Innovative and Participatory Risk-Based Approaches to Assess Milk-Safety in Developing Countries: a case study in North East India

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Abstract

Food safety is a major problem and of increasing concern in developing countries. Risk-based approaches are current best practice but have been little applied. We present a case-study from Assam, North East India, illustrating 3 key elements of risk-based approaches in the context of the informal dairy sector. We used risk-based targeting to categorise milk vendors into a risk hierarchy, thus allowing vendors which pose most risk to human health to be identified and inspection and intervention directed accordingly. We also describe pathway analysis, in which the food product is traced from production on farm to consumption. This helps identify critical control points where action can, and must, be taken to avoid risk to human health. In Assam, the last step of the pathway (house-to-house vendor to consumer) was where risk increased most for raw milk; while, for milk sweets the holding time of the prepared sweet was critical. Participatory risk analysis posits that building on indigenous knowledge will be more effective than top-down solutions and we looked at indigenous risk management that is the existing practices that reduce risk. We found a range of good practices among all actors. Consumers had the highest level of good practice. We also examined the relation between good practice and low bacterial counts and were able to identify the practice most associated with safe production. This case study shows that risk-based approaches can be usefully applied in informal markets in developing countries.

Introduction

Food is a major source of hazards to human health and food-borne disease is globally the single most common illness. In India, it is estimated that 20% of deaths among children under five are caused by diarrheal disease (WHO 2006), 70% of these being associated with unsafe food or water (Unnevehr & Hirschhorn, 2000). In most developing countries, food safety systems are dysfunctional and, despite increasing concern from consumers, India is not exception. A recent internet discussion pointed out that regulation isn't working, adulteration is widespread, testing inadequate, corruption rampant, rules not effective or followed and there are major hygiene and safety problems in all areas of food production and retailing (Solution Exchange, 2008).

Risk-based approaches offer a new way of managing food safety in developing countries. Not only are they more effective at decreasing risks, but they can also be a bridge between food safety and livelihood concerns. The first component of risk analysis, risk assessment, generates an estimate of negative health impacts of a hazard as well as the likelihood of their occurrence. This information can then be compared with economic data on the costs and benefits of smallholder production and marketing (including externalities such as income opportunities for poor women or environmental degradation from abattoirs), and the costs and benefits of risk mitigation. This allows decision-makers to set appropriate levels of protection based on evidence rather than anecdote and subjective preference. Moreover, the focus on a 'farm to fork' pathways approach allows the identification of risk mitigation points along the food value chain. This can help identify interventions that maintain market access for smallholders. But although risk-based approaches have been formally adopted by most developing country governments there have been few applications to the problem of food safety in the informal markets where most of the world's poor buy and sell.

Studies by the International Livestock Research Institute (ILRI) and partners suggest this is partly due to lack of expertise in the relatively new field of risk analysis and partly due to difficulties in applying risk-based methods to diverse, non-linear, shifting, and data-scarce systems in which formal and informal (or traditional) food supply systems co-exist and overlap; views of various stakeholders on food safety objectives diverge; there is low willingness or ability to pay among consumers for improved food quality, and low enforcement capacity (Cole et al., 2008). Based on previous analysis and research, we believe that incorporating participatory methodologies can meet this need for contextualisation of risk analysis (Grace et al., 2008). Since their introduction in the 1970s, participatory methods and techniques have become central to community development. They are promoted on the basis that they are more effective, more sustainable and less costly and more ethical in their inclusion of the poor in the planning and decisions that affect them. Applied to risk assessment, participation applies both the use of participatory methods and a on people-based, bottom-up, and empowering approach to development.

This case study shows the application of risk-based approaches, including Participatory Risk Assessment, to the informal dairy sector Assam and the strengths and weaknesses of this methodology. The study focused on the hazard caused by bacterial pathogens (animal and human) to the health of milk and milk-sweet consumers in Assam. Three components of risk-based approaches are featured:

1. Risk-based targeting: Conventional food-safety assurance applies inspections and interventions uniformly across all elements of a population. Risk-based inspection concentrates scarce resources on the most problematic areas by allocating according to the performance of each food processing or retailing facility.
2. Pathway analysis: Conventional epidemiological studies look at the presence of hazards at haphazard points (e.g. end of production, point of sale, point of consumption etc.) The 'stable to table' or 'farm to fork' perspective systematically considers the movement of

hazards from point of origin to consumption. This allows assessing the change in pathogen loads along the chain and hence a better estimation of risks to consumers; it also helps identify the points where risk can be best reduced.

