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Handling practices and contamination of raw milk sold for consumption in markets of Kwara State, Nigeria

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Milk handling practices in the Nigerian informal sector are usually poorly done. This is a threat to food safety and public health. We investigated the common practices by handlers involved in the milk processing and the contamination levels of raw cow milk marketed for consumption in Kwara State, Nigeria. In a cross-sectional survey, a pre-tested questionnaire (n = 500) was administered to consenting vendors to assess practices employed in milk processing. Raw cattle milk (n = 1225) sold in markets of Kwara State were assessed for contamination using the Total aerobic count (TAC) and Total coliform count (TCC) methods. Data were analysed by descriptive and inferential statistics. The majority of respondents were married (84%), females (65.2%), and had no formal education (43.2%). Some unwholesome practices among vendors such as pooling unsold milk (40.6%), adding unsterilized water to milk (22.2%), and sourcing water from streams (53.2%) were reported. Females (OR = 0.09; 95% CI: 0.040, 0.170; $p < 0.001$) and those with tertiary educational level (OR=0.01, 95% CI: 0.002, 0.041; $p < 0.001$) were less likely to be associated with unsatisfactory hygienic practices. All TAC and TCC were higher than 5logcfu/ml and higher counts were observed in the dry season. Because of public safety, a high-level hygienic and good milk handling practices – while enlightenment of vendors on standard hygiene, are required.

Keywords: Hygienic practices, Kwara State, Milk contamination, Total aerobic count, Total coliform count

Introduction

In Nigeria, local production of milk is less than 1% with milk consumption falling below the global average of about 40 litres per head annually (FAO, 2010). Milk production growth over the years in Nigeria is associated with a change of fewer than 0.05 million tons per year (FAO, 2010). Over 90% of total yearly milk output is derived from cows raised in low-input, low-yielding pastoral systems and marketed in informal value chains (CSIRO, 2021). The average milk yield in traditional low-input schemes is 6 liters per cow per day (CSIRO, 2021). Thus, limited amount of milk and milk products are available for consumption by the populace as the average milk consumption in Nigeria is between 20 and 25

liters/capital/year (CSIRO, 2021). Milk handling practices in the informal sector are done commonly without observing good hygiene (Okeke *et al*., 2016), thereby constituting a threat to public health as chances of consuming unsafe milk are high (Odetokun & Adetunji, 2016). The Nigerian diary sector is largely categorized into the formal and informal value chains. The informal value chain comprises mainly the milk and milk products obtained from pastoral systems (CSIRO, 2021). Inadequate quality control for milk produced and handled in the informal channels, makes milk easily contaminated by zoonotic pathogens (Kurwijila *et al*., 2006; Adetunji, 2010; Odetokun & Adetunji, 2016). Thus, milk handlers constitute a major critical point in the transmission and control of milk-borne infections to consumers.

The sale of unpasteurized milk to consumers, either directly or indirectly through small-scale vendors, is a common scene in the rural and urban areas of Nigeria, including Kwara State (CSIRO, 2021). Unpasteurized milk is 150 times more likely to cause foodborne illness and results in 13 times more hospitalizations than the pasteurized milk (CDC, 2004). The widespread marketing of unpasteurized milk is of concerns among stakeholders regarding milk-borne health risks to consumers. Various foodborne outbreaks have been associated with the consumption of unpasteurized milk and milk products (Oliver *et al*., 2009; Langer *et al*., 2012; Mungai *et al*., 2015). However, reports of contamination of vended milk and milk products in Kwara State are scarce while most milk-borne diseases outbreaks could go unnoticed and under-reported. It becomes significant to determine the common practices among handlers involved in the cattle milk production value chain and assess the microbial contamination status of the milk marketed in Kwara State, Nigeria.

