

# THE ROLE OF PRODUCER ORGANIZATIONS IN PROMOTING FARM-LEVEL IMPLEMENTATION OF MILK HYGIENE STRATEGIES AMONG DAIRY FARMERS IN KENYA

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**Abstract.** Food safety remains a critical concern globally, particularly in the dairy industry of developing countries, where quality standards are often insufficient. This is attributed to low milk production, poor milk handling practices and domination of the sub-sector by informal and unregulated milk marketing channels. An improvement in the quality of the milk produced is necessary to alleviate concerns about food safety and health. This study employed a multi-stage sampling technique to select a sample of 282 dairy farmers in Meru County, Kenya. Relevant data was collected on identified variables using a structured questionnaire, and a Poisson Regression Model was used to determine the role of producer organizations in promoting farm-level implementation of milk hygiene strategies. The results indicate that producer organization membership has a positive and significant influence on the extent of farm-level implementation of milk hygiene strategies. The findings of this study provide relevant information for policy formulation aimed at improving the performance of producer organizations and the growth of the dairy industry. Therefore, dairy farmers experiencing technical difficulties should be identified and incentivized to actively participate in producer organizations, so as to increase their access to relevant extension services such as training in milk hygiene strategies, which would enhance their implementation of milk hygiene strategies at the farm-level.

**Keywords:** producer organizations; milk hygiene strategies; dairy; milk quality; safety standards; Africa

## INTRODUCTION

Food safety is becoming an important issue globally, and the dairy industry in most developing countries is reported to lag behind in terms of quality standards. A study by Ledo et al. (2019) observes that the milk value chain in Africa is struggling to improve and enforce milk quality and safety standards. Milk is the most

perishable farm produce because of its nutritional balance, which also means that dairy products are more likely to be contaminated by microorganisms. Microbial growth can affect milk quality and safety, making it unsuitable for human consumption and processing (Gashaw and Gebrehiwot, 2018; Ndungi et al., 2021).

Processing capacity is hampered by slowing milk production. Milk production in the country is dominated

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by small-scale farmers who experience myriad constraints, resulting in low marketable volumes. Furthermore, the competitiveness of Kenya's dairy sector is hampered by non-compliance with quality and safety standards throughout the value chain (Bebe et al., 2018). Milk contamination mainly occurs at farm level and during marketing because of the informal nature of collection and distribution. There are several factors that contribute to poor milk quality and safety concerns in the least developed countries. At farm level, Orregård (2013) reported that farmers in Kiambu exceeded the two-hour limit for storing and transporting milk after milking, raising an important non-compliance issue. Unhygienic milk handling practices are another important cause of poor milk quality. Poor personal hygiene (Onyango et al., 2021), poor udder hygiene, poor workspace hygiene, inadequate milk handling equipment, and poor storage (Phiri et al., 2021) are identified causes of poor milk quality at farm level.

Low compliance with quality and safety standards is attributed to poor knowledge of milk handling by smallholder dairy producers and milk dealers. A rapid literature review by Brown et al. (2019) indicated that poor milk quality was due to lack of or partial awareness of quality and safety regulations among farmers and dealers. A study by Orwa et al. (2017) focused on farm level transportation and bulk milk handling activities in Nakuru. The results revealed that antimicrobial contamination was more than 43% above the recommended levels, which increased as the milk moved along the value chain.

Collective action has emerged as a pathway for improving milk quality and safety. Nonetheless, despite the recognition of the role of producer organizations in enhancing milk quality, the available literature focuses on post-milking and milk collection hygiene practices. For instance, a study by Nyokabi et al. (2021) revealed that the majority of farmers surveyed adopted animal health measures and hygienic measures such as hand washing and udder cleaning during milking. However, the use of plastic containers, the use of unsterilized water, the lack of teat dipping, and the generally unhygienic milking environment compromised milk quality and safety, a strong indication that the health of consumers is at high risk. Nyokabi et al. (2021) focused on milk quality in dairy farming systems and associated value chains in Kenya but did not focus on farm-level implementation. The demand for high quality milk still

outstrips its supply. This is attributed to low milk production, poor milk handling practices and domination of the sub-sector by informal and unregulated milk marketing channels. An improvement in the quality of the milk produced is necessary to alleviate concerns about food safety and health. Furthermore, the role of producer organizations in enhancing milk quality at farm-level has not been adequately exploited.

