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**Editors:** Donald **Cole** • Diana **Lee-Smith** • George **Nasinyama**


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CHAPTER 11

# **City dairying in Kampala:** integrating benefits and harms

**Delia Grace • George W. Nasinyama • Thomas F. Randolph, Frank Mwiine • Erastus Kang'ethe**



## INTRODUCTION AND CONTEXT

In developing countries, urban agriculture is not limited to growing of crops for food and sale or keeping of small stock such as poultry. Thousands to tens of thousands of cattle are kept in cities and peri-urban areas, sometimes for transport and meat but more often for milk. Poor but aspiring urban populations constitute a rapidly growing and relatively undiscriminating market for dairy products. On the supply side, readily available inputs, ability to transform the by-products of urban society and low transaction costs allow urban farmers to successfully compete with industrial producers and capture a considerable share of the lower-price milk market.

Urban dairies provide income, employment, nutritious food and valuable by-products; they also pollute soil and water, use scarce resources (water, feed) and generate biological, physical and chemical hazards, the more important of which are listed in Box 1 (Birley & Lock 2000; Campbell *et al.* 1999). While the environmental impacts of dairying are considerable and highly visible – one dairy cow, for example, produces 35 kg of semi-liquid feces per day, compared to 1.5 kg of dry feces from a goat and 100 g from a hen – it is typically the human health impacts that are of most concern to policy makers, often leading to attempts to suppress city dairies. But despite this concern, little empirical work has been done to determine the extent and impact of zoonotic and food borne diseases and other public health risks associated with livestock keeping in urban and peri-urban areas (Mougeot 1999; Lock & de Zeeuw 2001).

The magnitude and visibility of both benefits and harms make urban dairying a test case for exploring the trade-offs of urban agriculture. This chapter presents a case study from Kampala where a stakeholder assessment (described in Chapter 2) identified cattle as the second most common type of livestock kept (David *et al.* forthcoming). We briefly review the literature on dairying in Kampala, and then summarize the benefits of dairying as perceived by urban small holders and the risks derived from our analyses of milk safety. Conventionally, public health studies focus on the risks of informally produced food; we focus on the spontaneously practiced strategies that mitigate risk and introduce the concept of 'indigenous risk mitigation'. We argue that this could under-pin a bottom-up risk management to replace or complement the existing ineffective top-down, command-and-control regulatory system. Finally we synthesize lessons from the case study on best-practice assessment of benefits and risks of dairying in developing country cities.

**Box 11.1** Hazards which may be associated with dairying in developing countries

**Hazards in manure**
- Aesthetic: smell, attraction of flies, visual disturbance
- Chemicals: ammonia, nitrates, hydrogen sulfide, methane, carbon monoxide
- Xenobiotics[1] : antimicrobials, pesticides, heavy metals
- Pathogens:
  - Virus: reoviruses, rotaviruses, enterovirus, caliciviruses
  - Bacteria: *Listeria monocytogenes, Escherichia coli* serotypes, *Salmonella* spp., *Campylobacter jejuni, Campylobacter coli, Aeromonas hydrophila, Yersinia enterocolitica, Vibrio* spp., *Leptospira* spp., *Clostridium perfringens*
  - Parasites: *Cryptosporidium parvum, Giardia lamblia, Fasciola* spp., *Taenia saginata, Trichostrongylus* spp., *Schistosoma* spp. and *Balantidium coli*





**Hazards in milk**
- Xenobiotics: antimicrobials, pesticides, hormones, mycotoxins, blue-green algae toxins, polychlorinated biphenyls, heavy metals, perchlorate, plant alkaloids and glucosinlates, chlorodibenzofurans
- Pathogens:
  - Virus: Foot and mouth disease virus, rabies virus, bovine leukemia virus
  - Bacteria: as above plus *Brucella spp. Staphylococcus aureus, Streptococcus* spp., *Coxiella burnetti, Mycobacterium* spp.
  - Parasite: *Cryptosporidium parvum*
- Allergens, lactose (for people with lactose intolerance)

**Zoonotic diseases transmitted by direct contact, aerosol or other routes**
- Anthrax, actinomycosis, babesiosis, Congo-Crimean fever, cowpox, dermatophilosis, echinococcois, dermatomycosis, fascioliasis, foot and mouth disease, hydatidosis, leptospirosis, milkers nodes, new variant Creutzfeldt Jakob disease, nocardiosis, Q fever, rabies, rhinosporidiosis, Rift Valley fever, schistosomiasis, tetanus, trichostrongylosis, tuberculosis, vesicular stomatitis

**Other hazards associated with cattle**
- Robberies and cattle rustling
- Traffic accidents
- Injuries to people from aggressive/frightened animals
- Destruction of crops and gardens by cattle leading to conflict
- Creating an environment suitable for pests and disease vectors

## BACKGROUND: DAIRYING IN KAMPALA

Interest in small-scale dairying in developing countries is a new phenomenon; industrialization and modernization were long seen as both desirable and inevitable (Schiere & den Dikken 2003) and Uganda is no exception. Since the 1980s, more than $25 million was granted or loaned for large-scale dairy development (Okwenye 1994), but despite these investments, all major milk-processing plants in the country are operating much below their capacities (overall only 23 percent of capacity is met) while the biggest plants are suffering losses (Aliguma & Nyoro 2004). Under-utilization of capacity keeps operating overheads high

[1] Substances not normally present in the reference organism

in relation to output, resulting in increased milk prices and, as a result, nearly all is purchased by well-off (and over-supplied) urban consumers.