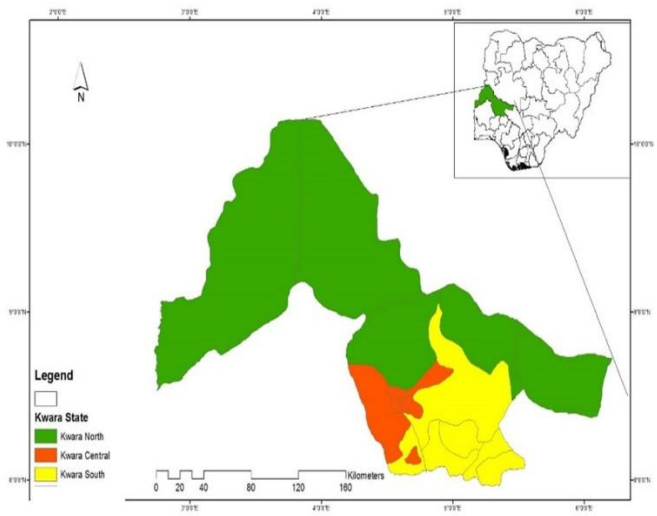

Figure 1: Map of Kwara State (Study area) showing the sampled regions

Materials and Methods

Study area

The study was conducted in Kwara State, Nigeria. Kwara State is located between latitudes 8° 30' 00" and 10° 05' 00" N and longitudes 2° 80' 00" and 6° 20' 00" E (NGIA, 2002) (Figure 1). The state is among the 19 northern states in Nigeria, and produces high quantities of milk and milk products due to the high concentration of cattle in this region and other northern states (CSIRO, 2021). The state is divided by agro-ecological demarcation into three regions (North, Central, and South). The North, Central, and South agro-ecological zones (also constitute the senatorial zones of the state) are comprised of 5, 5, and 6 Local Government Areas (LGAs), respectively. Kwara State has over three million inhabitants (NBS, 2018). The state also has a high cattle population as hundreds of animals are herded and transported from northern Nigeria's arid/semi-arid regions to the country's sub-humid and lush humid southern regions including Kwara State (Elelu *et al*., 2020). Thus, ready markets dairy products are available in the state due to the presence of sizeable livestock owners.

Study design

A cross-sectional study involving questionnaire administration and milk sample collection from April 2016 to March 2017 was carried out.

Questionnaire design, implementation, and data collection

To determine the common practices among milk handlers involved in the milk production value chain, questions on demographics, personal, and environmental hygiene (practices) were asked. A pre-tested semi-structured questionnaire was administered to 500 milk processors and vendors across the zones. In this study, milk processors are defined as those who play important roles in the milk value chain from collection to the point of sale to retail vendors while milk vendors comprise individuals who sell the milk and milk products to consumers at the market

level. The questionnaire is divided into two major sections. The first section comprised questions regarding the demographic characteristics of participants (age, marital status, gender, level of education, secondary occupation, market location, and LGA). The second part covered questions on practices, which focused on personal and environmental hygiene of the respondents. In the second section, the questions (14) asked included among others: changing/washing of personal clothing; availability of separate clothing when handling milk; and use of gloves/bare hands when milking; cleaning of the environment before milking and processing; use of water for milk expansion; pooling milk of different sources together; selling/handling of left-over milk.

The questionnaire was pre-tested on a group of milk vendors at the Ilorin East market and improved based on feedback before final administration. To validate the questionnaire, three experts in the field of milk hygiene reviewed the questionnaire for appropriateness and quality to address the study objective before a pre-test was carried out. All milk handlers within the market who had spent at least one year on the business were identified and given a unique identity with which randomization was conducted. The Ethical Review Committee of the Faculty of Veterinary Medicine, University of Ilorin, approved the study (FVER/004/2018). Respondents provided informed consent orally and were given the option to voluntarily withdraw from the study at any time.

Sample size and milk sampling

The number of milk samples collected was estimated using the formula for cross-sectional studies: $n = Z_{1-\alpha/2}^2 P_{exp} (1- P_{exp})/d^2$ (Charan & Biswas, 2013) where n is the required sample size for the number of milk samples to be collected across the markets, $Z_{1-\alpha/2}$ is the degree of confidence, P_{exp} is the expected prevalence, and d is the desired absolute precision. In this study, an expected prevalence of 50% (Thrusfield, 2007), $Z_{1-\alpha/2}$ at 1.96, and an absolute error margin of 5% were used in the calculation of the sample size for the quantity of milk collected in the markets across the state in each season. Therefore, n = 384. An attrition of 30% was added to give a total sample size of at least 499, for each season sampled. In this study, a total of 548 and 677 milk samples (n = 1225) were collected during the rainy and dry seasons, respectively. Concurrently, 500 questionnaires were administered to the milk processors and vendors.

