knowledge, attitudes and practices towards reducing food loss at the producer and trader levels cannot be overemphasised (Despoudi, 2021; Totobesola et al., 2022). Additionally, reliable context-specific data on the magnitude of food loss and information on the causes of losses in crops such as beans are still quite scanty, posing a key challenge for food loss reduction interventions along supply chains (Schuster and Torrero, 2016; Sheahan and Barret, 2017).

Moreover, numerous literature in Kenya regarding food loss tends to concentrate on socio-demographic factors such as age, sex, household size, employment status, gross national income, technology and supply chain economics while ignoring the social/human factor of the supply chain actors relevant to` knowledge on food quality management, attitude towards the appropriate food quality management practices and actual practices adopted (Grasso et al., 2019; Tröger et al., 2020; Chrisendo et al., 2023). Additionally, knowledge, attitude and practices (henceforth KAP) on food loss may differ in different socio-demographic situations and, thus, could lead to varied outcomes and strategies towards food loss reduction (Kumar and Kalita, 2017).

Some studies on farmers' KAPs have been conducted in different value chains (Adesuyi et al., 2018; Anitha et al., 2019; Kamano et al., 2021; Dunn et al., 2023). However, there are limited studies on KAP on pre-harvest, postharvest and food quality management of beans even though appropriate practices underpinned by sound knowledge can lead to loss reduction. Only a few studies have assessed KAPs linked to food loss and waste among food truck vendors in Malaysia and Fish associations in Ethiopia (Tesfay and Teferi, 2017; Nawawi et al., 2022). Furthermore, several studies have focused on producer or consumer socio-economic characteristics when assessing the underlying causes of food loss in bean supply chains, such as age, gender, and years of education (Strecker et al., 2022).

However, information on how the KAPs of supply chain actors affect food loss remains limited. This study aims to contribute to bridging the existing knowledge gap by assessing the impact of KAP of farmers and traders participating in the HGSMP on food loss within the bean supply chain in Kajiado and Kitui counties, Eastern Kenya. By focusing on these specific regions, known for significant food losses in beans (Verma et al, 2019; Totobesola et al., 2022), this research seeks to uncover actionable insights. The findings are expected to highlight the relevance of food quality management knowledge, attitudes toward behaviour on adequate food quality management and actual practices along the supply chain in reducing food losses.

The assessed KAPs will also provide evidence on determinants of losses for producers and traders involved in supplying beans to the home-grown school feeding program, unveiling clear entry points for targeted interventions to reduce food loss. Ultimately, this could contribute to realising sustainable development goal number 2 (zero hunger), by ensuring more efficient food systems and improved nutritional outcomes in vulnerable communities.

2 Methodology

2.1 Theoretical framework

This paper is anchored on the theory of planned behaviour (TPB), a socio-psychological model designed to predict and further explain the drivers of an individual's behaviour and actions drawn from their attitudes (Ajzen, 1991). This theory has recently been applied to establish producer and consumer behaviour in different fields, such as the adoption of climate-smart agriculture, integrated pest management and conservation agriculture and biodiversity (Maleksaeidi and Keshavarz, 2019; Vaz et al., 2020; Atta-Aidoo et al., 2022).

Despite numerous studies using TPB to predict farmers' behaviour, several have failed to fully assess its core constructs: attitude toward the behaviour, perceived behavioural control, and subjective norms, as outlined in the theory's principles. As a result, much of the research on food loss and waste has focused on food handling and management practices rather than the behavioural intentions of actors along these value chains (Visschers et al., 2016). For a comprehensive measurement of behavioural intention, assessing at least attitude toward the behaviour and perceived behavioural control is recommended, as these constructs directly influence an individual's motivation and capacity to perform a specific behaviour within the value chain context.

In TPB, attitude toward the behaviour reflects a person's positive or negative evaluation of performing the behaviour, shaped by beliefs about its outcomes. Subjective norms refer to perceived social pressures to engage in the behaviour, influenced by important others' expectations and the motivation to comply. Perceived behavioural control relates to an individual's belief in their ability to perform the behaviour, determined by available resources and perceived obstacles.

This study mostly assessed knowledge, practices and the attitude toward the behaviour. Findings from past studies have found many interconnections amongst knowledge, attitudes and practices (e.g., Yang et al., 2022). For instance, regarding relationship between practices and knowledge, Hungerford and Volk (1990) suggested that having knowledge and skills on issues are a requirement for behaviour change. However, in this study assessing all TPB constructs proved to be resource intensive. Due to time and resource constraints, conducting a more comprehensive KAP study covering all TPB constructs was not feasible, particularly due to the lack of robust, pre-existing KAP questionnaires on food loss.

Additionally, such an endeavour would require a deeper understanding of the social, political, and economic characteristics of the value chain stakeholders and communities under study. This includes formulating specific questions to assess perceived social pressures from key stakeholders (subjective norms) and farmers' beliefs about their ability to control food loss outcomes (perceived behavioural control).

In the context of this study, knowledge is defined as a crucial understanding of science-based practices for food quality management, particularly postharvest techniques such as appropriate pod placement, harvesting containers, drying methods, and threshing operations. The level of knowledge assessed helped identify subject areas requiring education and information interventions.

