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REVIEW

Pathways from livestock to improved human nutrition: lessons learned in East Africa

Valerie L. Flax[1] · Emily A. Ouma[2] · Isabelle Baltenweck[3] · Esther Omosa[3] · Amy Webb Girard[4] · Nathaniel Jensen[3] · Paula Dominguez-Salas[3,5]

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Abstract

The Livestock CGIAR (Consultative Group on International Agricultural Research) Research Program (Livestock CRP) generated evidence on livestock-to-nutrition pathways through the implementation of nutrition-related livestock programs and research. In this analysis, we compiled lessons learned from Livestock CRP projects and identified recommendations for nutrition-sensitive livestock programming and research in the context of the literature and through the development of an updated livestock-to-nutrition pathways framework. The updated framework shows the interconnected nature of the three main pathways—own-consumption, income, and women's empowerment—along with other pathways and includes contextual factors, which were lacking in previous frameworks. Eight Livestock CRP projects were reviewed, including five integrated livestock and human nutrition projects, two studies on drivers of food choice, and one study to develop and test a tool to measure nutrition outcomes among pastoralists. Key lessons learned were that women's empowerment in livestock-to-nutrition pathways is important, but challenging to measure; engaging male partners improves nutrition in livestock-keeping households; nutrition-sensitive livestock programs and researchers should articulate and measure livestock-to-nutrition pathways they are addressing; livestock keeping does not guarantee access to animal source foods; context and livelihoods are not static and program design should be adapted accordingly; and digital data collection systems can provide accurate and timely nutrition information. Key recommendations include developing tools to fill measurement gaps; creating shorter versions of validated tools for ease of use; using complexity-aware evaluation methods to capture the interconnected nature of livestock-to-nutrition pathways and shifting livelihoods; and conducting pathways analyses to better understand linkages in the framework and further refine it.

Keywords Livestock · Nutrition · Nutrition-sensitive programs · Pathways · Women's empowerment · Social and behavior change communication · Drivers of food choice · Africa

1 Introduction

The theoretical impact pathways between agriculture and nutrition are complex (Herforth & Harris, 2014). Within the overarching connections from agriculture to nutrition, the pathways between livestock and nutrition have been further delineated (Dominguez-Salas et al., 2019; Randolph et al., 2007). These livestock-to-nutrition frameworks show pathways that may have either positive or negative impacts on human dietary intake and nutritional status, including anthropometric measurements and micronutrient status. The three main pathways from livestock to nutrition are own-consumption, income, and women's empowerment. Own-consumption is the most direct pathway, when household members consume the milk, eggs, or meat they produce through livestock keeping. Animal source foods (ASFs) provide important nutrients in the diet and contribute to micronutrient status, growth, and health (Dror & Allen, 2011; Murphy & Allen, 2003). The income pathway hypothesizes that households sell the livestock or ASFs they produce and use the proceeds to purchase nutritious foods and other

✉ Valerie L. Flax
vflax@rti.org

1 RTI International, Research Triangle Park, North Carolina, USA

2 International Livestock Research Institute, Kampala, Uganda

3 International Livestock Research Institute, Nairobi, Kenya

4 Rollins School of Public Health, Emory University, Atlanta, GA, USA

5 Natural Resources Institute, University of Greenwich, London, UK

inputs beneficial to nutrition, such as health care (Ahmed et al., 2000; Alderman, 1987; Darrouzet-Nardi et al., 2016; Mullins et al., 1996; Nielsen, 1996). Improvements in women's empowerment are hypothesized to strengthen the role of women in household decision-making and lead to increases in own-consumption of home-produced ASFs or decisions about using income to purchase nutrient-rich foods, ultimately resulting in improved diets and human nutritional status (Kumar et al., 2018; Miller et al., 2014; Mullins et al., 1996; Murty et al., 2016; Nielsen, 1996; van den Bold et al., 2015). Through several other pathways, livestock can increase overall farm productivity, including crop quality and yields through use of manure as fertilizer and use of animals for ploughing, access to transport and mobility, and production of fuel through manure (Manzeke et al., 2014). These factors can lead to improved market and resource access, increased income, and improved agricultural production (Powell et al., 2018), all of which ultimately lead to improved human nutritional status. Conversely, livestock keeping may also result in human exposure to animal pathogens (Ercumen et al., 2017; Kwong et al., 2020), which may negatively affect human health and nutritional status (Chen et al., 2021b). The increased physical activity and energy expenditure required to care for livestock can also negatively impact human nutritional status when dietary intake is insufficient (Daum & Birner, 2021; Sellen, 1996). Some livestock, such as buffaloes, donkeys, or mules, are used for transport or ploughing, which may reduce human physical activity and energy expenditure required for those tasks. Women often play a major role in caring for livestock and time spent on these activities may reduce time available for food preparation, selfcare, childcare, and infant and young child feeding, which can negatively affect the nutritional status of women and children (Johnston et al., 2018; Kumar et al., 2018; van den Bold et al., 2021).

Livestock-to-nutrition frameworks can be useful tools to guide research and programs that seek to study or carry out activities in livestock-keeping households with the aim of improving human nutritional status in any of its forms. However, to increase their utility, it is necessary to understand the evidence undergirding each of the pathways and the gaps in evidence. Several reviews have found that the evidence for agriculture-to-nutrition pathways is modest, but the choice and measurement of variables along the pathways is inconsistent across studies and the quality of the study designs is mixed (Berti et al., 2004; Grace et al., 2018; Leroy & Frongillo, 2007; Ruel et al., 2018; Sharma et al., 2021; Webb Girard et al., 2012; Webb & Kennedy, 2014). Within those reviews, a subset of studies included livestock, so the evidence for livestock-to-nutrition pathways is even more limited.