But as industrial development failed to take off, a quiet revolution has been taking place in city and country. Seven hundred thousand smallholder farmers selling raw milk through informal channels have now captured 90 percent of the milk market (DDA 2006). Marketing chains vary from single intermediaries sourcing directly from farmers and selling to consumers to complex channels involving some processing and an organized system of milk vendors (Dannson *et al.* 2004). And while pasteurized milk is sold to a restricted clientele of shoppers in large supermarkets (just three in Kampala), local stores and petrol stations, raw milk is sold by many thousands of small shops, kiosks, ambulant vendors and hotels (for consumption on the premises). In a market driven by price rather than quality, informal sector traders offer better prices to farmers and in turn lower prices to consumers, making them more competitive than the formal sector.

Dairying as an urban phenomenon first came to attention during the civil unrest of the 1970s and 1980s when urban wages declined precipitously in the face of social breakdown and explosive inflation (Maxwell & Zziwa 1993). The availability of urban and rural land allowed urban households to survive by retreating into subsistence, with an estimated 90 percent of Uganda's population involved in subsistence cultivation and urban farming becoming a persistent feature of the capital's landscape (Amis 1992). Cattle keeping has increased in Kampala since the 1970s. Official figures of 6500 cattle in Kampala District in 2002 are thought to be too low by a factor of 12: other sources estimating 74 000 in 2001 (Muwanga 2001; Nasinyama *et al.* 2008). About 25 percent of urban households and between 38 up to 90 percent of peri-urban households in Kampala are involved in farming, and from 8 to 39 percent of these keep cattle (David *et al.* forthcoming).

Farms typically keep two to five cattle and zero-grazing (cut-and-carry) is common, with cattle confined in stables and brought fodder crops, household waste and concentrates. Tethering, grazing derelict land and verges and, to a lesser extent, keeping cattle in fenced enclosures, are also practiced. The majority of dairy cows are improved breed[2] and give around 10-15 liters of milk per day. Milking is by hand, and is carried out twice a day; sometimes the calf is allowed to suckle for a few minutes to encourage milk let-down. Cattle keeping is profitable; one study reported annual sales of $1614 per cow for zero-grazed cattle (Tumutegyereze 1997), another reported a cow in a zero-grazing enterprise produced $1327 worth of milk sales (CNRIT 1999) which, after the costs of production are deducted, generated an income of $495; in contrast a study in peri-urban dairies showed total farm profits (1-3 cows) were only $52 (Fonteh *et al.* 2005).

Major constraints reported by farmers include cattle disease, theft, disposal of manure and high cost of inputs (Atukunda *et al.* 2003; Mwiine 2005). On the other hand, constraints noted by external analysts include predominance of middlemen resulting in adulteration and spoiling of milk, asymmetries of information leading to over-priced inputs and under-priced outputs, a weak formal sector, lack of credit and delayed payments to farmers (Dannson

[2] This value-laden term is commonly used for exotic cattle originating in Europe and bred for high milk production, but often lacking resistance to African diseases and tolerance of African environmental conditions. It will be used for the sake of clarity.

*et al.* 2004). The constraints of a disabling policy environment currently faced by the Ugandan and African smallholder sector have interesting parallels in the history of dairy development in America and Europe (see Box 11.2).

**Box 11.2** The struggle continues: lessons from the dairy development history

Milk is a culturally loaded commodity and its symbolic value as wholesome goodness and purity made it a favored organizing tool for social reformers. In America, urban dairying grew rapidly after the 1850s when breast-feeding fell out of favor for cultural reasons (Du Puis 2002). Cattle were kept in unhygienic and over-crowded "swill dairies" and fed on hot brewers wastes straight from the still. Temperance leagues joined with physicians to campaign against these filthy conditions and resultant "white poison", and call for "pure country milk" (Shaftel 1978). Consolidation and concentration of dairies was actively encouraged by (an otherwise non-interventionist) government. As Roosevelt's director of public health said in regard to the dairy sector "One of the real sources of trouble in the milk industry is that the great bulk of the milk comes from the small farm…. It is evidently much easier to control, educate, and regulate a few large contractors than hundreds of small independent dealers" (Rosenau 1912). Farmers both questioned the effectiveness of new technologies being imposed and stressed that the expense of implementing them would drive small local producers out of business and thus raise the price of milk beyond what working class families could afford (Koslow 2004), but ultimately lost the battle. The last century has seen a steady exodus from family farming and increasing dominance of industrial producers; dairies with more than 500 cattle now produce nearly half the milk in America, and less than 1 percent of the population are farmers.