Therefore, this study builds on the work of Nyokabi et al. (2021) by investigating the role of producer organizations in the farm-level implementation of milk hygiene strategies among dairy farmers in South Imenti sub-county, Meru County, Kenya. Increased production of safe and high-quality milk is vital for the sustainability and development of the dairy sub-sector. It facilitates the exploitation of opportunities in the global market and ensures that consumer demand for safe and high-quality milk and milk products is efficiently and effectively met. This study contributes to a body of knowledge around milk production with an emphasis on the analysis of safety. Furthermore, the findings of this study provide relevant information for policy formulation aimed at improving the performance of producer organizations and the growth of the dairy industry in the area under study, the country, the continent and the world at large.

## MATERIAL AND METHODS

### Study area and sample design

This study was conducted in South Imenti sub-county, Meru County because it is among the most significant milk-producing regions in Kenya (Rademaker et al., 2016) and has a relatively high degree of both individual and collective milk marketing systems. Moreover, it experiences high demand for milk from both local traders and the nearby urban population. The data for this article was collected by the Local and International Business Collaboration for Productivity and Quality Improvement in Dairy chains in Southeast Asia and East Africa (LIQUID) project in Kenya between October and December 2018. The LIQUID project was supported by Wageningen University, Netherlands in collaboration with Egerton University and other local partners. During the process of data collection, cross-sectional data from dairy farmers was collected in a survey that was conducted in South Imenti sub-county, Meru County using a structured questionnaire

(Mwambi et al., 2020). To accommodate a comparative analysis of sub-groups such as an evaluation of producer organization (PO) participants with non-participants, an adjustment in the sample size was necessary. A minimum of 100 elements was needed for each major sub-group in the sample, and for each minor sub-group, a sample of 20 to 50 elements was necessary. In addition, the sample size was increased by 20% to compensate for persons whom the researcher was unable to contact and for those who did not respond. PO members were considered the major sub-groups and non-members as minor sub-groups. (Israel, 1992; Mwambi et al., 2020).

### Variable construction

Farmers were asked to rate their perceptions of the extent of farm-level implementation of milk hygiene strategies as a percentage. Farmers with a zero response on the 0–100 scale were considered not to be implementing milk hygiene strategies. 26 milk hygiene strategies were rated by the farmers. New variables were constructed from the scale, with farmers selecting 0 being considered not to have used the practice, while a value of 1 was taken to imply that at least they had used it. The second variable was constructed as a summation of the scores for the 26 practices with binary responses of 1 and 0 for each. The resultant variable was a count variable with maximum value of 26 if the farmer implemented all the milk hygiene strategies. The new count variable measured the extent of farm-level implementation of milk hygiene strategies.

### Analytical framework

The study used both descriptive and inferential statistics to analyze milk hygiene data.

#### *Descriptive statistics*

The processing of descriptive statistics involved cross-tabulation of variables of interest, including milk hygiene practices, training in milk hygiene, and participation in inspections to check compliance with milk hygiene strategies. Frequency distributions and percentages were tabulated and also visualized using bar plots. Three inferential statistical tests were deployed: the independent samples t-test, the chi-square test of independence, and the Poisson Regression Model. The independent samples t-test tested the significance of differences in the distribution of the total count of

milk hygiene strategies, chi-square test of independence whether or not there existed significant differences in the distribution of farmers' responses with respect to training, the providers of training, the use of each milk practice, and inspection for adherence to milk hygiene standards.