3. Indigenous risk mitigation strategies: Conventional food-safety promotion concentrates on what is being done wrong and on rules and punishments to correct this. Development theory suggests that basing food safety on participation, local needs and knowledge will be more effective than control and command.

Materials and Methods

1. Risk based targeting

A cross-sectional survey of milk outlets was carried out in 2006 in Guwahti and Jorhat the two major cities of Assam, one of the seven states of North East India. In each city, a list of all the administrative areas (wards) was obtained (60 in Guwahti and 19 in Jorhat) and in each city 6 wards were randomly selected from this list. Enumerators then visited the wards and constructed a census of all points of milk-sale and households. A stratified random sample was carried in each ward out of shops selling pasteurised milk (12), shops selling un-pasteurised milk (12), distribution points (6) and households purchasing milk from door-to-door vendors (12). If the number of elements in the strata were less than the quota for the strata then all elements of the strata were selected. Milk was aseptically collected into sterile containers which were put on ice and analysed within 4 hours.

Milk physical quality was assessed using an ultrasonic analyser (Akashanga®) which measured added water, fat, and solids non-fat. Milk safety was assessed by total plate counts and total coliform counts using dehydrated media (Petrifilm 3M®). Total plate counts are a non-specific measure of poor milk handling while the presence of coliform bacteria indicates milk has been contaminated by human or animal faeces.

The importance of different factors on milk safety was assessed through two linear regression models in which the dependent variables were log of total bacteria counts and log of total coliform counts respectively and the independent variables included city, point of sale and processing method. All statistical calculations were carried out using Stata®. Independent variables which had a significant effect on bacterial load were retained to categorise sellers and products into different risk categories.

2. Pathway analysis

For the milk pathway analysis we identified 12 ‘farm to fork’ pathways that aimed to cover the range of pathways found in Guwahti (e.g. a maximum variation sample). A questionnaire used at farm level asked the name and address of everyone who bought milk. We then traced these and administered a questionnaire where respondents listed all the sources of milk and all the buyers of milk. The process continued until the point of consumption. Milk physical quality and safety was assessed as described above.

In addition, ten sweet shops were randomly selected from one ward in each city. A partial pathway was constructed for Kalakan, a dairy-based sweet; this started with raw ingredients entering the shop and ending with the ready-to-eat sweets on display. Raw milk was aseptically sampled, as were sweets at the start of display, half way through the display period and at the end of the display period (e.g. the last sweet to be sold). These were assessed for total bacteria, coliforms and presence *of Listeria monocytogenes*, an emerging and important pathogen often associated with dairy products, using the dehydrated media described earlier. Bacterial counts were compared to national standards and statistical comparisons between groups made by the chi square test.

3. Indigenous risk mitigation

An objectively scored check-list of hygiene practices was administered at each step of the 12 milk pathways as well as the ten sweet shops. Separate check-lists were developed for farmers, vendors, sweet-shops consumers. A score was then given to each good practice observed and these were summed to give an overall 'good practice score' which was then normalised to a scale from 0 to 100. Different groups were compared using the Mann Whitney statistic.

Results and Discussion

1. Risk-based targeting:

We assessed how safety and quality of milk varied according to city of sale, point of sale, and processing method. In total 345 samples were taken, 202 in Guwahati and 143 in Jorhat. Points of sale were: shops, distribution points and door to door vendors. Distribution points consisted of sites on the pavement where vendors set up in the morning and evening and sold milk from metal churns. Milk was categorised according to processing method as: ultra-heat treated milk (UHT), pasteurised milk, and raw milk. The linear regression model showed a significant association between processing and point of sale and bacterial counts, but not between city of sale and bacterial counts. By categorising according to point of sale and type of processing we were able to develop a hierarchy of risk, shown in Table 1. Milk sold from shops and UHT milk is associated with lower levels of hazard and raw milk and milk sold by door-to-door vendors with higher levels.