Practice refers to observable or reported actions, highlighting how producers manage food quality throughout the value chain. Practices assessed included the use of suitable harvesting containers, tarpaulin mats during threshing and drying, hermetic bags for storage, and moisture metres to measure grain dryness. These actions pinpoint where improvements are needed to preserve food quality and reduce postharvest losses.

Within the TPB framework, attitude toward the behaviour relates to how producers evaluate and respond to adopting better postharvest management practices. This includes their willingness to acquire new knowledge and adjust practices based on newly gained information. For example, producers' attitudes toward adopting loss-reducing practices, such as covering pods at night during drying, depend on how beneficial they perceive the outcomes to be. Questions assessing attitudes explored whether producers would change their practices if given new information or training.

2.2 *Analytical model*

This study used the t-test, chi-square test and factor analysis to generate the key factors of KAPs and identify the key variables with the highest loading in relation to the actors' KAPs towards food loss reduction.

The multivariate regression model was used to assess the effect of KAPs of actors on the magnitude of food loss in bean value chains in Kajiado and Kitui counties. The multivariate regression model helps to define the association between dependent and independent variables. This study shows that the KAPs of farmers and traders in the two counties under study are different. Thus, the decision to use food loss reduction practices is multivariate, and there is inter-dependency between KAPs. The multivariate regression presupposes that the KAPs of actors affect the magnitude of beans lost along its value chain, and this is shown in the equation below:

$$y = \beta_0 + \beta_i K_1 + \beta_i K_2 + \ldots\ldots \beta_i K_n + \beta_2 A_1 + \beta_2 A_2 \ldots. + \beta_2 A_n \\ + \beta_3 P_1 + \beta_3 P_2 + \ldots. \beta_3 P_n + \varepsilon$$

where y = quantity of food lost in Kgs

β_0 intercept

β_1, β_2 & β_3 are regression coefficients to be estimated

K_n Knowledge variables that are included in the model

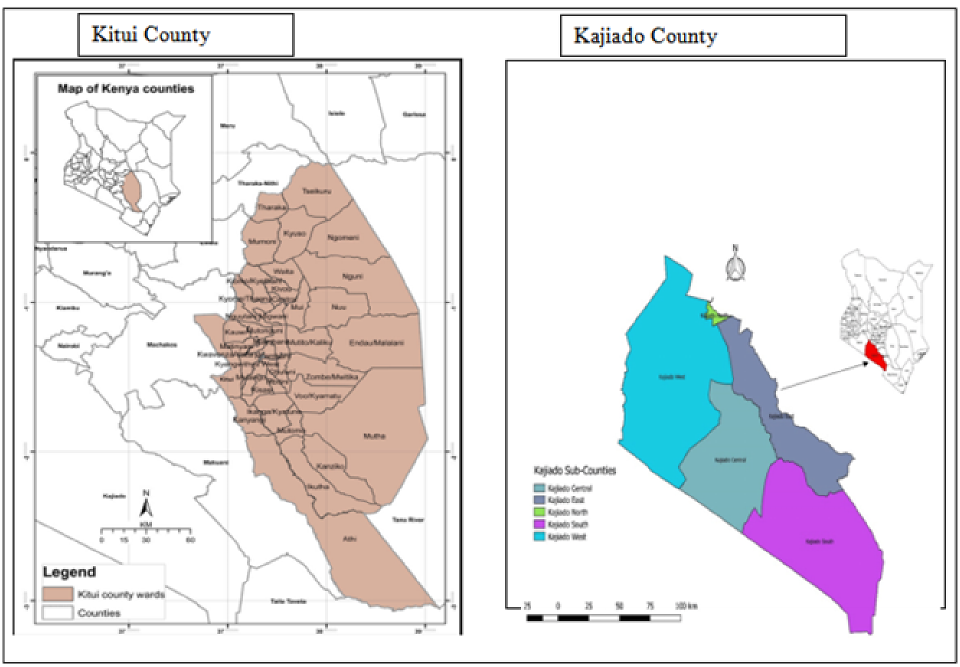
A_n Attitude variables included in the model

P_n Practice variables included in the model

ε error term.

The KAPs variables used in the model comprise the actor's KAP regarding the different aspects of bean handling from pre-harvest to postharvest stages of the value chain. The processes captured in relation to KAPS were pre-harvest factors, harvesting processes, drying, threshing, cleaning and sorting, storage, packaging, transportation and market distribution. For instance, knowledge of how the weather should be on the day of harvest, positive attitude towards appropriate harvesting methods and practicing drying of beans using Tarpaulin mats are some of the key variables to be considered and expected to reduce losses along the bean value chain.

Figure 1 Map showing Kitui and Kajiado counties (see online version for colours)



2.3 *Study area and sampling technique*

The survey was conducted in Kajiado and Kitui counties (Figure 1) in Eastern Kenya. The study was done in five sub-counties of Kajiado, Kenya, namely, Isinya, Kajiado Central, Kajiado West, Loitoktok and Mashuru. The county of Kajiado is located within Longitudes 360 5' and 370 5' E and between Latitudes 10 0' and 30 0' S, covering approximately 21900.9 km2 (CIDP-2023). Kitui, on the other hand, is comprised of nine sub-counties namely, Tseikuru, Katulani, Kyuso, Ikutha, Mumoni, Thagicu, Mutitu North, Mutitu and lower Yatta and is located within lies between latitudes 0°10 South and 3°0 South and longitudes 37°50 East and 39°0 East (CIDP-2023). These sub-counties were selected as part of the FAO food loss assessment project, taking into consideration locations in semi-arid and arid lands (ASALs) comprising a high number of schools under the HGSMP. Food insecurity in the two counties results in under-nutrition and malnutrition among children (Wainaina, 2019).