## OBJECTIVES, APPROACH AND METHODS OF THE CASE STUDY

Researchers from Makerere University and the International Livestock Research Institute (ILRI) designed and implemented the study. Its objective was to assess both qualitatively and quantitatively the benefits to urban livestock-keepers' livelihoods and associated risks to their health and public health more generally to show how evidence-based decisions on appropriate policy and action for these activities can be made. The approach is of an information-rich case, combining participatory and conventional surveys, that manifests the phenomenon of city dairying intensely but not extremely[3] (Patton 1990).

An innovative and important part of our urban dairy case study was the risk-based approach to investigating hazards of dairying. A major challenge to food safety epidemiologists in developing countries is selecting from the universe of hazards (see Box 1 above), those that are of most importance to the health of communities. Selection of the four hazards for biological testing was based on public health importance as well as anecdotal information. This choice, though to some extent informed by existing knowledge, may have led to biases given the incomplete knowledge of the importance of hazards in developing countries. The four hazards selected were:

- *Brucella abortus* in milk, the cause of undulant fever, a serious disease with a wide variety of symptoms which may include fever, neuro-psychiatric problems and testicular pain.
- Total bacteria and total coliforms present in milk, a rough indicator of milk hygiene and cow health

[3] This sampling strategy "permits logical generalization and maximum application of information to other cases because if it's true of this one case it's likely to be true of all other [similar] cases" (Patton 1990)

- *E.coli* O157:H7, a cause of gastro-intestinal disease and, less frequently, serious kidney disease and blood disorders
- Antimicrobial residues in milk, which may disrupt the normal gut bacterial flora which acts as a barrier against infection and rarely cause allergic reactions in susceptible people[4].

As described in the previous chapter, ten of Kampala's 98 Parishes were purposively chosen for the study, presenting a range of urban and peri-urban parishes using Kampala City Council's classification system. Livestock-keeping households were selected from a list drawn up in each parish or identified by local partners. The selection of households was non-probabilistic, since comprehensive sampling frames were not available and some leader-based or self-selection occurred (with resultant implications of decreased generalizability beyond the sample). Using different sources to identify farmers increased sample comprehensiveness. Participatory Urban Appraisals (PUA) with, on average, seven participants were carried out using a checklist in each of the ten parishes. Next, questionnaire-guided interviews were conducted in 150 cattle-keeping households and 50 neighboring households without livestock, with the livestock manager (cattle-keeper) and household head respectively. Questions covered education, income and awareness of policy related to urban dairying. For cattle-keepers questions on husbandry and hygiene practices as well as production and health were included; the age, sex and breed details on 713 animals, of which 357 were adult cows, were reported.





We collected 165 milk samples and 245 serum samples from the 150 cattle-keeping households. Blood was tested for *B. abortus* antibodies using the serum agglutination test (SAT) and milk was tested for *B. abortus* antibody using the milk ring test (MRT) (Morgan *et al.* 1978). In addition, milk was cultured in a medium which permits growth of bacteria and total bacterial counts and total coliform counts were estimated using petrifilms (3M PetrifilmTM) and positive samples tested for specific 'O157' and 'H7' antibodies (Denka Seiken Co. Ltd, USA). Milk was tested for common antimicrobial residues by the Charm Farm-960 and Charm Rosa Test (Charm Sciences Inc., USA) according to manufacturer's recommendations.

We investigated risk management by constructing a 'stable to table' pathway model starting at the cow and ending with the consumer. For each step we identified practices that were likely to mitigate risk. Next a linear regression model was developed to predict the number of different strategies practiced, using variables from the questionnaire with theoretical or empirical bases for inclusion. Some households could not be included as too many data were missing, so the final sample size was 121 of the original 150 households. Robust standard errors were used to account for clustering of respondents by parish. A checklist (Ryan 1996) was used to ensure the assumptions of linear regression were met; diagnostic tests conducted did not reveal problems that would invalidate the model.

[4] There is reasonable evidence to suggest that use of antimicrobials in farm animals may contribute to the development of antimicrobial resistance in pathogens affecting humans, although scientists generally agree that the problem is largely due to misuse of drugs used to treat humans. On the other hand, there is very little evidence of actual harm from ingestion of veterinary antibiotic residues, and it has been argued that levels found in animal products are unlikely to cause ill effects (Gomes & Demoly 2005).

## BENEFITS OF CATTLE-KEEPING

The focus group discussions showed that agriculture was the main occupation for most cattle keepers (64 percent) and over a third of participants claimed cattle keeping was their principal occupation, suggesting that dairying is a specialized occupation. This is consistent with other studies of urban farming in neighboring Kenya (Kang'ethe *et al.* 2007 a & b), which find livestock keepers are more likely to farm for commercial reasons than those growing crops, and that cattle keepers are the most commercially minded. Only 13 percent of the questionnaire respondents (hereafter referred to as respondents) were formally employed; employment generation was considered an important subsidiary benefit of urban dairying.