Table 1 Bacterial quality of milk samples in Assam according to processing and point of sale

Processing	***Point of sale***	***Total bacteria (log)***	***Total coliforms (log)***	***n***
UHT	Shop	3.1	0.0	120
UHT	Distribution point	4.7	0.0	3
Pasteurised	Shop	5.5	2.1	34
Raw	Distribution point	5.8	3.5	33
Raw	House-to-house vendor	6.1	3.7	144
Pasteurised	Distribution point	6.9	5.4	4

We also compared the bacteriological quality of milk originating from different dairies. Milk from dairies within the state of Assam (local dairies=30) contained higher levels of total bacteria and coliforms than milk from dairies outside the state (n=134); other differences were not significant (Table 2). However, UHT milk, which inherently has higher bacteriological quality, was produced only by dairies outside the state, and when we compared pasteurised milk from local dairies with pasteurised milk from the one dairy outside Assam we found the later had substantially worse bacteriological results. This is logical given the greater distance it is transported. However, sample size was not large enough to show if differences between dairies producing pasteurised milk were significant.

Adulteration with water was present in milk from all dairies. Among local dairies, there was considerable variation in adulteration with water (from 2 to 20%). In all samples, total bacteria counts were correlated with coliform counts (associated with faecal contamination).

Table 2 Bacterial quality of milk samples in Assam according to dairy of origin

Dairy	***Fat****	***Solids non fat****	***Added water****	***Total bacteria^***	***Coliforms^***	***Origin 1=local***	***Processing***	***Count***
Taaza	3.6	7.9	6.0	3.0	0.0	0	UHT	120
Prithbi	1.9	7.3	6.8	4.3	0.0	1	Pasteurised	4
Mother	3.2	7.0	17.0	4.7	0.0	0	UHT	3
Central	1.6	6.8	20.0	5.2	2.2	1	Pasteurised	5
Purabi	3.1	8.1	3.0	5.3	1.9	1	Pasteurised	13
Dairy Fresh	2.6	7.1	16.0	5.7	1.5	1	Pasteurised	5
Seema	4.3	8.1	4.0	5.9	5.6	1	Raw, chilled	1
Komul	3.2	8.0	4.0	6.9	4.5	0	Pasteurised	11
Suruchi	4.4	8.2	2.0	7.1	6.2	1	Raw, chilled	2

* median ^mean

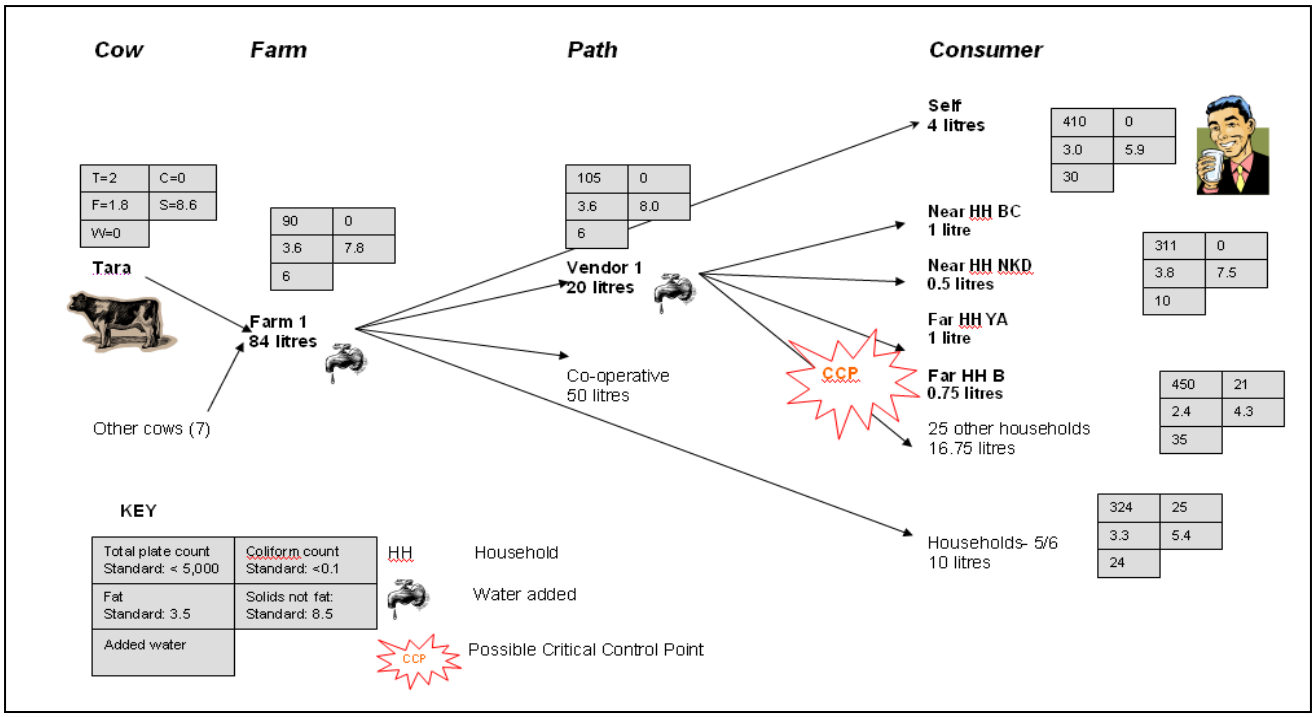
This case study shows that it is possible to categorise milk actors into different groups with respect to the risk they are likely to pose to consumer health. Further studies would be needed to see if these trends are stable over time and, in the case of dairies, larger samples are needed to evaluate the statistical significance of differences between groups.