2.4 Data collection sampling procedure and analysis

A cross-sectional survey was conducted (Ishtiaq, 2019; Rainsford and Saunders, 2024), and data was obtained through in-depth face-to-face interviews of actors (farmers, traders and transporters) linked to HGSMP using structured questionnaires. This data was triangulated through observations made during the interviews. Quantitative data was collected on actors' KAP. The information and data captured pre-harvest factors, harvesting processes, drying, threshing, cleaning and sorting, storage, packaging, transportation and market distribution. The selection of respondents was done through a multi-stage sampling technique. The first stage involved purposively selecting Kitui and Kajiado Counties, given that they intensely participated in HGSMP. In the second stage, the number of schools under HGSMP from each sub-county was obtained. The third stage entailed attaining the list of traders supplying schools from the Kajiado and Kitui county education officers. The fourth stage involved identifying the farmers from whom the traders procured their beans through a simple random sampling procedure. A sample of 56 farmers and 40 traders in Kajiado County and 52 farmers and 52 traders in Kitui County were achieved through this process. Data was collected on actors` demographics, food loss magnitudes and KAPs-related issues. Data was collected using open data kit (ODK) and analysed using SPSS and STATA.

Descriptive statistics were used to tabulate data and describe socio-demographic statistics and estimated pre-harvest and postharvest losses that were experienced to help establish the effect of KAP on these magnitudes as an output for this paper. Chi-square analysis was also applied to identify KAP factors that trigger food loss in beans. Assessing KAP requires the generation of composite indices for the KAP score and also for its three scores, i.e., knowledge, attitude and practices. Composite indices were achieved using factor analysis to extract factors with the highest loading of above 0.7 using principal component analysis (PCA) for KAP following Krishna (2010). Questions on the level of agreement, on topics touching on pre-harvest factors, harvesting processes, drying, threshing, storage and transportation, were asked and used to measure the KAPs of the respondents on food loss. Knowledge and Practice were measured as categorical (yes/no/not sure), while Attitude was measured using a 5 – Likert scale statement. The statements were rated on a scale of 1 to 5, whereby 5= strongly disagree, 4 = disagree, 3 = neutral, 2 = agree and 1 = strongly agree.

Reliability and validity were checked using Cronbach's alpha formula, and a reliability index for knowledge was 0.79 and 0.78 at the farm and trader level, respectively. Consequently, attitude was 0.72 and 0.74; practice was 0.89 and 0.81 at the farm and trader levels, respectively; hence, the questionnaire was declared reliable.

Factor analysis was used, and based on the PCA, three components were extracted based on factors that had the highest loading, namely the KAPs that were finally fitted into the multiple linear regression model. Data accuracy tests were conducted to determine if the data collected were fit to undergo factor analysis or otherwise through the KMO, Barlett's Test of Sphericity and Varimax rotation method.

Data analysis and interpretation were then done based on the results of the statistical statements. Additionally, Pearson's r was applied to establish the relation between the farmers' and traders' socio-demographic variables and their KAPs.

3 Results and discussion

3.1 Farm level results and discussions

3.1.1 Socio-economic profile of the sampled households

Table 1 presents the socio-demographic profiles of the sampled households in Kajiado and Kitui counties. About 80 and 90% of the farmers in Kajiado and Kitui were male-headed households, which is expected given the African patriarchy. This could be explained by the cultural underpinning that regards all resources and assets as owned by the males. Previous literature indicated that women contribute to more than 80% of agricultural production, but males control decisions and, most especially, income from that enterprise (Delgado et al., 2021). Furthermore, the average age of the farmers in Kajiado and Kitui counties were 47 and 48 years, respectively. The bean farmers in Kajiado County were more educated and experienced in bean production compared to bean farmers in Kitui County. The majority of the respondents in the two counties were married with an average household size of 4 persons, which is in line with the population and housing census (KNBS, 2019).

Table 1 Social demographic characteristics of the sampled households in Kajiado and Kitui in the year, 2022

	Kajiado (N-56)	*Kitui (N = 52)*	*Comparison results*
Variable	Mean (SD)	Mean (SD)	Test statistic
Experience	13.79(0.369)	12.77(0.98)	2.01**
Land size	4.04 (0.57)	9.83 (0.92)	3.45***
Age	46.75(6.16)	48.81(5.47)	1.564
Education	9.36(0.18)	8.78(0.03)	1.789*
Household size	3.86 (0.17)	4.23 (1.21)	1.68
Average income from school supplies	100,296(3,456)	39,201 (2,001)	2.245**
Pre-harvest losses	1.99 (0.01)	9.46 (0.89)	2.67***
Harvest losses	2.06(0.03)	5.7(0.91)	2.34**
	Percentages (%)	(Percentages (%)	Chi-square statistic
Marital status (married)	86.37%	89.14%	3.24
Gender (male)	89.36%	90.42%	1.63
Group membership	61.54%	46.19%	8.34**

Source: Authors' survey 2022

The majority (62%) of the farmers in Kajiado belonged to farmer groups compared to farmers in Kitui Counties (46), respectively. Moreover, on average, bean farmers in Kitui County encountered higher pre-harvest losses and harvest losses of 9.5% and 5.7%

compared to Kitui County, which encountered 2.0 and 2.1 units, respectively. A possible explanation is that group membership positively influences the adoption of loss-reduction practices (Abdoulaye et al., (2016). This could be attributed to the significantly higher levels of pre-harvest, harvest losses and low group membership in Kitui. Additionally, the average income from the supply of beans to schools was significantly higher in Kajiado (Kshs 100,296) compared to Kitui Counties (Kshs39, 201).