The PUA found milk was by far the most important benefit of dairying, with manure, cattle sales and employment playing subsidiary roles (see Table 11.1). However, cattle contributed less than a quarter of household income for half the respondents, while only 15 percent obtained more than half their income from dairying. Again, this is consistent with other studies of urban farming (Prain *et al.* forthcoming), indicating a diversified portfolio of livelihood strategies. Farmers also cited benefits from household consumption of milk production. Milk and dairy products are important sources of protein and micro-nutrients, some of which are found only in animal products, and this is an important health benefit (see Chapter 6). Milk consumption in Uganda has doubled in the last decade to around 30 liters (or kilograms) per capita annually (40 liters in urban areas), but is still far below the levels internationally recommended (e.g. FAO recommends 200 kg and the US Department of Health recommends 248 kg per year, USDH 2005).

**Table 11.1** Benefits accruing from cattle production in ten urban and peri-urban parishes in Kampala using proportional piling

| | | Mean proportion of specific benefits associated with cattle production | | | |
|---|---|---|---|---|---|
| Parish | Type of parish | Milk sold/ consumed | Manure sold/ used in own fields | Employment | Cattle and calves sold |
| Bukesa | Urban | ..........<br>10 (9-13) | ..<br>2 (2-5) | ...<br>3 (2-5) | .....<br>5 (1-4) |
| Kamwokya | Urban | ..........<br>10 (8-16) | .<br>1 (0-3) | ...<br>3 (2-5) | ......<br>6 (1-8) |
| Ggaba | Urban transition | ...........<br>11 (9-13) | ....<br>4 (2-5) | ...<br>3 (2-3) | ..<br>2 (1-4) |
| Banda | Urban transition | ............<br>12 (9-13) | ...<br>3 (2-5) | ..<br>2 (2-4) | ...<br>3 (2-4) |
| Bukasa | Urban transition | ...........<br>11 (9-13) | ...<br>3 (2-5) | ...<br>3 (2-3) | ....<br>3 (1-4) |
| Bukoto | Urban transition | .............<br>13 (10-16) | .<br>1 (0-3) | ...<br>3 (2-5) | ...<br>3 (1-7) |
| Buziga | Peri-urban transition | ..............<br>15 (12-20) | ..<br>2 (0-3) | .<br>1 (0-3) | ..<br>2 (1-4) |
| Kyanja | Peri-urban | ............<br>12 (9-13) | ...<br>3 (2-5) | ...<br>3 (2-4) | ..<br>2 (1-4) |
| Mpererwe | Peri-urban | ............<br>12 (5-17) | ...<br>3 (0-6) | 0 (0) | .....<br>5 (0-12) |
| Komamboga | Peri-urban | .........<br>9 (0-12) | .........<br>9 (5-13 | .<br>1 (0-6) | .<br>1 (0-3) |
| Total score | | 115 | 31 | 22 | 32 |

**Note:** The numbers show the mean (and range) of five cattle-keeping farmers per Parish distributing 20 beans to represent the total household income.

The importance of milk is not surprising given the urban context, but contrasts sharply with the situation in agro-pastoral farming systems which predominate in Africa and much of Asia. In those systems, traction and manure are the dominant reasons for cattle keeping (Sere & Steinfield 1996). In urban farming, like intensive farming of industrialized economies, manure is often regarded as a problem rather than a product. Dutch farmers, for example, pay up to $30 a ton to dispose of manure, and European countries now have legislation strictly limiting the amount of animal manure that can be applied to land (Oenema 2004). In contrast, developing countries typically suffer from a scarcity of organic fertilizer and manure is regarded as a valuable output rather than a problem. Indeed, a study among agro-pastoralists in West Africa found that manure was ranked above milk in terms of benefits provided by cattle (Grace 2005). It would appear that urban dairy farms in Kampala are sufficiently small and dispersed that manure is a source of profit rather than cost.

The household sample survey showed there were on average four cattle per household, 73 percent of them of the improved, high-yielding type. This proportion, higher than official estimates of 50 percent, is again supported by other studies (Ossiya *et al.* 2003; Fonteh *et al.* 2005; Staal & Kaguongo 2003); cattle represent a considerable embodied value given that the price of an improved dairy cow in Uganda is as much as USD $500-1000. The official under-estimation both of the number and productive potential of city cows leads to similar under-estimation of their importance to livelihoods and local economies and consequently deficiencies in institutional support (credit, health delivery, input supply and distribution) and technical advisory services. It is also easier to take action against an activity if it is perceived as minor and affecting very few people; until recently, the keeping of cattle in Kampala was illegal, although in practice action was rarely taken.