Currently, most government attention is paid to the sub-groups which present least risk: this type of analysis can present a case for focusing more inspection and extension activities on raw milk and informal sector channels. The study also gives insights which might not otherwise be available: for example, in some cases pasteurised milk can actually be of lower standard than unpasteurised.

2. Pathway analysis

Analysis of the raw milk pathway found most pathways were relatively short with only one to four intermediaries between farm and consumer. For 9 of the pathways mapped, all milk was channelled to the informal sector, either being sold directly to households (1 chain) or passing through one to 3 transporters and bulkers before being sold to vendors who sold from door-to-door. For one pathway all the milk went to the dairy co-operative and for another pathway, just over half the milk. One pathway was the “Gosala” (several hundred cows are housed together and the milk sold directly to consumers without intermediary). In all cases, farmers consumed some of the milk produced within the household. There was a high level of diversity: farmers market their own or other farmers’ milk to a combination of traders, vendors, co-operatives and also sell direct to households, or sell indirectly to households via a hired intermediary, and all farmers consume within their own household; similarly, traders sell to other traders, hotels, sweetshops, kiosks or households as well as consuming within their own household.

Figure 1 Example of a pathway showing changes in milk quality between cow and consumer

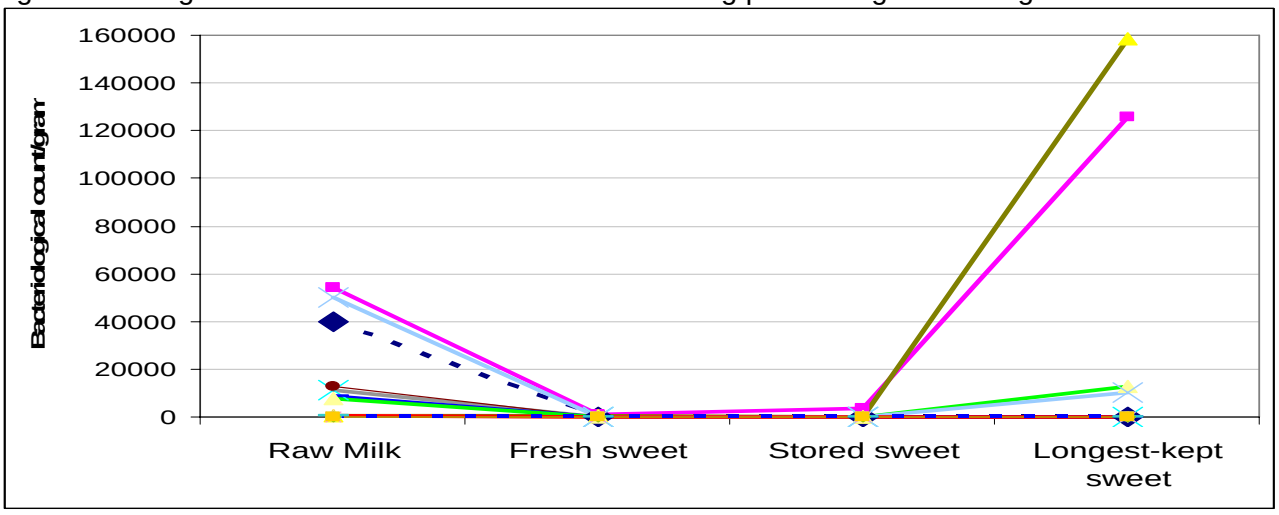


Bacterial quality declined consistently along the milk pathway and the level of adulteration with water increased. However, at point of consumption, all raw milk was had an acceptable total bacteriological plate count according to national standards. On the other hand, the majority of raw milk was adulterated with water and only half samples had acceptable coliform counts. In the case of coliform quality, the main risk amplification step (i.e. where quality deteriorated most) was between the last vendor and the consumer. Likewise, the main point of water adulteration was the step immediately preceding the consumer. Nearly half (46%) of farmers and intermediaries reported adding water to milk, and the only two path structures without water adulteration were the ‘Gosala’ model and the milk co-operative model.