Ten (10) out of the 16 LGAs with at least three each from each agro-ecological zone (i.e. 3, 3, and 4 from Kwara North, Kwara south, and Kwara central, respectively) were randomly selected for sampling by simple balloting. Milk samples (100ml) were collected aseptically from milk vendors from selected markets across the 10 LGAs in Kwara State. At least one market where milk is sold in the selected LGA was sampled. A total of 1225 milk samples were collected across the rainy and dry seasons from April 2016 to March 2017. At least 100 milk samples were collected from each LGAs comprising 5 markets from the 4 LGAs in Kwara north, 6 markets from Kwara central, and 4 markets from Kwara south. Sterile universal bottles were used for the collection of the milk samples and collected samples were immediately transported in the cold chain to the Food Safety and Zoonoses Laboratory, Department of Veterinary Public Health and Preventive Medicine, University of Ilorin, Ilorin, for further processing and analyses.

Total coliform count and Total aerobic plate count

Enumeration of total coliform count (TCC) in cow raw milk was carried out on MacConkey agar (Oxoid Ltd., Hampshire, England) plates as previously described by Barrow & Feltham (1993). This agar was prepared according to the manufacturer's specification. One millilitre of each milk sample was serially diluted using peptone water (Oxoid, UK). One millilitre of a six-fold dilution was cultured. All plates were incubated at 37ºC for 24h. Bacterial counts were expressed as log colony forming units per ml (log cfu/ml). The total aerobic plate count (TAC) was carried out as described above for TCC but with the use of the plate count agar (Oxoid Ltd., Hampshire, England) prepared according to the manufacturer's specification.

Data management and statistical analysis

Data from the questionnaire were summarized in Microsoft Excel Office package 2013 and analysed using Open-Source Epidemiologic Statistics for Public Health (OpenEpi), version 3.03a. In this study, a major dependent (outcome) variable was assessed: practices among respondents that may be associated with good milk processing. A scoring system was used to assess the outcome variable as earlier described (Odetokun *et al*., 2017; 2019, 2021). Each correct score for the 14 practice questions were scored as a point. The practice score ranged from 0 to 14 (mean ± SD: 9.56 ± 2.30). To evaluate this outcome variable, a cut-off point (mean + 1 standard

deviation of scores) was set to determine good practices. Scores greater and lower than the cut-off were considered satisfactory and unsatisfactory, respectively. Predictive covariates or independent variables evaluated for associations with the outcome variable were the demographic parameters. Data were subjected to descriptive and inferential statistics. Chi-square (χ^2) analysis was used to test the association between demographic factors and practices of the respondents that were likely to be associated with a satisfactory state of milking practices. For binary (2 × 2) variables, Fisher's exact test was utilized. Variables with significant association ($p < 0.05$) were further subjected to a likelihood multivariate logistic regression analysis to identify the demographic characteristics significantly associated with good practice levels. All analyses were carried out at the 95% confidence level. Results of bacterial counts indicating the quality of milk sold in Kwara State were expressed as log colony forming units per ml (log cfu/ml). Comparison of bacterial counts across zones was tested using ANOVA using SPSS v.21 with significant values set at $p < 0.05$.

Results

The demographic characteristics of respondents to this survey are presented in Table 1. Age categories of respondents varied with participants in the age range 20-29 years having the highest (168; 33.6%) respondents. Only 18 (3.6%) respondents were at least 60 years of age. The majority of respondents were mostly married (420; 84%), a few being single (70; 14%), and the remaining separated (10, 2%). More females, 326 (65.2%), than males, 174 (34.8%), participated in this survey. Twenty-four respondents (4.8%) had tertiary education while 216 (43.2%) have no formal education. The majority of participants were involved in a secondary occupation such as farming 280 (56.0%) and trading 172 (34.4%).

Some unhygienic practices carried out by respondents were reported (Table 2). Over a quarter (>29.0%) of the respondents reported milking from dirty/lacerated udder or teat and also obtain milk directly into any containers. Pooling unsold milk with freshly obtained milk is another unhygienic practice reported by 203 (40.6%) of the participants.