3.1.2 Knowledge, attitude, and practices of the farmers

3.1.2.1 Knowledge, attitude, and practices for farmers in Kajiado

Table 2 presents the KMO test for sample adequacy to be 0.789, 0.68, and 0.71 which was above the recommended 0.5 threshold for factor analysis (Yong and Pearce, 2013). Bartlett's test of sphericity was significant at 1% ($p < 0.001$) for all items. Bartlett's test confirms if there is a significant difference between the correlation matrix and an identity matrix (Field, 2013, 2024). Based on the PCA, three components were extracted based on the factors with the greatest loading, namely the KAP. The extracted factors were found to explain about 21.85%, 23.67%, and 19.82% of the KAP total variances, respectively as indicated in Table 2.

The results are in relation to the knowledge of different activities at the farm that would be associated with food loss levels. The results revealed that knowledge of the weather at the time of harvest, type of harvest containers, pod separation, covering at night during drying, and cleaning of grains would impact the level of losses at the farm level. According to Canali et al. (2016), covering pods during dying helped reduce losses, as well as harvesting when the weather is favourable.

The second was on attitude and perception of the postharvest activities around the farm and if they would practice them. It was reported that the harvesting method, drying time, drying method, threshing method, turning of beans regularly and perception of removal of dirt while drying would impact the level of losses. The results are evidence of the importance of positive attitudes on activities undertaken by farmers to reduce losses. For instance, positive attitude towards sun drying of beans significantly reduced losses. A study by Anitha et al. (2019), concurs with the current study as it revealed that farmers` positive attitude toward production and postharvest handling practices is critical to loss reduction.

The third was on the practices undertaken by the farmers to minimise food loss in beans. The study revealed that weather during harvest, harvest containers, removal of dirt, immediate drying from the field, methods of separation of grains from pods, pods placement in tarpaulin mats during threshing, proper grain drying, and covering at night during the week of drying would affect the level of losses. According to Canali et al. (2016), proper harvesting and postharvest handling practices are paramount to loss reduction and are linked to the farmers' knowledge and positive attitude.

3.1.2.2 Knowledge, attitude, and practices for farmers in Kitui

Table 3 showed that the KMO test for sample adequacy was 0.692, 0.73, and 0.71 for Knowledge, Attitude, and Practices, respectively, which was above the recommended 0.5 threshold for factor analysis to be possible (Yong and Pearce, 2013). Bartlett's test of sphericity was significant $p < 0.001$) at 1%. Bartlett's test also affirms that the identity matrix was significantly different from the correlation matrix (Field, 2013). Based on the

PCA, the first component with a high Eigen value was used. The extracted factors with loading > 0.5 are as displayed in Table 3, and the components were found to explain approximately 23.98%, 20.46%, and 24.12% of the KAP total variances, respectively (Table 3).

Table 2 Principal component analysis for farmers in Kajiado in the year 2022

Description of variables	*Knowledge*	*Attitude*	*Practices*
How weather should be around harvest time	0.7494		
How to harvest to minimise contamination	0.7214		
How should beans be separated from the pods	0.6913		
During drying should beans be covered and stored	0.6673		
Beans should be cleaned and graded	0.6557		
If knew recommended harvesting methods, would you practice them?		0.7865	
If knew pods should be dried immediately, would you practice?		0.7446	
If knew recommended drying beans is sun drying, would you practice?		0.7340	
If knew before drying pods leaves should be removed, would you practice?		0.7287	
If knew right beans separation methods, would you practice any?		0.7145	
If knew beans should be turned regularly during drying, would you practice?		0.6977	
How is the weather on the days you harvest			0.7944
Type of container put harvested pods/produce			0.7640
Before drying the pods do you remove the leaves and immature pods			0.7559
Do you start drying? immediately after harvest			0.7512
How do you separate beans from pods			0.7469
Where place beans during threshing operation			0.7392
Do you properly dry beans			0.7243
During the week of drying the pods, at night, do you cover and store			0.7165
Variance explained in (%)	21.85	23.67	19.82
Measure of sampling adequacy (Kaiser – Meyer – Olkin)	0.789	0.679	0.7124
Bartlett's test of Sphericity or approximated Chi-square (66)	3451.7***	567.1***	673.3***
Significant levels (* = 10%; **= 5%; ***= 1%	1%	1%	1%