Among studies that assessed the relationship between livestock keeping and human diet or nutritional status or that included a nutrition-sensitive livestock intervention, we identified several areas where evidence was limited or conflicting. Studies tended to examine associations between pairs of elements in livestock-to-nutrition pathways or measured the impact of livestock productivity and production interventions on nutrition outcomes, but very few studied or followed full pathways, likely because of limitations in indicators to adequately measure some constructs along the pathways and funding or logistical constraints in implementing or evaluating pathways (Olney et al., 2009, 2013; Sharma et al., 2021). Nutrition-sensitive livestock intervention studies often included multiple and quite different components (e.g., poultry raising, homestead gardening, and nutrition behavior change communication) (Dulal et al., 2017; Fanzo et al., 2010; Kuchenbecker et al., 2017; Marquis et al., 2018; Murty et al., 2016; Olney et al., 2009, 2015; Osei et al., 2017), making it challenging to tease out whether the livestock component had an impact on diet and nutritional status. Some elements of livestock-to-nutrition pathways are not commonly measured in nutrition-sensitive livestock research, with few studies including information on changes in livestock productivity or production (Alderman, 1987; Berti & Cossio, 2017; McKune et al., 2020), effects of livestock keeping on women's time use and subsequent impacts on their other tasks (Johnston et al., 2018; Kumar et al., 2018; van den Bold et al., 2021), or pathways linking physical activity, ploughing, or use of livestock for transport to nutritional status (Sellen, 1996). Other elements of livestock-to-nutrition pathways, particularly those related to women's empowerment, decision-making, and control of assets, have been measured using dissimilar methods or indicators (Kumar et al., 2018; Miller et al., 2014; Mullins et al., 1996; Murty et al., 2016; Nielsen, 1996; van den Bold et al., 2015). When measurement of pathway elements or selection of indicators varies across studies, it is difficult to discern clear patterns. Studies testing the association of livestock keeping with human morbidity have had mixed results (Chen et al., 2021a; de Bruyn et al., 2018; Kaur et al., 2017; Penakalapati et al., 2017; Zambrano et al., 2014). However, contact with livestock feces has been linked with environmental enteric dysfunction and subsequent deficits in anthropometric status among children (Harper et al., 2018).

Research on the impact of nutrition-sensitive livestock interventions on diet, including ASF consumption and dietary diversity, and nutritional status, including anthropometric indicators and micronutrient status, also has had mixed results. Livestock keeping interventions led to increases in consumption of ASFs in several studies (Berti & Cossio, 2017; Fanzo et al., 2010; Kuchenbecker et al., 2017; McKune et al., 2020; Mullins et al., 1996; Murty et al., 2016; Olney et al., 2009, 2013; Rawlins et al., 2014), but several other

studies found no change in ASF consumption (Alderman, 1987; Boedecker et al., 2019; Kassa et al., 2003; Marquis et al., 2018; Rosenberg et al., 2018) or increases only in households where production (Begum, 1994) or number of livestock (de Bruyn et al., 2018) was high. For those studies where ASF consumption did not change, the lack of pathways analysis made it difficult to understand why the interventions did not have an effect. Several studies that included a livestock keeping component found increases in dietary diversity of women and/or children (Boedecker et al., 2019; Darrouzet-Nardi et al., 2016; Dulal et al., 2017; Fanzo et al., 2010; Kuchenbecker et al., 2017; Marquis et al., 2018; Olney et al., 2015; Osei et al., 2017), while two studies found no change in dietary diversity (Olney et al., 2009; Rosenberg et al., 2018).

Research on the effects of livestock keeping on child anthropometry has had inconsistent results and findings frequently differ for different anthropometric indicators within the same study. Several studies have shown that keeping livestock, often in combination with other agriculture and empowerment interventions, increased weight-for-age z-score (WAZ) or reduced underweight (Fanzo et al., 2010; Marquis et al., 2018; McKune et al., 2020; Miller et al., 2014; Rawlins et al., 2014) or increased weight-for-height z-score (WHZ) or reduced wasting (Kumar et al., 2018; McKune et al., 2020; Rawlins et al., 2014), while others found no effect of livestock keeping on underweight (Olney et al., 2015; Osei et al., 2017) or WHZ or wasting (Marquis et al., 2018; Osei et al., 2017). Similarly, some the same studies showed that livestock keeping reduced child stunting or increased height-for-age z-score (HAZ) (Fanzo et al., 2010; Kaur et al., 2017; Marquis et al., 2018; Miller et al., 2014) while other studies found no effect on child stunting or HAZ (de Bruyn et al., 2018; Kumar et al., 2018; McKune et al., 2020; Olney et al., 2015; Osei et al., 2017; Rawlins et al., 2014). Researchers have previously noted that the short duration of interventions, nutritional status at baseline, and age of children at enrollment may make it difficult to detect effects on child height or stunting (Leroy et al., 2020; Sharma et al., 2021), so appropriate selection of nutrition outcome indicators in nutrition-sensitive livestock research is essential (USAID Advancing Nutrition, 2020).

Few livestock studies have measured micronutrient status of participants, but they have generally shown benefits of combined livestock and agriculture interventions. Two studies found that interventions that included livestock reduced anemia in mothers and/or children (Olney et al., 2015; Osei et al., 2017), and third study showed that vitamin A deficiency in children decreased in a multipronged intervention that combined food distribution and livestock rearing, among other components (Fanzo et al., 2010). Given that measures of nutritional status are at the far end of the pathways, researchers have called for focusing attention of nutrition-sensitive agriculture and livestock research on nutrition outcomes that lie most directly on causal pathways, such as diet, rather than anthropometry or micronutrient status (Ruel et al., 2018).

For the last decade, the Livestock CGIAR (Consultative Group on International Agricultural Research) Research Program (Livestock CRP for short) has been contributing to the evidence base on livestock-to-nutrition pathways through implementation of nutrition-related livestock projects by the International Livestock Research Institute (ILRI) and its partners. ILRI is a research organization that aims to improve food and nutrition security and reduce poverty in low- and middle-income countries by developing and testing practices for the safe and sustainable production and use of livestock. The main aim of this paper was to summarize the findings of the Livestock CRP's livestock and nutrition projects, compile lessons learned and missed opportunities, and identify next steps for nutrition-sensitive livestock programming and research within the context of the literature and frameworks delineating the pathways from livestock keeping to human nutritional status.