Table 1. Demographical distribution of respondents

Age	**n (%)**
<20	30 (6.0)
20-29	168 (33.6)
30-39	144 (28.8)
40-49	80 (16.0)
50-59	60 (12.0)
≥60	18 (3.6)
Marital status	
Single	70 (14.0)
Married	420 (84.0)
Separated	10 (2.0)
Gender	
Male	174 (34.8)
Female	326 (65.2)
Education	
No formal education	216 (43.2)
Primary	166 (33.2)
Secondary	94 (18.8)
Tertiary	24 (4.8)
Market location	
Kwara north	152 (30.4)
Kwara central	175 (35.0)
Kwara south	173 (34.6)
Secondary occupation*	
Farming	280 (56.0)
Trading	172 (34.4)
Others	48 (9.6)

* - responses are not mutually exclusive

Table 2: Practices employed during milk processing by handlers in Kwara State

Practices	n (%)
Unhygienic practices	
Milking from dirty/lacerated udder or teat	150 (30.0)
Obtaining milk directly into any container	147 (29.4)
Pooling of unsold with freshly obtained milk	203 (40.6)
Sources of container used in packaging milk	
Use of old traditional gourd	104 (20.8)
Pick used plastic bottles	356 (71.2)
Others	40 (8.0)
Milk preservation methods	
Reducing milk temperature by keeping in cool place	186 (37.2)
Adding water when milk becomes hot	111 (22.2)
Pooling of old and fresh milk	203 (40.6)
Source of water	
Stream	266 (53.2)
Hand-dug well	204 (40.8)
Pond	30 (6.0)
Timely washing of milking utensils	
Immediately	75 (15.0)
After the market	230 (46.0)
Whenever needed for re-use	195 (39.0)

The majority of respondents, 356 (71.2%), package milk in thrown-away used plastic bottles while 104 (20.8%) make use of old traditional gourd in milk packaging. Some 186 (37.2%) respondents reported keeping milk in a cool place to reduce milk temperature as a traditional method of milk preservation while about a quarter of respondents, 111 (22.2%), use the practice of adding water to cool off hot milk. Respondents to this survey indicated various water sources for milking processing. A little more than half of the respondent, 266 (53.2%), reported sourcing water from streams, 204 (40.8%) from hand-dug wells while the remaining 30 (6%) sourced water from ponds and use it for milk processing. The majority, 230 (46.0%), of respondents wash milking utensils after market activities, 195 (39.0%) wash milking utensils whenever needed for use while 75 (15.0%) wash them immediately after use. For effectiveness of washing, 416 (83.2%) of respondents make use of only water when washing utensils while the remaining 84 (16.8%) respondents reported washing with soap and water. Overall, respondents displayed poor hygiene practices during milk processing with less than half 146 (29.6%) of respondents having satisfactory scores.

The association between socio-demographic characteristics of respondents and satisfactory milking practices is presented in Table 3. Only gender ($p < 0.001$) and education ($p < 0.001$) were significantly associated with satisfactory milking processing practices. Other factors such as age and marital status of respondents were not significant.

For the multivariate logistic regression (Table 3), females are less likely (OR = 0.09; 95% CI: 0.040, 0.170, $p < 0.0001$) to be associated with unsatisfactory hygienic practices than males during the milking process. Respondents with higher levels of education are also less likely (OR = 0.01, 95% CI: 0.002, 0.041, $p < 0.0001$) to be associated with unsatisfactory hygienic practices during milk processing.

The total aerobic count (TAC) and total coliform count (TCC) obtained in Kwara State across the seasons are presented in Table 4. All counts recorded were high and above 7 logcfu/ml. The total

Table 3: Association between socio-demographic characteristics of respondents and hygienic practices in milking