Farmers reported an average milk yield of 10 liters per cow per day, considerably more than the 1-2 liters per day produced by indigenous African cattle (Agyemang *et al.* 1987), but considerably less than the 25 liters average daily production in industrial farms in, for example, Great Britain (MDC 2006). This production short-fall is partly genetic (the cross-bred cows used in Kampala have lower potential than pure dairy breeds found in the UK) and partly environmental (heat stress and endemic diseases of tropical countries lower output) but the fact that farmers in this study obtained lower yields than reported from agricultural stations and from neighboring Kenya suggests that farmers are choosing to produce at less than maximum levels (Staal & Kaguongo 2003). High production increases input costs and places metabolic stress on the cow, increasing susceptibility to disease; as such it may be a rational management strategy. Lameness, mastitis, retained placenta, milk fever, displaced internal organs and keto-acidosis have all been conclusively linked to high production in dairy cows; for western cattle, like western humans, the main diseases are now 'life-style' rather than infections (Le Blanc *et al.* 2006). Faced with higher health risks, as well as input costs and given the easily-saturated Ugandan milk market, farmers' decisions not to maximize production seem both rational and conducive to dairy cow welfare.

In countries with poorly performing financial markets, livestock act as savings, insurance and collateral, allowing consumption smoothing and decreased household risk. Farmers recognized the sale of cattle and calves as a major benefit, but unlike in commercial farming where animals are sold at fixed intervals dictated by the production cycle (reflected in dedicated markets for day-old calves, in-calf heifers, cull cows etc.), farmers in this study typically accumulated cattle and then sold them to meet planned or unplanned household needs. Examples of the former are school fees and bride-price payments, while examples of the latter are sickness and funerals.

## HEALTH RISKS ASSOCIATED WITH URBAN DAIRYING

Perceived health risks associated with urban cattle production in Kampala were assessed using proportional piling (a participatory appraisal technique) in the focus groups. Zoonoses or infectious diseases transmissible from cattle either directly or via milk, specifically tuberculosis and brucellosis, were ranked highest, followed by accidents caused by cattle roaming in the city.



When milk samples from the surveyed households were tested using the milk ring test (MRT), 44 percent of the households had milk containing antibodies to B. *abortus.* Individual cow prevalence based on the serum agglutination test (SAT) was 42 percent. These tests are often regarded as preliminary and indicate that a cow has been exposed to *brucella* by infection or vaccination and its immune system has mounted an attack, rather than confirming that the milk contains *brucella* organisms, per se. For example, using an enzyme linked sorbent immunoassay (ELISA), Kang'ethe *et al.* (2007a) found *brucella* antibodies in only about 1 percent of Nairobi milk samples, from dairy and non-dairy households. Another type of brucellosis, *B. melitensis*, a known and serious zoonosis of small ruminants and emerging cattle disease (CDC 1997), was not investigated in this study.

Brucellosis is certainly a problem for people in Kampala; a study among hospital patients with chronic fever found 13 percent had antibodies to *B. abortus* and 26 percent antibodies to *B. melitensis* (Natala 2003). Eight previous studies from Uganda report cattle *brucella* prevalences ranging from 3 to 33 percent with most results towards the lower end; comparing our results suggests brucellosis might be more prevalent in urban dairying. However, a pan-African review of brucellosis in cattle found no relation between farming system and prevalence (Mangen *et al.* 2002).

Depending on the parish, from 0 to 33 percent of milk samples had unacceptably high levels of bacterial contamination of milk (as defined by the East African community standards) while from 0 to 23 percent had unacceptably high levels of coliforms. Total bacterial counts are an imprecise measure of poor milk hygiene as counts may be high because of mastitis (inflammation of the udder) or other factors. One study in Uganda found that nearly half the cows had sub-clinical mastitis, suggesting that this might be a more important source than poor hygiene (Muhumza 2001). Interestingly, the bacterial loads of smallholder milk compare well with those of milk in the formal sector in Uganda where a study found from 27 to 77 percent of packaged, pasteurized milk had unacceptably high bacterial counts (Lukwago 1999). Poor microbiological quality of pasteurized milk was also reported by studies in neighboring Kenya (Omore *et al.* 2005).

Of the 165 samples examined for *E. coli* O157:H7, 18 out of 69 isolates were suspect when cultured on specialized growth medium, but only two were serologically confirmed as positive (1.8 percent). Such low prevalence is similar to that found among Nairobi milk samples from urban dairying and non-dairying households (2.2 percent, Kang'ethe *et al.* 2007b). Despite under-developed surveillance systems in Africa, there are many reports of *E. coli* O157:H7 (Raji *et al.* 2006). Cattle are the major reservoir of *E. coli* O157:H7, e.g. 5.2 percent of pooled cattle fecal samples among Nairobi urban cattle (Kang'ethe *et al.* 2007b). Infection is via oral ingestion of pathogens from cattle feces that contaminate food, water or environment, while person to person transmission can be important in institutional settings. The levels of infection in cattle milk found in this study are similar to those of initial studies in the North but later investigations there suggested prevalences ten times as high, so further investigation is warranted.