2 Methods

The preparation of this paper followed an iterative process. The authors compiled project documents, reports, and peer-reviewed publications from all Livestock CRP projects that directly measured and/or intervened to improve human diets or nutritional status. These were reviewed by one author, who then held a series of conference calls with individual project leaders to elicit lessons learned using a structured list of questions followed up by probing questions. Lessons learned were summarized in Excel tables. Two authors proposed using either the Randolph et al. (2007) or Dominguez-Salas et al. (2019) livestock-to-nutrition pathways diagram for framing the paper, but agreed that these frameworks lacked key pathways and linkages between pathway elements. All authors met to discuss a process for adapting the frameworks, then one author conducted a narrative literature review, summarized in the introduction to this paper, to identify evidence for updating the pathways diagram. Findings from the literature review and from the Livestock CRP project review were shared with all authors to read prior to holding group conference calls where we collaboratively used MURAL to place elements onto the framework and show linkages. One author then used the brainstormed MURAL framework, conducted a further review of the literature where authors identified additional gaps, and drafted

an updated version of the framework for comment by other authors. We held several additional group conference calls to further refine the framework diagram for the paper and incorporate the contextual domains, which were modeled on the domains in the agriculture-to-nutrition framework (Herforth & Harris, 2014). During one framework meeting, other ILRI experts in gender, animal science, and food safety attended and were invited to provide their feedback on the draft diagram, which was incorporated into the final version of the framework.

We acknowledge that the literature review conducted to set the context for the ILRI nutrition-sensitive livestock projects and for updating the livestock-to-nutrition framework was not exhaustive. Similarly, this paper focused on ILRI livestock projects and did not review all nutrition-sensitive livestock interventions. For a review of non-ILRI livestock interventions, we refer readers to the systematic review conducted by Ruel et al. (2018).

3 Results

3.1 Adapted livestock-to-nutrition pathways framework

We have adapted the Randolph et al. (2007) and Dominguez-Salas et al. (2019) livestock-to-nutrition pathways diagrams to include several additional elements. The new livestock-to-nutrition pathways framework shows the three main pathways—own-consumption, income, and women's empowerment—in the boxes with thicker outlines (Fig. 1). Like the Randolph framework, it demonstrates the interconnected nature of the framework constructs and shows whether relationships between framework constructs are positive or negative. The new framework includes empowerment, which was lacking in the Randolph framework but was part of the Dominguez-Salas framework. It differs from the Dominguez-Salas framework by excluding elements

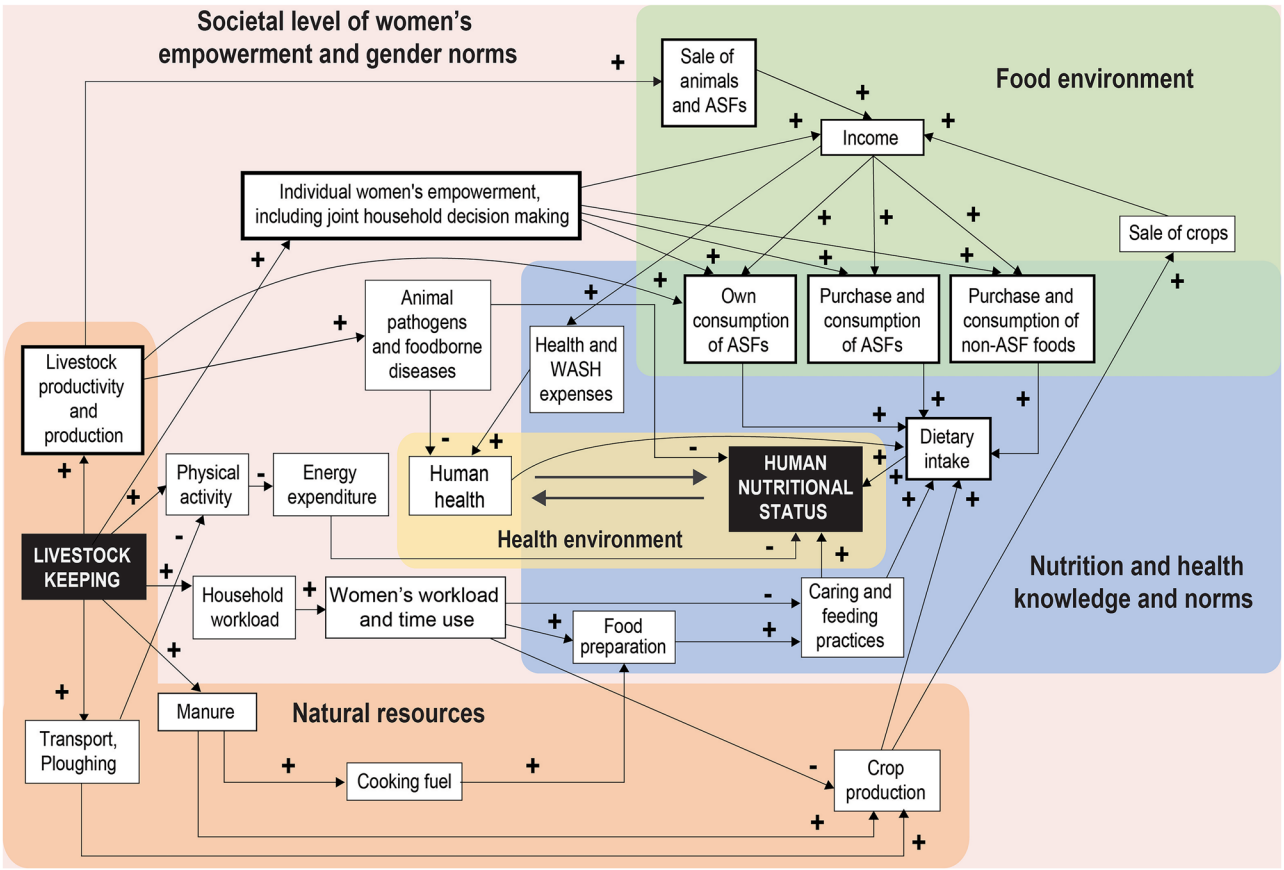

Fig. 1 Livestock-to-nutrition pathways framework. ASFs, animal source foods. The colored boxes in the background of the diagram show the contextual domains, which are underlying factors that influence constructs within the framework and that nutrition-sensitive livestock programs frequently seek to modify. The pluses and minuses on the arrows indicate whether a construct positively or negatively impacts a neighboring construct in the diagram. Constructs that are part of the three main livestock-to-nutrition impact pathways—own-consumption, income, and women's empowerment—have thicker lines around them.