Source: Authors' survey 2022

Table 3 Principal component analysis for Farmers in Kitui in the year 2022

	Knowledge	*Attitude*	*Practices*
Container type should be used during harvesting	0.7618		
Pods should be aggregated and transported same day from field	0.7537		
Beans should be revolved/turned regularly during the days of drying	0.7426		
During the days of drying the beans, at night, should covered	0.7309		
If knew pods should be aggregated/transported same day, would you practice		0.8346	
If knew that during drying pods should be covered, would you practice		0.7921	
If knew right methods of grain separation, would you practice any of them		0.7503	
If knew the right pod placement during threshing, would you practice any		0.7377	
If knew that beans should be dried right after threshing, would you practice		0.7271	
Pods placement during harvest			0.8156
What type of container do you put the harvested pods/produce			0.7953
How do you dry the pods			0.7787
During the week of drying the pods, at night, do you cover and store			0.7634
Before drying pods do you remove leaves			0.7568
How do you separate grains from pods			0.7492
How do you dry the beans			0.7114
How do you know when the pulses are dry enough			0.6959
Variance explained%	23.98	20.46	24.12
Kaiser – Meyer – Olkin measure of sampling adequacy	0.692	0.732	0.7122
Bartlett's test of Sphericity; approximate chi-square (66)	1243***	934.2***	834.1***

Source: Authors' survey 2022

The findings of knowledge items revealed that containers used during harvest, pods aggregation, grain turning regularly, and grain covering during drying would have an impact on the level of losses in Kitui. This would mainly be due to allowing for proper air circulation during drying. In addition, knowledge affects individual decisions and the actions farmers would take, which explains why having knowledge of best practices is critical to loss reduction. On the other hand, the result revealed that farmers' attitudes towards pod aggregation, covering, methods of separating from pod, drying after threshing, and pod placement during threshing would affect the level of losses. Delay in threshing and drying increases losses as it exposes the crop to the atmosphere, making it susceptible to rodents and insect attacks. The results corroborate with Canali et al. (2016) in Europe, who found a positive association between pod placement during threshing and loss levels, indicating that proper pod placement during threshing significantly reduced loss levels.

The items on practice showed that pods placement in tarpaulin mats after harvest, the container used, how drying is done, covering, dirt removal, grain separation, grain drying, and ensuring pulses are dry would impact on the level of losses at the farm level. These results conform to the findings according to Anitha et al. (2019), who found a positive relationship between KAPs and the level of losses experienced at the farm level.

3.1.2.3 Effect of KAP among home-grown school meal programme producers

Table 4 presents the findings from the regression model. The results showed that the models for both counties fit with an R2 of 68.4% and 54.4% for Kajiado and Kitui, respectively. The F-statistics were fit indicating that the estimator fitted the data well. Individual marginal results indicated that the knowledge factors that influenced loss levels in Kajiado included weather conditions whereby, harvesting on a sunny day would reduce losses by 3.5%, grain covering allowed beans to dry naturally without much exposure, which helps reduce qualitative loss by 3.1%, and grain grading and cleaning which would reduce losses by 2.4%. Kajiado farmers were knowledgeable about harvesting under favourable weather and removing dirt through cleaning and practiced them as well, which reduced losses by 8.1% and 7.3%, respectively. This could be attributed to the farmers harvesting when the weather is favourable. It could be explained by their experience acquired over the years and traditional knowledge in bean production. The results, especially on the weather, were significant since Kajiado was reported to be more humid than Kitui. This means that farmers needed to be aware of the weather to reduce losses caused by rotting and moulds. Conversely, in Kitui, the farmers had knowledge of the requirement of turning beans regularly during drying but had a negative attitude towards it and instead placed pods directly on the soil, which often increased losses.

The multivariate regression model results revealed that actors' knowledge, positive attitudes and practices are crucial to the reduction of postharvest losses. Knowledge of grain turning and covering while drying by farmers reduced losses by 15.3% and 10.6%, respectively, in Kitui. This could be because turning grains during drying ensures the moisture content is reduced to safe storage level and covering reduces grains` rotting due to humidity build-up at night if not covered. Covering was necessary as the beans would be allowed to dry naturally without much exposure which helps reduce quality loss, while turning would reduce losses as it helps in aeration, and uniform drying of the beans. Furthermore, knowledge of the use of appropriate containers ensured that the farmers carry their pods properly, which would reduce losses due to spillage by 2.3% in Kitui.

While Kitui farmers practiced appropriate drying methods of pods using sun drying and pod placement in tarpaulin mats, which reduced grain breakage, rotting and spillage, which explains the reduction of losses by 0.12% and 2.3%, respectively, they did not use the tarpaulin mats during threshing which still led to losses due to spillage. Kajiado, on the other, practiced immediate drying after harvest and used tarpaulin mats during threshing, which reduced losses by 0.12% and 14.5%, respectively. These findings explain why they still experienced losses during the drying of pods as they dried directly on soil, which caused spillages. Therefore, both Kajiado and Kitui farmers need to understand that for postharvest losses to be minimised during drying, proper handling is critical immediately after harvesting, and not only at certain stages of the crop's value chain.