This case study shows how mapping risk pathways can reveal the complexity of milk value chains and the variety of actors involved. By identifying steps where there is a sudden, large quality decline, and interventions can be better targeted. On the other hand, identifying the minority of actors who maintain quality in circumstances where quality declines for other actors may help identify transferrable innovations. In this case, the incentives resulting in the absence of adulteration to co-operative and gosala milk may be worth further investigation.

The process of sweet-making was analysed in ten shops, five in Guwahti and five in Jorhat. A flow chart was constructed of the movement of milk from entry to the shop to finished product. Eleven different processes were identified and the time taken for each, quantities of materials involved, and temperature for each noted. The average production time was 112 minutes which included boiling for 41 minutes. One third of sweet samples met national standards for bacterial counts and coliform counts, and half, though sub-standard were close to standard while the remaining 13% were well below standards. *L. monocytogenes* was not found in any samples. Samples from Jorhat were of significantly higher quality than Guwahti (67% meeting standards versus 0%; $p<0.000$ Chi 2).
In all cases bacteria count declined to zero as a result of processing and then increased again with storage time (Figure2) indicating a critical control point for milk sweets is the length of time for which prepared sweets are stored.

Figure 2 Change in bacterial counts of milk sweets during processing and storage



3. Indigenous Risk Mitigation strategies

The survey found numerous good practices used by actors each step in the milk value chain. Some practices were used by the majority of actors (e.g. wash hands before milking; discard milk unfit for human consumption). Other good practices were used only by a minority, (e.g. wash hands between milking; sieve milk to remove gross contamination). Table 3 gives examples of good practices observed by different actors.
Conventional hygiene assessment tends to focus on what is being done rather than what is being done well and participatory learning and action theory shows that this is less effective than taking

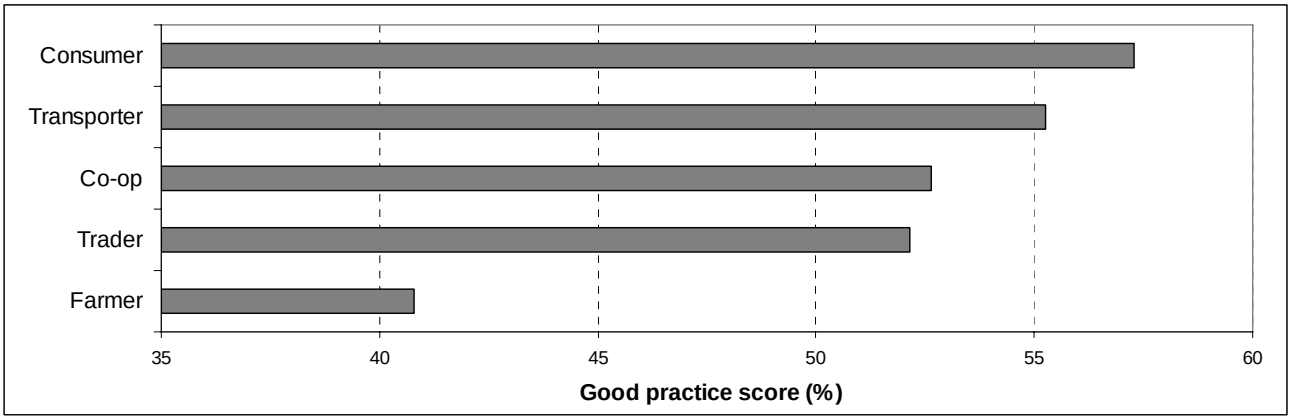
the starting point of people's knowledge and competencies and building on this. Indigenous practices and technologies can often be quite effective at decreasing risk (Grace et al., 2008) and have the added advantage of being 'pre-adapted' for the context in which they are used.