that were specific to an emergency context, streamlining elements (such as income) which were shown several times in the diagram, and adding some missing linkages between framework elements. The new framework also shows various contextual domains (i.e., societal level of women's empowerment and gender norms, food environment, health environment, nutrition and health knowledge and norms, and natural resources), which are underlying factors that influence constructs within the framework. These contextual domains are important because nutrition-sensitive livestock programs frequently implement interventions to modify them. For example, programs can improve acceptability, availability, and accessibility of ASFs and enhance their allocation to those who need them most, namely women and children, by including social and behavior change communication (SBCC) to change perceptions about food proscriptions, implementing women's empowerment interventions to influence gender norms and shift decision-making, and designing market strategies to strengthen ASF value chains.

3.2 Livestock CRP project descriptions and lessons learned

The nutrition-sensitive work conducted within the Livestock CRP included a total of eight projects—five integrated livestock and human nutrition studies and programs that include nutrition-related SBCC, two descriptive studies related to drivers of food choice, and a study to develop and test a tool to measure nutrition outcomes among pastoralists. This section describes the projects, their main findings, and lessons learned. Table 1 summarizes the projects and how they relate to livestock-to-nutrition pathways. Fig. 2 shows the pathways diagram with the pathway elements and linkages included in Livestock CRP projects shown with solid lines and the elements and linkages not included shown with dashed lines. Fig. 2 also indicates which projects focused on or measured each pathway element. We found that Livestock CRP projects tended to be situated within the food environment, nutrition and health knowledge and norms, and societal level of women's empowerment and gender norms domains of the livestock-to-nutrition framework, and to a lesser extent within the health environment domain. The projects were only connected to the natural resources domain in that most of them were conducted in livestock-keeping households and two of them specifically promoted livestock production.

3.2.1 Enhancing milk quality and consumption for improved income and nutrition in Rwanda

Project description In Rwanda, ILRI and partners worked in collaboration with the National Child Development Agency and the Rwanda Biomedical Center to design, implement, and evaluate an SBCC intervention promoting own-consumption of milk by young children in households that had received an improved breed of cow through the government's "One Cow per Poor Family" livestock asset transfer program, commonly referred to as "Girinka" (Flax et al., 2021). Government community health workers (CHWs) were trained to use a set of five counseling cards, a poster, and a brochure to conduct home visits with the target households and to guide community-level meetings, which any community member could attend. The SBCC intervention was based on formative research. It focused on the own-consumption pathway and was evaluated using a cluster-randomized controlled design that tested impacts on children's milk consumption. The analysis compared households that had a Girinka cow and received SBCC with households with a Girinka cow only and found no significant differences in children's milk consumption measured by 24-hour recall. The main reason children's 24-hour milk consumption did not increase was the low production of the cows, largely attributed to poor husbandry practices and lack of advisory and support services. However, in the SBCC study arm, mothers' intervention exposure was associated with increases in the percentage of children who consumed milk two or more times per week.

To better understand the nutrition impacts of the government's Girinka program, the study also included a third group of households that were eligible for Girinka but that had not yet received a cow. A comparison of the two Girinka study groups with the Girinka-eligible group at baseline showed that household food security, child milk consumption, child minimum dietary diversity, and HAZ were higher in households participating in Girinka compared with those that were Girinka eligible but not yet participating.

Lessons learned The Girinka program itself improved household food security enough to have a beneficial effect on child nutrition outcomes in participating households as compared to Girinka eligible households, but low production of the cows among Girinka beneficiaries limited the ability of the SBCC intervention to increase consumption of home-produced milk. Researchers were able to determine this because they collected data on milk production, sale of home-produced milk, milk consumption, and other factors in the livestock-to-nutrition pathways. To achieve stronger nutrition impacts from the Girinka program, the government should add a component on livestock productivity best practices that addresses challenges to low production, including appropriate husbandry practices, herd health, nutrition, and breeding. Collaboration with the government on the SBCC intervention was time intensive because it involved coordination at both national and district levels on the design and implementation of the intervention. However, the effort paid off when the ASF SBCC messages from the study were

Table 1 Summary of Livestock CGIAR (Consultative Group on International Agricultural Research) Research Program nutrition-related projects, livestock-nutrition framework constructs measured, and lessons learned