A total of 165 milk samples were screened for the presence of some broad-spectrum antimicrobials in milk and 14 percent tested positive for residues above the recommended maximum residue limits. Milk samples that tested positive for residues on screening were tested specifically for beta-lactam drugs (popular antibiotics related to penicillin) at levels above maximum residual limits and 13 percent were positive. Antibiotic use is higher in industrial dairies in the North because intra-mammary antibiotic treatments are given routinely, whereas in smallholder systems antibiotics are only used if infection is suspected.



The presence of hazards does not always imply harm to human health. Of the two pathogens present, *E. coli* O157:H7 was found at low levels in cattle milk, and though *Brucella abortus* was not detected directly, the high level of antibodies suggest this disease may be common in the cattle population. Both pathogens have multiple potential exposure pathways (ways of getting from animals to humans) including food, water, environment, cattle to person and, for *E. coli*, person to person. Milk is a major route of transmission for brucellosis and a minor route for *E. coli* O157:H7. In the absence of information about the most important exposure routes, it is difficult to estimate globally the risk of *E. coli* O157:H7 infection from dairy cattle; but given the seriousness of the disease it certainly warrants further investigation. As with brucellosis, consumer practices (93 percent boil their milk) have a major role in decreasing the risk of adverse effects: boiling is completely effective at eliminating *E.coli* and partially effective at eliminating antibiotic residues (see risk mitigation below).

For urban agriculture policy makers it is necessary to distinguish between the negative externalities associated with the product and those associated with the place of production. Some dangers to human health in milk are present no matter where it originates, others are more frequent in milk from rural areas, and still others more frequent in milk from urban dairies. For example, tuberculosis is considered a disease of confinement while leptospirosis is more associated with extensive farming. Because this study focused only on urban dairies, it was not possible to answer the question empirically as to how much harm is associated with urban as opposed to generic dairying, but review of the literature would suggest that, in Uganda, health externalities are not especially associated with city dairies: among the hazards examined in the present case study, brucellosis is thought to be more prevalent in extensive African farming systems than urban areas (Mangen *et al.* 2002). Risk factors for *E.coli* O157:H7 in cattle include age, breed, season, housing, herd management and feeding, but there is no information on their relevance in the East African context which would allow us to judge whether city or rural farms are more affected. Some studies have shown that antibiotic residues are higher in milk coming from rural dairies (Omore *et al.* 2005). Hence, for the hazards examined, there is no evidence yet to suggest that they present relatively greater risk in urban versus rural settings.

## INDIGENOUS RISK MITIGATION STRATEGIES

Having identified possible hazards in milk, the case study went on to examine how production, marketing and handling factors affected milk safety and how risk might be better managed. Risk management, the key to moving from a zero-sum mentality to one where win-win situations are the mutually agreed objective, is most highly developed in, and for, situations that are linear and hierarchically organized, as in a meat processing plant, for example. This case study offers an analysis of risk mitigation strategies in the urban smallholder sector where production and informal marketing systems are non-linear, shifting, probabilistic and self-organized. By highlighting the spontaneous achievements of farmers and consumers, it opens the door to new approaches to managing health risks of urban dairies, based on empowering stakeholders to assure the safety and wholesomeness of the food they produce or buy.

We analyzed the extensive information on the practices of dairy farmers and consumers obtained during the study from a risk assessment perspective, first developing a pathway model describing the movement of milk from the cow to the consumer. This had six critical control points where interventions may prevent or eliminate a food safety hazard or reduce it to an acceptable level (FAO & WHO 2001).

1. Contact between cow and hazards in the environment
2. Contamination of milking shed with cow excreta and secretions
3. Contact between milk and containers or the environment
4. Handling of milk by processors
5. Storage and transport
6. Practices of food processing pre-consumption

The average of 17 risk mitigation strategies per farmer found on the pathway from stable to table showed a rich variety of farmer and consumer risk management strategies already in use, as shown in Figure 11.1

**Figure 11.1** Practice of risk mitigation strategies for decreasing hazards associated with milk by actors in Kampala at different Critical Control Points along the stable to table pathway

| Hazard Transmission | | Risk mitigation strategies currently practiced (%) | | | |
|---|---|---|---|---|---|
|  | Ecosystem to cow | Keep only one species<br>Zero-graze<br>Use own land only for feed<br>Avoid common grazing<br>Keep local breeds | 29%<br>38<br>41<br>56<br>27 | Treat cattle often<br>Don't keep calves<br>Use Artificial insemination<br>Vaccinate against brucellosis | 31%<br>39<br>44<br>1 |
|  | Milk shed to cow | Use feed/water trough<br>Have concrete/stone floor<br>Use bedding | 94<br>96<br>41 | Stack manure<br>Have a waste disposal strategy | 11<br>96 |
|  | Milk shed / dairy to milk | Have washable shed wall<br>Have metal/tin roof<br>Store containers off floor<br>Keep milk bar dry | 100<br>96<br>29<br>45 | Use just metal/ glass vessels<br>Use piped water<br>Keep premises clean<br>Depose waste >5m away | 19<br>75<br>51<br>38 |
|  | Milk handler to milk | Use hot water to clean<br>Use soap to clean<br>Wear protective clothing<br>Wash hands with soap before handling milk | 18<br>81<br>1<br>59 | Have no discharges/ wounds<br>Have clean hands<br>Have clean/short nails<br>Access to latrine<br>Good personal hygiene | 97<br>79<br>81<br>98<br>49 |
|  | Transport to milk | Don't drink unsold milk | 10 | Don't sell/store unsold milk<br>Sell milk quickly (=6 hrs) | 90<br>82 |
|  | Milk to consumer | Treat milk<br>Avoid drinking raw milk<br>Check milk quality by smell/taste | 50<br>93<br>48 | Don't consume milk until withdrawal period passed | 64 |