#### *Inferential statistics using econometric model*

The study involved determining the influence of producer organizations on the farm-level implementation of milk hygiene strategies. As previously stated, a new variable was constructed from existing data as a count of all the practices implemented by each farmer. The Poisson Regression Model (PRM) was adopted to estimate the influence of producer organization on the implementation of milk hygiene strategies by dairy farmers. The model was appropriate because the outcome variable is count data and consists of non-negative integers (Lukman et al., 2021). The PRM was estimated using maximum likelihood estimation (MLE) and its probability structural form was specified as follows:

$$f(y_i) = \frac{\exp(-\mu_i)\mu_i^{y_i}}{y_i!}, y_i = 0, 1, 2, \dots \quad (i)$$

where:  $y_i$  is the non-negative integer outcome variable, the number of milk hygiene strategies implemented by the farmer, and  $p > 0$ . The model assumes that the mean and variance of the count variable are the same. Thus, following a study by Myers et al. (2012), a function,  $g$ , which relates the mean of the outcome variable to a set of predictor variables can be written as:

$$g(\mu_i) = \eta_i = \beta_0 + \beta_1 X_1 + \dots + \beta_p X_p + \varepsilon_i = X' \beta, \quad (ii)$$

where:  $g(.)$  = the monotone differential link function,  $\beta$  = the parameters of coefficients to be estimated,  $X_1 - X_p$  = the predictor variables,  $\varepsilon$  = the stochastic error term. The function in equation (ii) is a link function such that  $g(\mu_i) = \ln(\mu_i) = \exp(X' \beta)$ , which is a log function that ensures the fitted values for the outcome variables are positive (Lukman et al., 2021). In this study, membership of producer organizations, socio-demographic, economic, and institutional variables were expected to influence the outcome variable – number of milk hygiene strategies implemented by farmers. Table 1 below shows the description of variables that were used in the Poisson regression.

**Table 1.** Description of variables used in the study

| Variable              | Description                          | Measurement   | Expected sign |
|-----------------------|--------------------------------------|---------------|---------------|
| Dependent variable    |                                      |               |               |
| MHI                   | Milk hygiene index                   | Index (0–100) |               |
| Independent variables |                                      |               |               |
| PO                    | Membership to producer organization  | Binary        | +             |
| AGE                   | Age of household head                | Continuous    | ±             |
| EDUC                  | Number of years of formal schooling  | Continuous    | +             |
| GND                   | Gender of household head             | Binary        | ±             |
| HHSZ                  | Composition of the household         | Continuous    | ±             |
| MRTS                  | Marital status                       | Binary        | ±             |
| FMSZ                  | Size of the farm allocated to fodder | Continuous    | +             |
| COWN                  | Cow ownership                        | Categorical   | ±             |
| CRT                   | Access to credit                     | Likert        | +             |
| TRN                   | Formal training on MHS               | Binary        | +             |
| INSP                  | Inspection on MHS                    | Binary        | +             |
| DIST                  | Kilometres to the nearest town       | Continuous    | -             |

Source: own elaboration.

## RESULTS

This section presents the descriptive and Poisson regression results from the analysis.

### Descriptive results

#### *Training in milk hygiene strategies*

The results on whether respondents had received training in milk hygiene strategies are presented in Table 2. Group membership was significantly ( $p < 0.01$ ) associated with the receipt of formal training on milk hygiene strategies by farmers. About 80% of producer organization members had received the training compared to 37% of non-members. The percentage of producers who had received training from producer organizations was significantly ( $p < 0.1$ ) higher for members (81%) than for non-members (68%). In contrast, significantly more non-members (30%) than members (11%) had received milk hygiene training from government extension officers. Other sources of trainings were NGOs, input dealers, milk processors and the media. There was no significant difference between the number of members

and non-members who had received training from these sources. Nonetheless, despite 147 (81%) producer organization members having received training in milk hygiene strategies from their respective cooperatives, a paltry 29% indicated that their farms had been inspected by producer organization staff.

#### *Farm-level implementation of milk hygiene strategies*

Farm-level results on the implementation of milk hygiene strategies are presented in Table 3. The percentage of farmers who ensured that sick milkers did not milk was higher among members (77.13%) than non-members (63.70%) of producer organizations. In addition, there was a marginally significant difference ( $p < 0.1$ ) between the percentages of members (84.10%) and non-members (79.52%) who ensured milked cows were free from diseases. Nonetheless, no significant differences between members and non-members were reported in the farm-level implementation of the other animal and personal health hygiene measures.