Project, Location, and Date	**Pathways** and **Constructs Measured**	**Project Description**	**Key Findings** and **Outputs**	**Main Lessons Learned**
1. Enhancing Milk Quality and Consumption for Improved Income and Nutrition in Rwanda Nyabihu and Ruhango Districts, Rwanda 2017–2020	Pathways: own-consumption Constructs: maternal knowledge of care and feeding practices; child morbidity; expenditures; milk production; milk handling; household decision-making; child animal source food (ASF) consumption; child feeding practices; child anthropometry	Randomized controlled trial targeting Girinka households with children aged 12–29 months at baseline. Girinka is a government program that gives an improved breed of cow to poor households that do not already own a cow. Study arms: (1) Treatment arm (Girinka + social and behavior change communication [SBCC] intervention), (2) Control arm (Girinka only), (3) Control arm (Girinka-eligible households but no cow yet). SBCC messaging in study arm 1 on appropriate nutrition practices and importance of ASF in diets of young children. Emphasis on cow milk consumption—when to introduce, quantities, proper handling and hygiene practices, and how to recognize allergies.	• SBCC intervention exposure was associated with children consuming milk more frequently • No association between SBCC intervention and milk consumption on 24-hour recall • Lack of change in daily milk consumption was related to low productivity • Girinka program itself was associated with increased child milk consumption, dietary diversity, and height-for-age z-score • SBCC tools and processes were developed and some messages were adopted by government for new community health worker counseling cards	• Collaboration with government was challenging but essential for implementation and intervention uptake • Nutrition SBCC interventions in the context of livestock keeping can modify frequency of ASF consumption • Livestock production interventions may need to accompany nutrition SBCC in livestock asset transfer programs to ensure adequate ASF production for home consumption and/or sale
2. Engaging Men in Supporting Maternal and Child Consumption of Milk and Other Animal Source Foods in Rwanda Nyabihu and Ruhango Districts, Rwanda 2020–2021	Pathways: own-consumption, empowerment Constructs: male engagement and support; men's nutrition knowledge; child feeding practices; expenditures; milk production; milk handling; household decision-making; household ASF consumption	Same households as Enhancing Milk Quality study, including those from all arms with a male partner in the household because a delayed intervention for the Enhancing Milk Quality study was provided to both control groups. SBCC messaging on maternal and child nutrition, especially importance of ASFs and role of men to support nutrition.	• An SBCC intervention targeted at men increased milk and overall ASF consumption among their children • Joint decision making about use of home-produced ASFs increased • Fathers' knowledge, awareness, and support for milk and other ASF consumption increased	• Fathers preferred to receive nutrition information from other fathers • Family members should be included in nutrition-sensitive livestock interventions because their participation can increase gender equity, joint household decision making, and ASF consumption

Table 1 (continued)

Project, Location, and Date	Pathways and Constructs Measured	Project Description	Key Findings and Outputs	Main Lessons Learned
3. Accelerated Value Chain Development Eighteen counties (Turkana, Isiolo, Garissa, Wajir, Marsabit, Makueni, Kitui, Taita Taveta, Elgeyo Marakwet, Nandi, Uasin Gishu, Tharaka Nithi, Kisumu, Homa Bay, Siaya, Migori, Busia, and Vihiga), Kenya 2015–2021	Pathways: own-consumption, income, empowerment Constructs: nutrition knowledge; dietary intake; livestock production; income	This was a development project that aimed to mainstream nutrition SBCC in dairy and livestock interventions in Kenya to improve availability, access to and consumption of milk (value chain commodity) and other diverse diets for women of reproductive age (15–49 years) and children (0–23 months).	• Developed agrinutrition dialogue cards • Trained community health volunteers and extension workers to use the cards and provide nutrition messaging to community members • Livestock production technologies were implemented and market linkages facilitated • Changes in nutrition knowledge and practice were documented through program surveys	• Collaboration with government and leveraging existing government structures was key for successful implementation and sustainability • Nutrition was mainstreamed in value chain work from the outset, but time and patience were required for livestock value chain actors to see the benefits of human nutrition integration • Targeted advocacy can increase nutrition investments and accountability by governments
4. MoreMilk Project - SBCC Component Select counties in western and southeastern Kenya 2017–2021	Pathways: own-consumption, income, empowerment Constructs: production; ASF consumption; child feeding practices	The purpose of this SBCC strategy was to inform the nutrition strategy of the Accelerated Value Chain Development project in Kenya and to guide nutrition strategies of related projects. The goal of the SBCC strategy was to close the gap between milk production and consumption.	• ASFs were the most expensive foods across vendors, communities, and seasons • Some ASFs were not considered appropriate for pregnant or lactating women or very young children • Problem and solution trees for key behaviors were developed along with recommended SBCC approaches to address contextually specific behavioral determinants	• Formative research is needed to understand target audience for SBCC and map out desired changes, behavioral bridges, and relevant behavior change activities • Local partners with knowledge in livestock, nutrition, and empowerment were essential to support SBCC design
5. More Milk in Tanzania Mvomero and Handeni Districts, Tanzania 2012–2017	Pathways: own-consumption, empowerment Constructs: women's empowerment; household food security; income; production; dietary intake; nutritional status	This project facilitated dairy market hubs for small-scale livestock producers in areas largely populated by pastoralists. Data collection to understand the relationship between women's empowerment, household food security, and nutrition included surveys and two rounds of qualitative data collection. The project developed and tested the Women's Empowerment in Livestock Index (WELI).	• Women's empowerment was associated with women's and children's dietary diversity but not household food security in the surveys • Qualitative results agreed with survey results on the association of women's empowerment with nutrition but not food security	• Human and social capital domains of empowerment need to be better captured • Guidance on contextualization of WELI and shortening the tool may be necessary • Governance related to natural resources may be relevant to empowerment in some contexts

Table 1 (continued)