Table 4 Multiple regression at farm-level in Kajiado and Kitui

Variables	*(1)* *Kajiado*	*(2)* *Kitui*
Weather should – K	–0.0346**	(0.015)
Harvest container – K	–0.012	–0.023**
	(0.023)	(0.0107)
Pods separation – K	0.113	(0.123)
Pods transp. same day – K	-	–0.001
		(0.002)
Should cover while drying – K	–0.0309***	–0.106**
	(0.005)	(0.045)
Should cleaned/grade – K	–0.0235**	
	(0.0124)	-
Grain turning – K	-	–0.153**
		(0.077)
Attitude harvesting method – A	–0.05171**	–0.047***
	(0.0256)	(0.013)
Pods aggregation – A	-	–0.134**
		(0.067)
Pods immediate drying – A	–0.0239*	–0.049***
	(0.0132)	(0.0123)
Pods drying methods – A	–0.04794***	–0.0460***
	(0.01234)	(0.0123)
Leaves removal – A	–0.0217***	
	(0.0027)	-
Grain separation methods – A	–0.0100***	
	(0.0021)	-
Pods turning – A	–0.0675	0.0245
	0.0432	(0.0514)
Pods covering – A	-	–0.112*
		(0.060)
Weather during harvest – P	–0.08075**	-
	(0.03185)	
Pods placement in tarpaulin mats – P	-	–0.023***
		(0.0056)

Note: Standard errors in parentheses, *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Source: Authors' survey 2022

Table 4 Multiple regression at farm-level in Kajiado and Kitui (continued)

Variables	*(1)*	*(2)*
	Kajiado	*Kitui*
Container put harvest – P	–0.03493	–0.0180
	(0.02383)	(0.0498)
Dirt removal before drying – P	–0.07356**	–0.0563
	(0.03203)	(0.0485)
Pods drying method – P	-	–0.0012***
		(0.00023)
Immediate drying after harvest – P	–0.0012***	-
	(0.0002)	
Grain separation from pod – P	–0.123	–0.034
	(0.0956)	(0.056)
Grain placement during threshing – P	–0.145***	
	(0.0333)	-
Proper grain drying – P	–0.091***	–0.0023***
	(0.028)	(0.00056)
Grain covering – P	–0.04763	–0.0509
	(0.03914)	(0.0528)
Know pulses are dry – P	-	–0.0034***
		(0.001)
Constant	–0.0187	0.216
	(0.0215)	(0.432)
Observations	55	49
F-statistics	19.45***	20.33***
R-squared	0.684	0.547

Note: Standard errors in parentheses, *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Source: Authors' survey 2022

Kajiado and Kitui farmers practiced proper grain drying to ensure moisture content was at the acceptable limit, hence reducing losses by 9.1% and 0.23%. This can further be explained by their positive attitude towards the pod drying method before threshing, which would reduce losses by 4.8% and 4.6%, respectively. Additionally, the farmers in both counties had a positive attitude towards pods` immediate drying after harvest, which would reduce losses by 2.3% and 4.9%, respectively. According to Canali et al. (2016), attitude determines actions, which are evidence that having a positive attitude towards post-harvest management would result in loss reduction by ensuring that beans are properly dried from harvest or storage since inadequate drying could result in mould growth, which translates to increased food loss. For example, in this study, a positive attitude towards pod aggregation and transportation the same day for drying would significantly reduce loss levels by 13.4%.

3.2 Trader's level results and discussions

3.2.1 Demographic profile of the traders

The results presented in Table 5 indicated that traders in both Counties had an average of 10 years of trading experience with an average of 4 persons per household. On average, traders in Kitui County were 51 years compared to Kajiado County, who had 49 years respectively. This implies that Kitui County had slightly older traders than Kajiado County. The traders from Kajiado County received an average income of Kshs. 212; 620 from the annual sale of beans to schools, which was slightly higher than Kitui County, which received an average income of Kshs 210,627. Furthermore, the majority of the traders were male headed, with Kajiado County having more traders belonging to groups (37%) compared to Kitui County (26%) respectively. The majority of the traders in the two counties were educated; however, traders in Kitui County experienced more storage losses (6.6%) compared to Kajiado County (1.6 &), respectively.

Table 5 Summary statistics of traders

Characteristic	*Kajiado (N = 40)*	*Kitui (N = 52)*	*Test-statistics*
Household size	4.46 (0.03)	4.45 (1.86)	1.28
Experience	10.34 (1.245)	9.67 (1.103)	1.567
Age	48.92 (3.45)	50.83 (1.67)	1.245
Average income from school supplies	214,612 (2,234)	210,627(1,356)	0.847
storage losses	1.6 (0.001)	6.62 (0.967)	2.786***
Education	10.21(1.03)	9.786 (0.678)	2.103**
	%	%	Chi-statistic
Gender (male)	70.21%	68.92%	3.243*
Group membership	36.84%	25.81%	4.982**

Source: Authors' survey 2022

3.2.2 Knowledge, attitude and practices of the traders

3.2.2.1 Knowledge, attitude and practices of the traders in Kajiado County

The results, as depicted in Table 6, show that Kaiser-Meyer-Olkin (KMO) test for sample adequacy was 0.812, 0.78, and 0.75 for Knowledge, Attitude, and Practices items, respectively which was above the recommended 0.5 for factor analysis to be possible (Yong and Pearce, 2013). Bartlett's test of sphericity was significant ($p < 0.001$) at 1%. Bartlett's test confirms whether the correlation matrix is significantly different from an identity matrix (Field, 2013). Based on the PCA and use of one component results based on the highest Eigen value the extracted factors with a loading above 0.5 are as displayed in Table 6. All items for Knowledge, Attitude, and Practices for this component were able to explain approximately 21.34%, 24.45%, and 19.32% of the total variance for knowledge, attitude, and practices respectively.