Furthermore, two personal hygiene practices were reported by farmers: washing hands with soap before

**Table 2.** Summary results of percentages of farmers who reported having received milk hygiene training over a three-year period

| Description of variables       | Pooled<br>( <i>N</i> = 282) | Non-members<br>( <i>n</i> = 100) | Members<br>( <i>n</i> = 182) | <i>p</i> -value |
|--------------------------------|-----------------------------|----------------------------------|------------------------------|-----------------|
| Milk hygiene training (%)      | 64.54                       | 37.00                            | 79.67                        | 0.000*          |
| Source of training (%)         |                             |                                  |                              |                 |
| Producer organization          | 78.02                       | 67.57                            | 80.69                        | 0.085*          |
| Government extension officer   | 14.84                       | 29.73                            | 11.03                        | 0.004***        |
| NGO                            | 8.79                        | 2.70                             | 10.34                        | 0.143           |
| Input dealer                   | 2.20                        | 5.41                             | 1.38                         | 0.136           |
| Milk processor                 | 15.93                       | 13.51                            | 16.55                        | 0.652           |
| Media                          | 4.40                        | 2.70                             | 4.83                         | 0.574           |
| On-farm hygiene inspection (%) | 21.99                       | 9.00                             | 29.12                        | 0.000***        |

\*, \*\*\* represent significance at the 10% and 1% levels respectively.

Source: research findings, 2023.

initiating milking and drying the hands with a clean, dry towel or cloth. While no significant differences were reported for drying the hands with a clean, dry towel or cloth, there was a marginally significant difference ( $p < 0.1$ ) between the percentages of members (84.10%) and non-members (79.52%) who ensured milkers washed their hands with soap before initiating milking. A further practice used was an udder hygiene strategy whereby teats were dipped in or sprayed with antiseptic solution after milking. In general, the implementation of udder hygiene practices was significantly higher among members compared to non-members.

There were significant differences in the implementation of the three milking equipment hygiene practices. The practices that significantly differed were cleaning and disinfecting the cloth or strainer after use and using milking equipment made from approved material, with significantly more producer organization members than non-members reporting that they implemented these practices at farm-level. There was a marginally significant difference ( $p < 0.1$ ) between the percentages of members (92.65%) and non-members (88.38%) who reported that milking equipment was put upside-down to dry after cleaning and sterilization. However, there were no significant differences in the cleaning and sterilization of milking equipment immediately after use. While the extent of farm-level implementation of two

storage hygiene practices – the storage of milk in clean, sealed containers and transportation within two hours of milking – among members and non-members was not significantly different, there were significantly higher perceived levels of hygienic storage practices in terms of the immediate filtering of milk after cooling by up to 10 degrees when stored for more than 2 hours among members than non-members. Nonetheless, workspace hygiene practices – concrete floor of milking parlor and thorough cleaning of milking area – were more commonly implemented by members than by non-members.

## Econometric results

### *Model diagnostics*

The study used a Poisson Regression Model to determine the role of producer organizations on the farm-level implementation of milk hygiene strategies. The model was appropriate because the outcome variable is count data and has non-negative integers (Lukman et al., 2021). However, the model suffers from high instability in cases where the predictor variables included in the model are correlated. Correlated regressions widen confidence intervals, affect the variance and covariance of significant coefficient estimates, enlarge the coefficient of determination, and cause *t*-ratios to be insignificant (Lukman et al., 2021). These issues negatively influence the performance of maximum likelihood estimation as