Project, Location, and Date	Pathways and Constructs Measured	Project Description	Key Findings and Outputs	Main Lessons Learned
6. Understanding the Drivers of Diet Change and Food Choice Among Tanzanian Pastoralists to Inform Policy and Practice Mvomero and Handeni Districts, Tanzania 2016–2018	No specific pathways targeted Constructs: women's empowerment; dietary intake; production	This study examined different factors that influence food choice among Tanzanian pastoralists undergoing rapid sedentarization. This observational study included focus group discussions, in-depth interviews, and key informant interviews.	• Climate affected food security and influenced decisions to settle via impacts on livestock health, reduced profits from cattle and milk sale, increased food prices, reduced number of meals, reduced healthy food intake, and increased human communicable and noncommunicable disease • Sedentarization and accompanying interethnic exchange drove changes in women's status, responsibilities of household members, and the types of food consumed	• Climate, political, and sociocultural pressures are changing livelihoods, gender roles and responsibilities among pastoralists with subsequent influences on diet patterns • Programs should consider how these and other factors influence food choice when designing interventions to influence diets
7. Drivers of Demand for Animal Source Foods in Low-Income Households in Nairobi Nairobi County, Kenya 2017–2018	Pathways: empowerment Constructs: women's empowerment; household decision-making; ASF consumption; nutritional status	This was a mixed-methods study of the demand- and supply-side factors that influence ASF purchase and consumption in low-income settlements. It included qualitative and participatory data collection, household and beef retailer surveys, and measurement of maternal and child hemoglobin.	• Food safety related to ASF consumption was a major concern • Households adopted several strategies to address these perceived risks • Women's empowerment was related to hemoglobin in women and to children's growth • Decision-making about ASF allocation depended on a couple's relationship, perceived quality of the retailer, ASF prices, and age of household member	• Objectively measuring food safety of beef vendors was challenging • Household members have their own perceptions of vendor food safety, which is not objective • Women's empowerment is important for maternal and child nutrition outcomes
8. Improving Dietary and Health Data for Decision-Making in Agriculture and Nutrition Actions in Africa Samburu County, Kenya 2018–2022	Not focused on pathways Constructs: nutrition knowledge; care and feeding practices	Caregivers recorded and tracked their own and their children's health and nutrition using a purpose-built app design for innumerate and illiterate people. The app provided feedback on actions to take if nutrition and health indicators were suboptimal. Trained caregivers to record data and to understand the tracking feedback and trained community health volunteers to collect benchmark data.	• A pictorial data collection app was developed • Data collected by mothers and community health volunteers did not differ • Mothers liked using the app and receiving feedback about child nutrition • Mothers requested feedback on maternal nutrition	• Participation was high • Mothers were willing and able to provide high frequency data on themselves and their children • Providing mothers with mobile phones loaded with the app and paying them a small incentive for sub-weekly data was less expensive than conducting monthly surveys among pastoralists

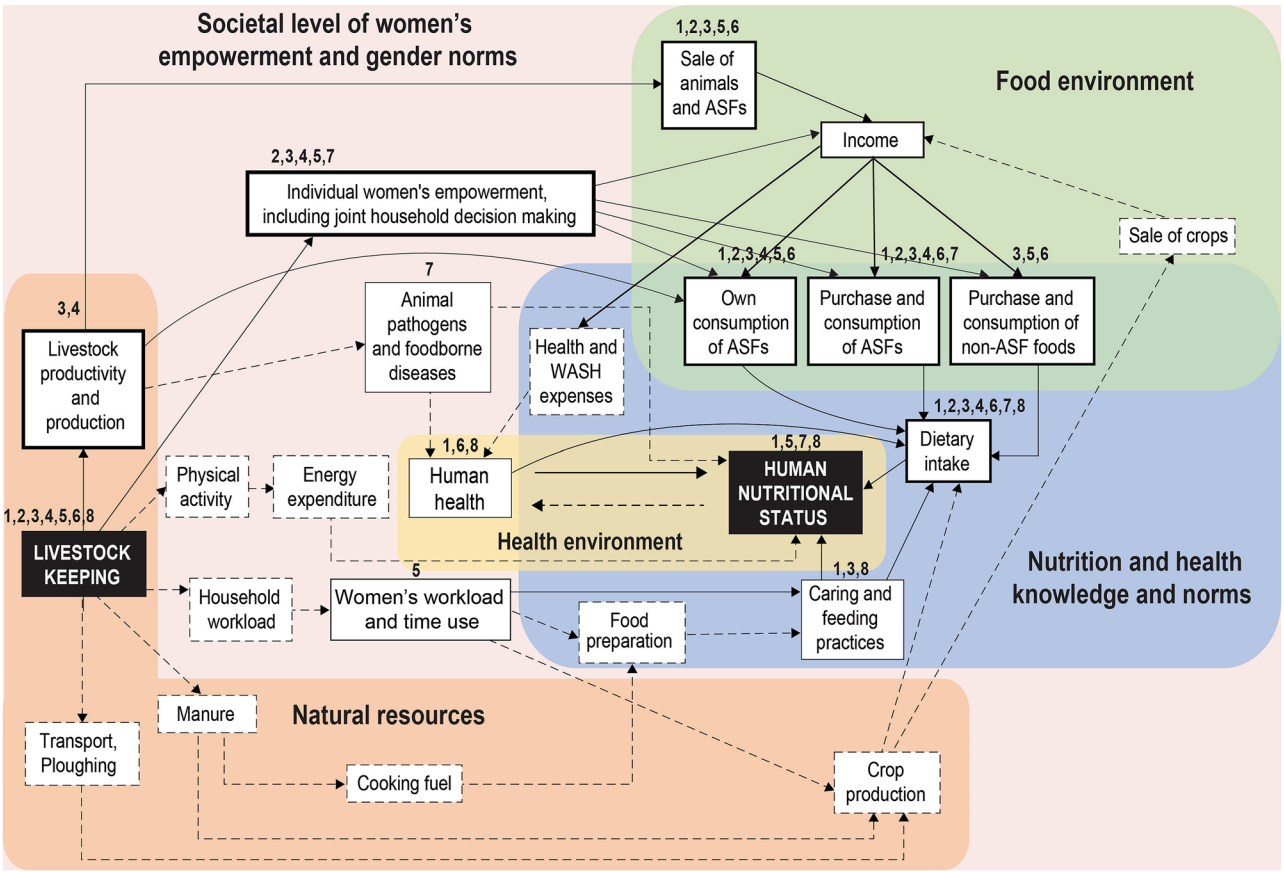

Fig. 2 Livestock-to-nutrition pathways included in Livestock CRP projects. ASFs, animal source foods. The colored boxes in the background of the diagram show the contextual domains, which are underlying factors that influence constructs within the framework and that nutrition-sensitive livestock programs frequently seek to modify. Constructs that are part of the three main livestock-to-nutrition impact pathways—own-consumption, income, and women's empowerment—have thicker lines around them. The numbers next to some constructs show which Livestock CRP projects measured or acted on those constructs. Constructs and linkages not measured in Livestock CRP projects are shown with dashed lines

incorporated into the revised national counseling cards for CHWs (Kimani, 2021). In addition, implementation through government structures enhanced sustainability of the SBCC activities.