Table 6 Principal component analysis for traders in Kajiado

Description	*Knowledge*	*Attitude*	*Practice*
How should proper grain drying be done before storage	0.7854		
What should be the good storage container	0.7612		
Should grain be covered while in store	0.7185		
Should grains be cleaned and graded before storage	0.7063		
If you knew proper grain drying should be done, would you practice		0.8341	
If you knew you should use right storage containers, would you use		0.8067	
If you knew grains should be covered while in store, would you cover		0.7843	
If you knew grains should be cleaned before storage, would you clean		0.7613	
Do you dry your grains before storage			0.7389
How do you know grains are dry enough			0.7125
Do you use storage containers to store grains			0.7098
Do you cover your grains in the store			0.6943
Do you clean your grains before storage			0.6648
Layout of stacks			0.6513
Do you treat produce during storage			0.6421
Variance explained%	21.34	24.45	19.32
Kaiser – Meyer – Olkin measure of sampling Adequacy	0.812	0.7822	0.752
Bartlett's test of sphericity; approximate chi-square (12)	657***	539.3***	679.29***

Source: Authors' survey 2022

The knowledge results indicated that in Kajiado, knowledge of proper drying before storage, storage containers used, covering in-store, and cleaning would influence the level of losses traders would incur at storage. The results are supported by the work of Anitha et al. (2019), who showed that proper storage knowledge is a precursor to better loss management.

The attitude results indicated that attitude towards proper drying, container use, covering, and cleaning would affect the level of losses incurred at the stores. Attitude is critical when it comes to making decisions. A study by Anitha et al. (2019) showed that when actors have the right knowledge and attitude towards interventions and practices for loss reduction, they are more likely to practice them. Consequently, the level of losses is reduced significantly.

Regarding practice, the results revealed that traders who ensured their beans were dried properly, dry enough, used storage containers, covered their grains, cleaned their grains, layout piles of bags properly, and treated produce would reduce the level of losses. According to Delgado et al. (2021), storage losses are a factor of knowledge, practices, and attitudes by the actors undertaking storage activities. Thus, good practices would help reduce losses.

3.2.2.2 Knowledge, attitude and practices of the traders in Kitui County

Table 7 presented the findings of the KMO test for sample adequacy, which was 0.692, 0.68 and 0.73 for KAP, respectively, which was above the recommended 0.5 threshold for factor analysis to be possible (Yong and Pearce, 2013). Bartlett's test of sphericity was significant ($p < 0.001$) at 1%. This test confirmed that the correlation matrix is significantly different from an identity matrix (Field, 2013). The three components of the PCA were extracted considering the factors with the highest loading, namely the knowledge, attitude, and practices. The extracted factors, as displayed on Table 7, explained approximately 19.41%, 18.36%, and 20.68% of the respective total variances.

Table 7 Principal component analysis for traders in Kitui

Description	*Knowledge*	*Attitude*	*Practice*
How should proper grain drying be done before storage	0.6965		
What should be the good storage container	0.6643		
Should grain be covered while in store	0.6534		
Should grains be cleaned and graded before storage	0.6167		
If knew grain drying should be done before storage, would practice		0.7431	
If knew right storage containers to use, would you use them		0.7289	
If knew grains should be covered while in store, would you cover		0.7045	
If knew grains should be cleaned before storage, would you clean		0.6842	
Do you dry your grains before storage			0.6549
Do you use storage containers to store grains			0.6397
Do you cover your grains in the store			0.6278
Do you clean your grains before storage			0.6114
Layout of stacks			0.6071
Do you treat produce during storage			0.6012
Variance explained%	19.41	18.36	20.68
Kaiser – Meyer – Olkin measure of sampling adequacy	0.692	0.689	0.734
Bartlett's test of sphericity; approximate chi-square (12)	431***	398.2***	562.1***

Source: Authors' survey 2022

Knowledge factors resulting from the knowledge aspect indicated that in Kitui, knowledge on proper drying before storage, storage containers used, covering in store, and cleaning would influence the level of losses traders would incur at the storage. Having knowledge is critical to loss reduction as it influences decisions by the actors. Attitude factors indicated that attitude towards proper drying, container use, covering, and cleaning would affect the level of losses incurred at the stores. Regarding practice factors, the results revealed that traders who ensured their beans are dried properly, used storage containers, covered their grains, cleaned their grains, proper layout of stacks, and grain treatment would impact on the level of losses they would incur. The results align with those of Delgado et al. (2021), who noted that storage losses as a factor of knowledge, practices, and attitudes by the actors undertaking activities that help them reduce losses.

3.2.2.3 Effect of KAP on food loss among home-grown school meal programme traders

The KAPs of traders are different in both study areas. The results of the factors influencing the loss levels at storage are displayed in Table 8 and indicate that traders' experience is a key determinant of the level of losses. At the trader level, the major factor in knowledge was whether to dry grains before storage, which reduced losses by 29.9% and 30.3% in Kajiado and Kitui, respectively. Knowledge of grain drying is the first step to actual grain drying, which is critical to ensuring that the actors make the right decisions towards loss reduction. Further knowledge of storage containers would reduce losses by 16.8% and 27% in Kajiado and Kitui, respectively. Storing grains in appropriate containers is important to avoid pests, diseases, and moulds that cause quantitative and qualitative losses. Similarly, the traders had a positive attitude towards the storage containers used, which would reduce losses by 3.7% and 1.6% in Kajiado and Kitui, respectively. The appropriate storage containers led to less exposure of the produce to pests and diseases, which would explain the loss reduction. Therefore, the knowledge and positive attitude influences the traders' decisions, which would therefore explain the use of appropriate storage containers in both counties, which reduced losses by 2.9% and 3.4% in Kajiado and Kitui counties, respectively.