**Table 3.** Comparisons of percentages of farmers implementing milk hygiene strategies by status of membership in dairy producer organizations

| Practice                                                         | Pooled<br>(N = 282) | Non-members<br>(n = 100) | Members<br>(n = 182) | p-value  |
|------------------------------------------------------------------|---------------------|--------------------------|----------------------|----------|
| Personal and animal health                                       |                     |                          |                      |          |
| Milkers do not milk when sick                                    | 72.37               | 63.70                    | 77.13                | 0.000*** |
| Milked cows free of diseases                                     | 90.32               | 87.78                    | 91.74                | 0.097*   |
| Cows with mastitis milk last and milk discarded                  | 91.70               | 90.99                    | 92.09                | 0.798    |
| Milk from cows on antibiotics not consumed                       | 97.54               | 97.73                    | 97.44                | 0.798    |
| Mastitis checking prior to milking                               | 77.65               | 76.49                    | 78.28                | 0.649    |
| Foremilk from each teat was examined and abnormal milk discarded | 74.58               | 71.53                    | 76.26                | 0.268    |
| Personal hygiene                                                 |                     |                          |                      |          |
| Wash hands with soap before initiating milking                   | 82.48               | 79.52                    | 84.10                | 0.087*   |
| Clean dry cloth used to dry hand after washing                   | 86.70               | 86.13                    | 87.02                | 0.768    |
| Udder hygiene                                                    |                     |                          |                      |          |
| Cow udder and teats washed before milking                        | 95.40               | 96.11                    | 95.01                | 0.403    |
| Teats wiped with clean towel after washing                       | 87.73               | 87.77                    | 87.70                | 0.981    |
| Use one towel per cow                                            | 77.06               | 77.10                    | 78.70                | 0.278    |
| Fast but gentle milking without interruptions                    | 94.17               | 94.58                    | 93.95                | 0.641    |
| Stripping to get last drop out of the udder                      | 94.28               | 93.56                    | 94.68                | 0.504    |
| Teats sprayed with antiseptic after milking                      | 42.20               | 33.19                    | 47.15                | 0.006*** |
| Equipment hygiene                                                |                     |                          |                      |          |
| Cloth/strainer cleaned after use                                 | 92.83               | 88.42                    | 95.25                | 0.004*** |
| Cloth/strainer disinfected after use                             | 64.58               | 55.69                    | 69.46                | 0.008*** |
| Equipment made from approved material                            | 79.88               | 65.51                    | 87.77                | 0.000*** |
| Equipment cleaned immediately after use                          | 94.75               | 93.72                    | 95.31                | 0.294    |
| Milk vessels/ sterilized after cleaning                          | 82.79               | 80.08                    | 84.28                | 0.257    |
| Vessels/equipment put upside down to dry                         | 91.13               | 88.38                    | 92.65                | 0.069*   |
| Post-milking milk handling and storage                           |                     |                          |                      |          |
| Immediate filtering of milk after milking                        | 93.91               | 89.55                    | 96.31                | 0.003*** |
| Milk is stored in clean sealed containers                        | 92.39               | 92.57                    | 92.29                | 0.883    |
| Milk transported within 2 hours of milking                       | 92.46               | 90.46                    | 93.57                | 0.156    |
| Cooling up to 10°C when stored for > 2 hours                     | 68.33               | 44.14                    | 81.63                | 0.000*** |
| Workspace hygiene                                                |                     |                          |                      |          |
| Concrete floor of milking parlour                                | 72.89               | 55.08                    | 82.68                | 0.000*** |
| Thorough cleaning of milking area                                | 65.70               | 45.52                    | 76.80                | 0.000*** |

\*, \*\*\* represent significance levels at 10% and 1% respectively

Source: research findings, 2023.

well as the Poisson regression. Therefore, the PRM was tested for the presence of multicollinearity. The results presented in Appendix I show that the model did not suffer from multicollinearity and, therefore, was stable.