3.2.2 Engaging men in supporting maternal and child consumption of milk and other animal source foods in Rwanda

Project description The Engaging Men study in Rwanda was a follow-on to the Enhancing Milk Quality and Consumption study described above. The Engaging Men study focused on the own-consumption and empowerment pathways to increase children's milk consumption by encouraging fathers in cow-keeping households to ensure that their children received milk from the household's cow; increase joint decision-making by men and women about use of home-produced milk; and increase fathers' purchases of ASFs for children (Flax et al., 2023). The Engaging Men study SBCC intervention was also designed in collaboration with the National Child Development Agency and Rwanda Biomedical Center based on formative research. The print materials included a poster and a leaflet. The intervention was implemented through community health extension officers and model fathers, who held small group meetings of fathers. Fathers were also reached through text messages and megaphone messaging blasts in their communities. The SBCC intervention was evaluated in a cohort of fathers using a pre-post design. The percentage of children 12-59 months reported to have consumed milk two or more times in the last week increased significantly from baseline to endline. More fathers purchased milk and other ASFs for their children, and more households reported that men and women made decisions jointly about use of home-produced milk at endline compared with baseline. Fathers' knowledge,

awareness, and support for milk consumption by their children increased from baseline to endline. Most men reported hearing the SBCC messages through group meetings and text messages and had received the leaflet.

Lessons learned SBCC for fathers about child milk and ASF consumption using strategies specifically designed for men can successfully engage them and encourage them to increase their support for child nutrition. Men preferred to get nutrition information through other fathers. This study supports the importance of engaging men, increasing gender equity, and encouraging joint household decision-making for improved ASF consumption in livestock-keeping households. It also reinforces the necessity of including gender norms as a key contextual factor in livestock-to-nutrition frameworks.

3.2.3 Accelerated value chain development in Kenya

Project description The USAID Accelerated Value Chain Development (AVCD) program was designed to mainstream nutrition SBCC in dairy and livestock interventions in Kenya to improve availability of, access to, safety of, and consumption of milk and other diverse foods by women of reproductive age (15–49 years) and children (6–23 months) (AVCD, 2016). The program worked through three main livestock-to-nutrition pathways—production, income, and women's empowerment. County staff in eighteen counties were trained as trainers who then trained Ministry of Health community health volunteers (CHVs) and Ministry of Agriculture community agriculture extension workers. The trained CHVs and agriculture extension workers offered nutrition messaging and training to caregivers, including mothers, fathers, and grandparents, in groups and/or during individual home visits, and by leveraging existing value chain trainings. The aim of the trainings was to increase knowledge and change dietary and care practices for women and young children, particularly dietary diversity for women of reproductive age (15-49 years) and feeding practices for infants and young children < 2 years of age. The AVCD program supported the development of a set of agrinutrition dialogue cards that were used as the main training materials for CHVs and agriculture extension workers and which these cadres used to communicate with community members. The dialogue cards have now been adopted for use throughout Kenya and are available on the government of Kenya website http://kilimo.go.ke/wp-content/uploads/2021/01/Community-Dialogue-Cards-on-Agri-Nutrition.pdf (AVCD, n.d.). The nutrition fact sheets developed by the program were used for resource mobilization in the counties. To ensure adequate livestock health and production, which was hypothesized to increase ASF consumption, the program used the Participatory Rangeland Management toolkit to improve pasture rejuvenation and grazing plans (Robinson et al., 2020) and implemented syndromic disease surveillance in collaboration with communities and county governments. Market linkages were facilitated for farmers and were expected to result in increased income at household level, which was intended to translate in improved ASF consumption. Encouraging and supporting women to equitably participate in value chain activities and facilitating them to move to more productive nodes of the value chain empowered them make better decisions that benefited themselves and their children.

This was a development program, so evidence generation was not the main goal. However, through annual surveys as part of the routine monitoring and reporting to the donor, the program documented changes in infant and young child feeding and care practices as well as improved dietary practices and care for women. In the livestock value chain intervention sites, women's minimum dietary diversity score showed a steady improvement from 3.5 food groups at baseline in 2016 to 5.2 food groups in 2018 (out of the recommended 10 per day), which was attributable to the SBCC (Wamwere-Njoroge et al., 2021). This declined to 4.9 food groups in 2020 because of the COVID-19 pandemic. There were also perceived improvements in knowledge on food preparation and hygiene and in utilization of health and nutrition services, but this was not systematically measured by the program.

Lessons learned Defining the livestock-to-nutrition pathways of interest at the outset of the program and actively working to target those pathways during implementation allowed the program to improve mothers' and children's diets. Collaborating with and leveraging existing government structures (e.g., working through the community health system) rather than setting up parallel structures was key for strengthening systems, influencing government at county and national levels, facilitating national adoption of the agrinutrition counseling cards, and enhancing sustainability. The nutrition component was mainstreamed in the value chain work from the start of the program, including through sensitization of value chain program staff. For example, before seed for animal fodder was distributed, farmers were sensitized on the nutrition benefits of increased milk at household level. It took a while for breeders, veterinarians, and animal nutrition specialists to see the benefits of incorporating human nutrition messaging into their work, but over time, they integrated animal productivity and human nutrition activities. This type of integration requires patience and planning, and programs should not expect 100% integration to be achieved. It was important to target the right audience with nutrition advocacy and regularly follow up with county decision-makers on agreed commitments to ensure

accountability. This helped obtain increased nutrition investments at county level and ensure that they were allocated on time.