Most were used at the milk processing premises (five strategies), followed by the milk handler (three strategies) and cow shed (three strategies). Some strategies used are completely effective, such as boiling milk for managing risk from *B. abortus* or observing milk withdrawal for managing risk from antibiotic residues, while others reduce but do not eliminate specific risks, such as the effect on coliform bacteria of selling milk within six hours of milking.

Some limitations of our study are that we did not check on application of some other risk mitigation strategies identified in developing countries, such as disinfection of the cow-shed, teat dipping, tail-hair trimming, feeding calves colostrum, using calf pens to reduce calf-to-calf contact, exposing dairy vessels to sunlight, composting manure, wearing gloves or protective clothing while handling manure, washing hands after contact with animals etc. (FAO 1990). These could usefully be investigated in future studies. Further, we lacked information on the motivation or cultural context for risk mitigating practices, some of which may be carried out for other reasons than milk safety. For example, cows may be kept permanently in stables because of their high value or land scarcity rather than to decrease their exposure to pathogens, and milk might be boiled because it is consumed in tea (customarily prepared by boiling milk, tea and water together), rather than to destroy bacteria. Socio-cultural and anthropological information could provide insight on the stability of practices and on how they can be built on, informed and improved to sustain and enhance their risk mitigating effect, while public health messages could be tailored to local understandings.

**Table 11.2** Factors associated with the number of household risk mitigation strategies used

| Factors | Descriptive statistics | Coef. | Robust se | p | 95% Conf. Interval | |
|---|---|---|---|---|---|---|
| Farmers believe UA is legal | 54 farmers | 2.169 | 0.802 | **0.024** | 0.355 | 3.983 |
| Number of household appliances | mean 2.08 | 2.429 | 0.649 | **0.005** | 0.960 | 3.897 |
| Productivity orientation (l milk/herd size) | mean 1.78 | 0.702 | 0.225 | **0.012** | 0.194 | 1.210 |
| Farmers have experienced harassment over UA | 4 farmers | -3.693 | 1.818 | 0.073 | -7.806 | 0.420 |
| Farmers consider disease the major constraint | 84 farmers | -1.604 | 0.736 | 0.057 | -3.269 | 0.062 |
| Access to electricity and water | 86 farmers | 2.602 | 0.581 | **0.002** | 1.287 | 3.916 |
| Constant | | 12.356 | 1.081 | 0.000 | 9.910 | 14.802 |
| Number of clusters 10 | R squared=0.335 | | | | | |
| Number of observations 121 | | | | | | |

The regression model demonstrated that access to services, belief that urban farming was legal, wealth and productivity orientation were associated with higher use of mitigation strategies, while those reporting cattle disease incidence were associated with lower use of mitigation strategies. The model explained 34 percent of the variation in the dependent variable (number of risk mitigation strategies used by farmers).

Access to services (water and electricity) makes the use of hygiene related mitigation measures easier. Cleaning the cow shed and the milk processing area as well as washing hands and utensils are facilitated by the availability of running water. Electricity may be directly used in processing and selling, but good lighting also makes cleanliness or its absence easier to inspect.

Many of the risk mitigation strategies used require information, effort and time as well as money, and farmers invest in disease mitigation when they feel more secure through believing their activities are recognized as legal. Another finding (significant at p<10%) was that farmers who had been harassed by officials used fewer risk mitigation strategies.

Wealth, as measured by a proxy index of possession of household appliances such as televisions and phones, had a highly significant relation with the use of mitigation strategies. The capacity to invest in resources such as soap, electricity, water, vaccines and so on is increased by wealth, which may also be associated with higher education, another factor usually positively linked to hygienic practices. Wealthier people may also be influenced by their community status to adopt some practices while poorer farmers, with less 'face' to lose, may be more inclined to cut corners on hygiene, suggesting special supports may be needed for lower-income producers.

Productivity orientation was measured by the proxy of liters of milk divided by number of cattle. Farmers producing more milk from fewer cows – representing more intensive systems – were linked with greater use of mitigation strategies. This is probably both because the farmers tend to be more professional and because there is greater need for mitigation, intensively kept animals being more vulnerable to disease.

Although it may seem paradoxical that farmers reporting cattle disease as their major constraint were less likely to use mitigation strategies (significant only at $p<10\%$), it is possible that those with less capability to invest in risk mitigation may take a more fatalistic or defeatist attitude. This is consistent with our findings presented in Chapter 2, that some farmers who perceive risks may be powerless to implement mitigation strategies due to their poverty.