*The influence of producer organization on the farm-level implementation of milk hygiene strategies*

A total count of the number of practices used out of the maximum possible of twenty-six was constructed to determine how producer organizations influenced the

**Table 4.** Poisson coefficient estimates of the influence of dairy producer organization membership on the farm-level implementation of milk hygiene strategies

| Variable                                | Coef.             | IRR               | p-value  |
|-----------------------------------------|-------------------|-------------------|----------|
| PO membership (1 = yes, 0 = otherwise)  | 0.072<br>(0.012)  | 1.074<br>(0.013)  | 0.000*** |
| Sex of household head                   | −0.008<br>(0.010) | 0.992<br>(0.010)  | 0.438    |
| Marital status                          | 0.012<br>(0.017)  | 1.012<br>(0.017)  | 0.477    |
| Log of milk per cow                     | 0.014<br>(0.009)  | 1.014<br>(0.009)  | 0.123    |
| Cow ownership                           | 0.003<br>(0.011)  | 1.003<br>(0.011)  | 0.779    |
| Total farm size                         | 0.001<br>(0.000)  | 1.001<br>(0.000)  | 0.000*** |
| Price per unit of milk                  | 0.001<br>(0.004)  | 1.001<br>(0.004)  | 0.836    |
| Hours spent on dairy farming activities | 0.006<br>(0.002)  | 1.007<br>(0.002)  | 0.001*** |
| Training in milk hygiene strategies     | 0.010<br>(0.012)  | 1.010<br>(0.012)  | 0.382    |
| Distance to nearest town                | −0.001<br>(0.001) | 0.999<br>(0.001)  | 0.062*   |
| Constant                                | 2.954<br>(0.135)  | 19.192<br>(2.584) | 0.000    |

\*, \*\*\* represent significance levels at 10% and 1% respectively. Source: research findings, 2023.

farm-level implementation of milk hygiene practices. The influence of membership on the farm-level implementation of the 26 practices, after controlling for socioeconomic and institutional variables, is presented in Table 4. The model fit statistics (Wald  $\chi^2 = 121.19$ ,  $p < 0.001$ ) were statistically significant, indicating that the Poisson model fit the data well. There were four variables that were significantly associated with the extent of farm-level implementation of milk hygiene strategies: producer group membership ( $\beta = 0.072$ ,  $p < 0.001$ ), total farm size ( $\beta = 0.001$ ,  $p < 0.001$ ), hours spent on dairy farming activities daily ( $\beta = 0.001$ ,  $p = 0.001$ ), and distance to nearest town ( $\beta = 0.001$ ,  $p = 0.06$ ). Table 4 also presents the incidence-rate ratios (IRR) which are transformations of estimated coefficients. The IRR are interpreted for ease of understanding of the model output given the type of distribution the Poisson model relies on.

The variable of interest – producer group membership – had a positive and significant influence on the farm-level implementation of milk hygiene strategies. The results show that producer organization members had 1.07 times the number of milk hygiene strategies implemented at farm-level. The hours spent on dairy production activities was associated in a positive and significant way with the level of implementation of milk hygiene strategies. The allocation of one extra hour of dairy production activities resulted in 1.01 more milk hygiene strategies (holding other factors constant).

## DISCUSSION

Group membership was significantly associated with the receipt of formal training on milk hygiene strategies by farmers, conforming to the results of the study by Sangadah et al. (2021), who asserted that milk cooperatives develop training programs that help increase dairy production capacity in multiple areas, including hygienic milking, storage and the maintenance of the milking environment, milk safety, and quality. The percentage of producers who had received training from producer organizations was significantly higher for members than for non-members. However, the relatively high percentage of non-members who had received training from producer organizations in the last three years could include those who had either resigned as dairy cooperative members by the time of the survey or paid for training.

Nonetheless, despite more producer organization members having received training in milk hygiene

strategies from their respective cooperatives, a very small percentage of respondents indicated that their farms had been inspected by producer organization staff for compliance with milk hygiene strategies. This result suggests possible capacity challenges that impede the work of producer organizations. For instance, these organizations may lack the financial capacity to conduct regular on-farm inspections for compliance with milk hygiene strategies. Second, some cooperative societies may not have adequate human resources to inspect farms and enforce milk hygiene strategies. However, these assertions were not tested, and they are beyond the scope of the current study.