Table 8 Multiple regression at trading level in Kajiado and Kitui

Variables	*(1)*	*(2)*
	Loss stored produce Kajiado	*Loss stored produce Kitui*
Grain drying before store – K	–0.299***	–0.303***
	(0.0343)	(0.0505)
Good storage container – K	–0.168***	–0.270***
	(0.0367)	(0.0456)
Grain covering in store – K	–0.0427*	–0.0301
	(0.0227)	(0.0407)
Clean and grading–K	0.0519*	0.0338**
	(0.0307)	(0.0146)
Proper grain drying – A	–0.0659*	–0.173***
	(0.0391)	(0.0556)
Storage container – A	–0.0365***	–0.0155***
	(0.0118)	(0.00212)
Grains covering – A	–0.0394***	–0.0638***
	(0.0121)	(0.0202)
Grain cleaning – A	–0.0104	–0.0214
	(0.0263)	(0.0373)

Note: Standard errors in parentheses, *** $p < 0.01$, ** $p < 0.05$, * $p < 0$.

Source: Authors' survey 2022

Table 8 Multiple regression at trading level in Kajiado and Kitui (continued)

Variables	*(1)*	*(2)*
	Loss stored produce Kajiado	*Loss stored produce Kitui*
Grain drying – P	–0.0231***	–0.107
	(0.00524)	(0.0707)
Identifying dry grain – P	–0.001**	–
	(0.0005)	
Storage containers – P	–0.0288**	–0.0341***
	(0.0055)	(0.0074)
Grain cover – P	–0.0154	–0.0622*
	(0.0241)	(0.0378)
Grain clean – P	–0.0150	–0.0453
	(0.0247)	(0.0444)
Stack layout – P	–0.023***	–0.012**
	(0.0079)	(0.0056)
Produce treatment – P	–0.0043***	–0.011**
	(0.0014)	(0.0047)
Constant	–0.174***	–0.786***
	(0.033)	(0.0579)
Observations	40	52
R–squared	0.632	0.665

Note: Standard errors in parentheses, *** $p < 0.01$, ** $p < 0.05$, * $p < 0$.

Source: Authors' survey 2022

Additionally, a positive attitude towards covering grains at the store among the traders would protect the beans from humidity and maintain the temperature of the dried grains, and this would reduce losses by 3.9% and 6.4% in Kajiado and Kitui, respectively. However, they did not practice it, hence the losses experienced during storage. Covering ensures the beans are in good condition with little exposure to dis-colouration, and attack by pests, Laying of stacks and grain treatment were significant factors in both counties, where proper stack layout in stores would help reduce losses by 2.3% and 1.2%, while grain treatment would help reduce losses by 0.4% and 1.1% in Kajiado and Kitui, respectively. These practices were deemed necessary as they would help reduce pest and disease attacks during storage at the trader and even after supplying the beans to the schools.

4 Conclusions and recommendations

This study aimed to assess the determinants of food losses for producers and traders involved in supplying beans to the home-grown school feeding program in two counties in Kenya. The results revealed that KAPs undertaken by farmers and traders influenced the level of losses at the farm and trader levels in both counties. The multivariate regression model results revealed that actors' knowledge, positive attitudes and practices are crucial to the reduction of postharvest losses. Knowledge of grain turning and covering at night while drying reduced losses by 15.3% and 10.6%, respectively, in Kitui. For Kajiado, knowledge of weather conditions during harvesting and grain covering during drying reduced losses by 3.5% and 3.1%, respectively.

Additionally, a positive attitude towards drying of pods before storage would reduce losses by 2.4% and 4.9% in Kajiado and Kitui, respectively. At the trader level, the major factor in knowledge was whether to dry beans before storage, which reduced losses by 29.9% and 30.3% in Kajiado and Kitui, respectively. Similarly, the use of appropriate storage containers reduced losses by 2.9% and 3.4%, whereas covering beans at the store reduced losses by 3.9% and 6.4% in Kajiado and Kitui, respectively. In conclusion, farmers' and traders' KAPs in Kajiado and Kitui are specific and distinct.

Therefore, a uniform approach to food loss reduction may not be favoured as it may not be effective. The study recommends tailored capacity-development efforts and incentives that encourage behavioural shifts and adoption of appropriate postharvest practices and technologies as vital to addressing food loss effectively. Based on the findings and considering the results of the regression model on the different knowledge, positive attitudes and practices, a significant reduction in losses in the beans supply chain can be achieved through conducting targeted training of the supply chain actors. At the farm level, the government and partner agencies should invest in the capacity building of farmers on recommended harvesting, handling, and drying practices. On the other hand, traders need training on recommended storage containers and produce handling at the stores, including treatment.

Disclaimer

The views expressed in this publication are those of the author(s) and do not necessarily reflect the views or policies of the Food and Agriculture Organisation of the United Nations.

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Declarations

All authors declare that they have no conflicts of interest.

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