Table 3 Good and bad food hygiene practices

Farmer		*Trader and hawker*	
Wash hands before & after each cow	92	Use aluminium containers	100
Discard milk unfit for consumption	75	Wash milk containers with soap	100
Concrete floor or slats	50	Milk holding < 4 hours	85
Milk outside cow shed	42	Have adequate cover for containers	69
Have clean floors	42	Wash water from hygienic source	69
Keep clean during milking	42		
No foul smells or airborne dirt	25	*Consumers*	
Wear suitable clean clothes	17	Clean milk utensils with soap	100
Dry hands before & after each cow	8	Boil milk before consumption	95
Separate milk unfit for consumption	8	Keep milk in fridge	44
Sieve milk to remove dirt	8	Store milk in clean place	35

When different groups of actors are compared it can be seen (Figure 3) that consumers have the highest observance of good hygienic practices and farmers the lowest. However, this reflects a greater number of practices identified for other actors and more homogeneity of practice within the consumer group. Interestingly, nearly all consumers boiled milk before consumption. This will eliminate risk due to living bacteria, which cause many serious milk-borne diseases including brucellosis and tuberculosis.

Figure 3 Average good hygienic practice score of milk value chain actors handling milk



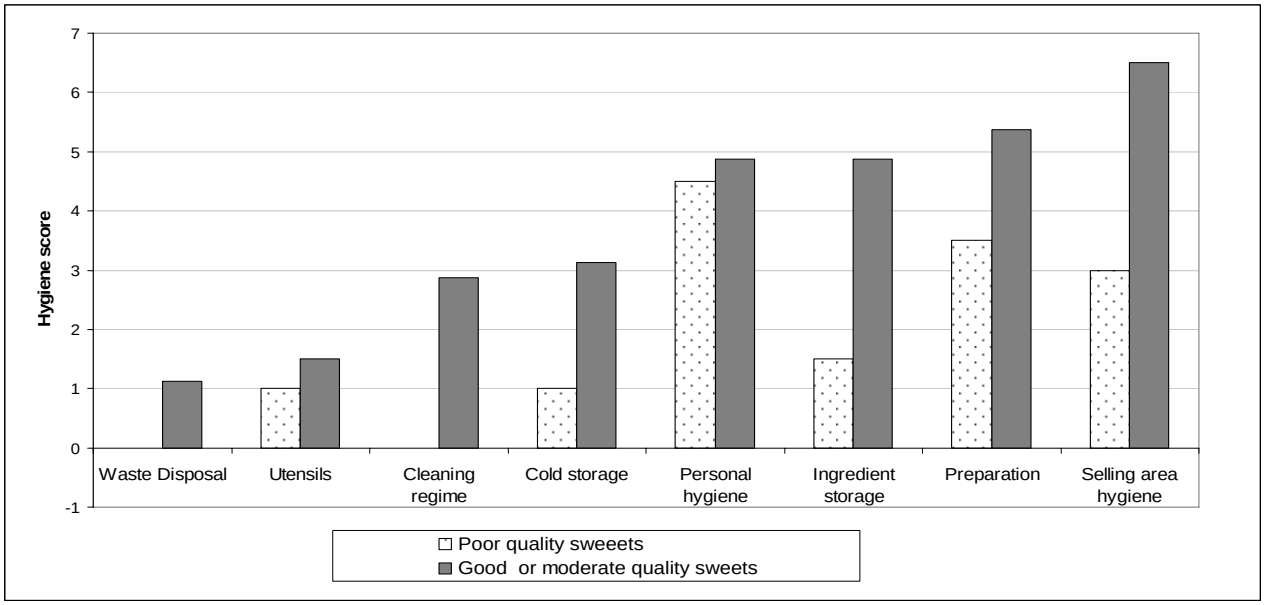
Sweet shops also varied considerably in the number of good practices followed. A total of 73 good practices were observed grouped under: personal hygiene, food preparation, cold holding, food storage, cleaning and sanitising, utensils and equipment, garbage management and pests and hygiene of sweet-selling area.