Producer group membership had a positive and significant influence on the farm-level implementation of milk hygiene strategies. This result was expected since more producer organization members accessed training in milk hygiene strategies and reported that their farms had been inspected for compliance with these strategies (Table 2). Furthermore, the significant influence of producer organizations on the implementation of milk hygiene strategies could be attributed to the institutional structures that cooperatives deploy to ensure milk quality. Producer organizations offer access to reliable formal markets, thereby compelling milk suppliers to adhere to quality standards. As demonstrated in Table 2, members of producer organizations were trained by multiple organizations and agents, possibly because of the mobilization and facilitative roles of dairy cooperatives. These results reaffirm arguments by Lemma et al. (2018), who asserted that the registration of dairy producers with a milk cooperative in Kenya ensured compliance with dairy industry regulations, as well as food safety standards. Secondly, total farm size owned by the farmers had a positive and significant relationship with the level of implementation of milk hygiene strategies. One additional acre of farm size increased the number of milk hygiene strategies implemented by one, holding other factors constant. Greater farm sizes possibly allow farmers to allocate more land to dairy infrastructure and forage cultivation, which in turn provide proper workspace conditions and feed availability for cattle, respectively. As argued by GlobeCore (2021), investment in food production and feeding infrastructure reduces the need for antibiotics, which improves milk quality.

Hours spent on dairy production activities was associated in a positive and significant way with the level of implementation of milk hygiene strategies. In this case,

more hours spent on dairy farming implied that dairying was a full-time activity for the farmer, hence more time was invested to enhance milk quality in order to access formal and guaranteed markets for an improved return on investment. Distance to nearest town had a significant negative influence on the intensity of farm-level implementation of milk hygiene strategies (Duncan et al., 2013). An extra kilometer from the farm to the nearest town reduced the number of milk hygiene strategies implemented by 1, *ceteris paribus*. A longer distance to market may have denied farmers opportunities to interact with other value chain stakeholders for valuable knowledge sharing on current trends or developments in milk hygiene regulations and important strategies to improve milk quality (De Vries et al., 2020). In addition, farmers further away from town were unable to access credit for investment in milk hygiene infrastructure. Furthermore, as espoused by De Vries et al. (2020), Ledo et al. (2021) and Migose et al. (2018), longer travel distances could have been associated with poor milk prices and low access to high quality inputs and equipment, thereby discouraging farm-level intensification of milk hygiene strategies.

## CONCLUSION AND RECOMMENDATIONS

This study has shown that membership of producer organizations such as dairy cooperative societies significantly and positively influences the extent of farm level implementation of milk hygiene strategies. Therefore, efforts to understand the technical knowledge needs of dairy farmers may be critical to classify members and customize training interventions to their needs. Despite the advantages offered by producer organizations, there are many dairy farmers who are yet to join, have resigned or are dormant members. Proper incentives can be utilized to encourage inclusivity and the active participation of dairy farmers in producer organizations to increase their access to extension services such as training in milk hygiene strategies, which may enhance the degree of implementation of farm-level milk hygiene strategies. The findings of this study provide insights into strategies for the improvement of milk handling, safety and hygiene at the farm level in one of the leading dairy farming areas in Kenya. Our research builds on cross-sectional data to draw its conclusions, hence the analysis does not capture ongoing changes or developments in



milk quality and safety. There is a need for similar research based on panel data to capture the dynamics that occur in production and collective action over time.

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## APPENDIX. MULTICOLLINEARITY TEST

| Variable                        | VIF  | 1/VIF    |
|---------------------------------|------|----------|
| PO membership                   | 1.43 | 0.700507 |
| Cow ownership                   | 1.40 | 0.714100 |
| Sex of household head           | 1.38 | 0.725604 |
| Training_hygiene                | 1.33 | 0.752778 |
| Hours spent on dairy activities | 1.29 | 0.777644 |
| Milk per cow                    | 1.16 | 0.861249 |
| Distance to the nearest town    | 1.13 | 0.883774 |
| Milk price                      | 1.07 | 0.930573 |
| Marital status                  | 1.05 | 0.950593 |
| Total farm size                 | 1.04 | 0.962173 |
| Mean VIF                        | 1.23 |          |

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