Variables	n (%)	Satisfactory	Unsatisfactory	*p value*[&]	OR	95% CI	*p value*
Age							
<20	30 (6.0)	9 (30.0)	21 (70.0)	0.224	-		
20-29	168 (33.6)	57 (33.9)	111 (66.1)		-	-	-
30-39	144 (28.8)	45 (31.2)	99 (68.8)		-	-	-
40-49	80 (16.0)	15 (18.8)	65 (81.2)		-	-	-
50-59	60 (12.0)	16 (26.7)	44 (73.3)		-	-	-
≥60	18 (3.6)	4 (22.2)	14 (77.8)		-	-	-
Marital status							
Single	70 (14.0)	24 (34.3)	46 (65.7)	0.050	-		
Married	420 (84.0)	116 (27.6)	304 (72.4)		-	-	-
Separated	10 (2.0)	6 (60.0)	4 (40.0)		-	-	-
Gender							
Male	174 (34.8)	10 (5.7)	164 (94.3)	<0.001*	1	-	-
Female	326 (65.2)	136 (41.7)	190 (58.3)		0.09	0.040, 0.170	<0.001*
Education							
Non formal	216 (43.2)	16 (7.4)	200 (92.6)	<0.001*	1	-	-
Primary	166 (33.2)	62 (37.3)	104 (62.7)		0.13	0.070, 0.240	<0.001*
Secondary	94 (18.8)	50 (53.2)	44 (46.8)		0.07	0.040, 0.130	<0.001*
Tertiary	24 (4.8)	18 (75.0)	6 (25.0)		0.01	0.002, 0.041	<0.001*
Market location							
Kwara north	152 (30.4)	50 (32.9)	102 (67.1)	0.559	-		
Kwara central	175 (35.0)	58 (33.1)	117 (66.9)		-	-	-
Kwara south	173 (34.6)	49 (28.3)	124 (71.7)		-	-	-
Secondary occupation							
Farming	280 (56.0)	81 (28.9)	199 (71.1)	0.102	-		
Trading	172 (34.4)	63 (36.6)	109 (63.4)		-	-	-
Others	48 (9.6)	11 (22.9)	37 (77.1)		-	-	-

& - p value at chi square

* - significant at 0.05

Table 4. Mean total aerobic and total coliform counts obtained from milk in Kwara State

		Rainy season April – October			Dry season November - March	
Region	n	TAC (logcfu/ml)	TCC (logcfu/ml)	n	TAC (logcfu/ml)	TCC (logcfu/ml)
Kwara north	206	8.3±0.28^{a}	7.8±0.84^{ab}	271	12.33±0.24^{a}	12.05±0.17^{a}
Kwara central	113	8.5±0.22^{ab}	8.1±0.23^{b}	204	12.38±0.38^{ab}	12.00±0.33^{a}
Kwara south	229	8.2±0.16^{b}	8.0±0.15^{a}	202	12.43±0.26^{b}	12.05±0.17^{a}

TAC: Total aerobic plate count

TCC: Total coliform count

Values are in means ± SEM; Values with similar superscripts along the same column across zones are significantly different at $p < 0.05$

coliform counts obtained from markets across the zones in both seasons were lower as compared to the total aerobic bacterial counts. Both TAC and TCC obtained during the rainy season were consistently lower by at least 4 logcfu/ml compared to the dry season. During the rainy season, the highest counts (TAC and TCC) were recorded in samples obtained from Kwara central and these were significantly ($p < 0.05$) different from other zones. In the harmattan season, the lowest counts for TAC and TCC were recorded in Kwara North and Kwara central, respectively.

Discussion

This study revealed the levels of hygienic practices demonstrated by market milk vendors and the contamination of the milk marketed in Kwara State, Nigeria. The varied age distribution of respondents to the questionnaire survey showed that milk processing and vending is carried out by both the youths and adults. The 33.6% of the total respondents were between the ages of 20 to 29, and is similar to the findings of Okeke *et al*. (2016). Over 80% of respondents are married and this was also observed in an earlier study where most milk processors and vendors were mostly housewives in Niger State (Okeke *et al*., 2016). It is worthy of note that men are involved in milking of the cows while the females are involved in cleaning of pens, sales of milk/milk products and processing of milk (Agboola *et al*., 2020).

About 65% of respondents whose primary occupation is milking are females, which is in agreement with submissions of earlier works (Waters-Bayer, 1994; Okeke *et al*., 2016). The skewed sex distribution indicates that this occupation (especially vending of milk) is mostly handled by the female gender in Kwara State. This is expected as it is the males that herd the cattle producing the milk, while the wives of these cattle herders engage in business involving products obtained from cattle to feed the family. The processing of raw milk into various products and household economy rests on the shoulders of women (Tona, 2014). It has also been reported that Fulani women in Nigeria are responsible for all milk processing and marketing for family consumption or sale (Kristjanson *et al*., 2010).