Shops which produced sweets of good or moderate quality had a median score of 42% while those producing sweets of poor quality scored 20%; the difference was highly significant, despite the small

sample size (10 shops), indicating a powerful influence of hygienic practice on safety of milk sweets (p=0.04).

Comparing shops with good food safety outcomes and those with poor showed greatest difference in the areas of *selling area hygiene, ingredient storage, cold storage* and *cleaning regime,* suggesting efforts to improve sweet-safety should focus on these control points (Figure 4).

Figure 4 Differences in hygiene practices between shops producing safe and unsafe sweets



Conclusions

This cases study showed how some of the key principles of risk-based approaches to food safety can be applied when assessing the informal milk markets in developing countries. Cross-sectional surveys showed that points of sales for milk could be divided into a hierarchy of risk. This would allow targeting of resources on high risk areas. Pathway analysis identified critical control points where action is needed to ensure raw milk and milk sweets are safe to consumers. Assessing practices revealed risk-amplifying practices: one of the most important being that nearly all milk (95%) is boiled before consumption. We were also able to identify those practices which had most impact on food-safety outcomes, allowing the development of risk-based extension messages.

Developing country informal markets are characterised by non-linear, un-regulated, heterogeneous and self-organising food value chains. In this difficulty context, conventional food safety based on command and control regulation has failed and risk-based approaches are considered to have greater potential. The challenges we encountered of applying risk-based approaches included: the lack of pre-existing information; great diversity of structures and practices; difficulties of working with informal sector participants due to poor relations with officials; and problems of carrying out laboratory analyses given extreme environmental conditions and lack of equipment and skilled staff. We responded to these challenges by extensive use of qualitative analyses to capture uncertainty,

diversity and complexity; incorporation of Participatory Learning and Action methods to engage study respondents and generate ownership; and adoption of rapid and robust laboratory tests for quality assessment. The results generated, though with wide margins of error and limitations to generalisability, represented a major improvement on the existing situation, where stakeholders had essentially no information on the harms present in informally marketed milk. This case study supports the hypothesis that risk-based approaches are the best way of addressing food safety problems in informal markets. However, these approaches but will need continued adaptation, testing and dissemination.

References

Cole D., Grace D., Diamond M., (2008), Researcher' approaches to evidence on urban agriculture and human health. In: Cole D., Lee-Smith D., Nasinyama G. (Eds) Healthy city harvests: Generating evidence to guide policy on urban agriculture. International Potato Center (CIP) and Makerere University Press

Grace D., Nasinyama G., Randolph T.F., Mwiine F., Kang'ethe E. (2008), City dairying in Kampala: integrating benefits and harms. In: Cole D., Lee-Smith D., Nasinyama G. (Eds) Healthy city harvests: Generating evidence to guide policy on urban agriculture. International Potato Center (CIP) and Makerere University Press

Grace D., Randolph T., Olawoye J., Dipelou M., Kang'ethe E. (2008). Participatory risk assessment: a new approach for safer food in vulnerable African communities. Development in Practice, 18: (4) 611 – 618

Solutions Exchange (2008), Solutions Exchange Food and Nutrition Security Community, at http://www.solutionexchange-un.net.in/food/cr/cr-se-food-02030901

Unnevehr L, Hirschhorn N. (2000). Food safety issues in the developing world. World Bank Technical Paper No. 469. The World Bank, Washington DC, 72 pp.

World Health Organisation, (2006), Core Health Indicators, www3/who/int/whois/core/core_select_process.cfm