The practical conclusion we drew from the model was that providing infrastructure and legitimization of urban agriculture may be effective strategies for improving practices and decreasing risks. However, poorer farmers and those using less intensive farming methods will need special support to improve their practices and so reduce the risk from consumption of their products. Adoption of risk mitigation varied from farm to farm, suggesting a role for farmer-to-farmer extension in improving milk safety (Plates 14 and 15).



## GENERAL DISCUSSION AND CONCLUSIONS

For Kampala stakeholders, our study shows the many significant contributions of smallholder dairying to income generation, household nutrition, employment generation and soil fertility. The findings also confirm the presence of hazards that harm human health. Importantly, it identifies the practices of actors along the milk value chain that reduce risk. A finding of profound implication for policy is that banning urban dairying may decrease milk safety through reducing risk mitigation practices. This paradoxical effect of food safety legislation was also found in a Brazilian study of the meat sector: the rationale being that illegality chills investment, blocks access to information on, and reduces social incentives to follow, good practices (Azevedo & Bankuti 2002).

For the wider audience of urban agriculture, veterinary and public health stakeholders, our study offers additional insights. Public health studies typically focus on health problems and their resolution. Our dual approach of assessing benefits as well as harms, and looking at what people are doing right as well as wrong, captures more of the system under study as well as being more farmer friendly. The following concepts that could radically enlighten the management of food safety in poor countries also emerge from our case study:

1. ***Risk based resource allocation.*** Resource allocation should be based on risk, meaning the probability of adverse consequences and their severity. This departs from current non-evidence based management (e.g. the regulation in Tanzania which permits the keeping of four cows but not of five). Similarly, it is better to tackle first the problems that cause most harm when resources are scarce. This requires identifying all hazards present and indicating their relative importance. Out of the 160 or so biological and many thousand chemical hazards potentially present in milk, our study looked at only two and one respectively. We have no way of knowing if these three are among the most important hazards in Kampala, although they were identified as such by stakeholders. Worldwide, E.

coli O157:H7 is considered among the 50 most important infectious diseases (WHO 2002) but there are many, more important, diseases that we did not assess. Globally, brucellosis is considered of less importance than *E.coli* although of significance in the communities in question, while the contribution of antibiotic residues to the global health burden is probably negligible.

2. ***Risk tolerance.*** it is hard for decision-makers and the public to accept that "Zero risk does not exist". There are almost no substances that are always dangerous or always safe. Some exposure to hazards is inevitable, the question being to establish the acceptable or appropriate level of risk. Obviously, this requires taking into account the benefits of UA as well as the harms, and the cost, equity and feasibility of mitigating risks. Setting appropriate levels of protection is a societal decision and should take into account social, economic and other issues of concern, including governments' obligation to protect their citizens' Right to Food as mentioned in Chapters 1 and 4 above. Different communities may choose different levels, and levels can change over time (Perry *et al.* 2005).
3. ***Risk is multi-source*** **and all sources need to be considered.** For example, halving the cases of salmonellosis from wastewater irrigation will have little impact if 99 percent of cases are transmitted through contaminated food (Bartram *et al.* 2001). Brucellosis is an occupational disease as well as milk borne, *E.coli* O157:H7 may be transmitted via meat, water or even from human carriers while antibiotic residues are present in all animal products. We did not consider the importance of sources other than milk, although without this it is harder for policy makers to decide what should be done about hazards in milk. Literature would suggest that milk is a major route for brucellosis but probably minor for *E.coli* 0157:H7.
4. ***The risk pathway.*** Hazards have an origin and may increase, decrease, and move before entering people. Our study mapped hazard pathways and identified critical control points where action can be taken to reduce hazards. This aids understanding of the many routes to risk reduction goals; it has been found most useful to specify the goal and leave the way of attaining it to stakeholders using various combinations of locally possible risk management options (WHO 2006). Although we mapped pathways, we did not measure changes in hazards along the pathway, a useful subject for further research.
5. ***Incrementalism.*** Standards, rules and norms developed in rich countries have probably hindered rather than helped poor countries to improve food safety when applied in their contexts. Instead of imposing standards that cannot be complied with, policy makers might look for attainable, cumulative improvements based on the local situation. Every degree of risk reduction saves lives; where the optimal technologies cannot (yet) be adopted it is still useful to make gradual changes that work towards higher standards. Our focus on indigenous mitigation strategies shows the benefits attainable by encouraging good practices already present.

Our case study suggests that risk principles can be usefully applied to food safety problems in developing countries and that cultivating a participatory, evidence-based process will improve understanding and management of both benefits and harms associated with urban livestock. In the case of Kampala, the study results appear to have achieved this more nuanced objective by figuring among the body of evidence that helped influence the revision of the Kampala municipal by-laws concerning urban agriculture, including livestock activities, as described in Chapter 12 below.

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