The majority of the respondents/vendors are from rural villages like Gbugbu, Kaiama, Omu aran, etc. This peculiarity of raw milk vendors away from the urban areas is a feature of sub-Saharan pastoralists (Kristjanson *et al*., 2010; Junaidu *et al*., 2011). On behavioral preservation of milk, only 37.2% of respondents allow proper cooling of milk. This effect of temperature on total milk flora has been described earlier as one of the major concerns of milk spoilage (Machado *et al*., 2017).

Furthermore, the observation of respondents (40.6%) pooling unsold with freshly obtained milk tallies with the submission of some researchers who traced the unhygienic practices of the milk processors and vendors to these acts (Murphy & Boor, 2003). Less than one-quarter (20.8%) of the respondents still use old traditional gourd calabash which is easier to wash and does not harbor microbes. The emergence of unsterilized plastic water containers widely used for storage and sales of milk was adopted by 71.2% of our respondents. This is similar to the findings of Okeke *et al*. (2016) where higher number of respondents utilize plastic utensils in some parts of Kwara State contrary to the use of widespread u calabash in Niger State. The use of calabash in addition to other factors like dirty hands during milking could lead to microbial contamination of milk (Addo *et al*., 2011).

Gender and educational level were associated with the level of hygienic practices among the respondents. Females are less likely to be associated with unsatisfactory hygienic practices than males.

Respondents with higher levels of education are less likely to be associated with unsatisfactory hygienic practices during milk processing. Higher education levels influence behavioural patterns and food processing and handling manners, hence, the reason for such observation. Low literacy levels make it difficult for processors and vendors in the informal milk value chain to utilize sound milk processing and handling techniques (Girei *et al*., 2013).

The various tests carried out to determine the contamination and keeping quality of milk showed that vended milk sourced from various parts of Kwara State were contaminated during the sampling period. Higher contamination levels were observed during the months of the rainy season. The high total aerobic plate and total coliform counts obtained from the vended milk across Kwara State in this study show that the vended milk is contaminated with bacterial spp (especially with coliforms). This may portend serious public health challenge considering the fact that the milk samples are contaminated with microorganisms. These counts far exceeded the EC Regulation (2005) of the European Parliament and the Council (EC) standards of ≤ 5 logcfu/ml milk for the total bacteria count (TBC) in cow's raw milk.

Lower bacterial counts have been recorded by other researchers on works on milk quality carried out in various parts of Nigeria. For instance, a total viable count ranged from 1.16 x 10^6 to 2.60 x 10^6cfu/ml was reported by Laba & Udonsek (2013) in a bacteriological evaluation of raw cow milk in Ilorin. However, these counts were only obtained from just 12 raw milk samples. The finding that total aerobic plate counts were higher than for the coliforms counts in surveyed milk samples is expected. Similarly, Agunbiade *et al*. (2017) in a study on bovine milk samples obtained from some farms in Northern Nigeria recorded a similar finding. Elsewhere in Nigeria, other researchers have also reported lower bacterial counts present in raw milk samples mostly obtained from markets of Jos (Ibeawuch & Daylop, 1995), Keffi (Obiekezie *et al*., 2012), Abuja (Olatunji *et al*., 2012), Kaduna (Egwaikhide *et al*., 2014), and some markets in Ogun, Osun, and Oyo States (Abike *et al*., 2015; Oluwafemi & Lawal, 2015; Oladipo *et al*., 2016). Poor milk processing and operational conditions facilitate microbial contamination of milk (Jayarao & Henning, 2001) thus affecting milk quality and safety. However, in fermented milk products such as nono, which is commonly sold in Northern parts of Nigeria, Ogbonna (2011) and Maikai & Madaki (2018) recorded counts of less than 2 logcfu/ml of aerobic and coliform bacterial contamination.

This study revealed that the majority of cattle milk vended in the sampled markets in Kwara State are contaminated. A good management system should be employed in milk collection and processing while transportation of milk for sale by the milk vendors should be improved. Local vendors of cow milk should be educated on the proper handling and processing of milk and milk products. Milk pasteurization is recommended since contamination of milk at the level of the market is high. Our findings could be useful and valuable at a national level to design health services interventions to develop projects for spreading knowledge and information about food hygiene and safety among sellers and consumers.

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Conflicts of Interest

The authors of this work declare no conflict of interest.

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