3.2.4 MoreMilk project – SBCC component

Project description The MoreMilk project was intended to produce evidence on leveraging dairy farming to improve child nutrition and health in Kenya and Tanzania (ILRI, 2021). The SBCC component targeted dairy-farming households to assess the drivers of milk consumption and address the gap between increased milk production and household milk consumption. It focused on the own-consumption, income, and empowerment pathways by examining the barriers to improved child nutrition as part of a dairy intervention that worked at the production and market levels. Mixed-methods formative research was used to develop the SBCC strategy for increasing milk consumption in Kenya through the MoreMilk and AVCD programs (Webb Girard et al., 2021). Researchers found that ASFs made up the majority of the most expensive foods across food vendors, communities, and seasons, but the cost of a nutritious diet could be reduced by using typically consumed local foods (maize and milk) from own-production. Participants generally had good nutrition knowledge, and they explained that a diverse diet was enabled by livestock keeping and raising fruits and vegetables. Despite this, the percentage of pregnant and lactating women who achieved minimum dietary diversity for women was low, and economic barriers were mentioned. Also, several ASFs were not considered suitable for pregnant women (milk, small fish, eggs) or lactating women (eggs, meat, small fish). Participants explained that children are served first, while mothers are served last and may go with less food or without food. Problem and solution trees were developed for each of the key behaviors to identify approaches and activities that could jointly influence behaviors. Priority target audiences, desired changes, and behavioral bridges were identified. Recommended approaches were advocacy, community mobilization, and SBCC.

Lessons learned To develop an effective SBCC strategy, it is necessary to have a thorough understanding of the target audience with profiles that describe the characteristics and daily routines of audience segments based on formative research. Mapping out the desired changes, behavioral bridges to those changes, and behavior change techniques and activities to support the changes for target audiences can help guide programming to address barriers and facilitate enablers identified through formative research. Partners with a local presence in the target country and a strong track record in SBCC across multiple domains (e.g., agriculture, women's empowerment, and nutrition) are needed to manage implementation and evaluation. This type of SBCC strategy should be jointly adapted as programs evolve and revisited annually and updated by government and partners.

3.2.5 More milk in Tanzania

Project description More Milk in Tanzania promoted dairy market hubs in order to facilitate access to inputs, services, and markets for small-scale livestock producers (ILRI, 2014). The goal of the project was to improve the livelihoods and food security of pastoralists in a context in which pastoralists are shifting to wage-based, agricultural, or a mix of agricultural and pastoral livelihoods. The project included a mixed-methods research component to investigate the relationship and pathways through which women's empowerment influences household food security and women's and children's diets through the own-production and income pathways (Galiè et al., 2019a). As part of this project, the women's empowerment in livestock index (WELI) was developed and tested (Galiè et al., 2019b). Survey results showed that women's empowerment, specifically access to and control over assets and control over and use of income, was associated with women's and children's dietary diversity (i.e., nutrition security), but not with household food security. The qualitative findings showed that women's empowerment was important for both nutrition security and food security. When women had greater control over assets and income, they were able to allocate milk through own-production for household use or sell milk produced in the household to purchase greater quantities and better quality of food. However, interventions to increase milk production of livestock resulted in men taking more control over household milk use and sales, and men did not prioritize purchases of food for the household (Galiè, 2019). Women are considered responsible for ensuring nutrition security, while men are responsible for ensuring food security. However, women feel that they need a larger role in overall household food security to help their families achieve nutrition security.

Lessons learned A conceptual framework of empowerment that includes economic and social domains is needed to better capture the elements of empowerment that are related to food security and nutrition. An empowerment-nutrition framework should be developed and should include human and social capital domains, which emerged as important in the qualitative data but were not measured through the survey data. It may be necessary to contextualize global measures of empowerment to make them relevant and useful in different settings. Researchers learned that WELI is useful for longitudinal measurements of women's empowerment in livestock-keeping households but recommend accompanying it with qualitative and participatory data collection with

women and men to understand locally relevant elements and the interactional aspects of empowerment. In addition, WELI is a long instrument that is burdensome for participants. More work is ongoing to distill the key elements of the tool so that it can be incorporated into other surveys.

3.2.6 Understanding the drivers of diet change and food choice among Tanzanian pastoralists to inform policy and practice

Project description This longitudinal mixed-methods observational study examined how cultural and gender norms, food access, and food valuation influence food choice among Tanzanian pastoralists in the context of changing livelihoods (Ripkey et al., 2021). The study was not designed to look at livestock-to-nutrition pathways; however, in examining how changing environmental, economic, market, and social factors influenced decisions related to livestock production practices, livelihoods, and diet choices, the study measured some elements within livestock-to-nutrition pathways. The study included two rounds of qualitative data collection using a grounded theory approach and three rounds of market surveys using the Cost of Diet approach in communities that were purposively selected to include varying levels of sedentarization, ranging from the least sedentary communities with large herds and regular seasonal movements of cattle to the most sedentary communities that were strongly crop focused and had few cattle. These distinctions were important for understanding how sedentarization and climate variability impact livelihoods and nutrition outcomes among pastoralists. The study identified two critical indirect drivers, namely climate change and sociodemographic and cultural shifts related to migration and schooling that contributed to more direct drivers. For example, climate variability significantly undermined the viability of traditional cattle-keeping strategies through decreased quantity and quality of grazing lands and water sources as well as increased disease and death of cattle. These climate-related impacts on land, fodder, water, and cattle health reduced milk production, milk sales, and profitability of cattle when sold. To cope, pastoral communities migrated, shifted livelihoods, and modified traditionally gendered household and livelihood responsibilities. Migration, a byproduct of shifting livelihoods, and broader sociopolitical issues contributed to interethnic exchange of food ideas, cultures, and values as well as exposure to religious considerations for foods, thus contributing to shifts in food preferences, especially among younger adults and children. Communities further attributed shifts in food preferences and acceptability to higher prioritization of schooling for children, noting children brought home new ideas about food and nutrition and made requests for new foods to be prepared in the home or to be prepared in new ways. Lastly, market expansion programs, climate variability, and shifting livelihoods to more sedentary crop production altered availability of foods, especially milk and wild foods, in markets and consequently their prices. Collectively, these drivers contributed to declines in consumption of milk, blood, and wild foods and to increases in consumption of staples (e.g., maize meal), fried foods, and more affordable crops available in local markets. The reduction in milk production and consumption was seen as having a negative impact on child nutrition while changes in types of foods consumed and food preparation techniques (e.g., more frying) were recognized as contributing to diabetes and heart disease among adults.

Lessons learned While drivers of food choice go beyond seasonal availability and price, these two factors carry significant weight in point-of-purchase decision-making. As such, both annual price and market availability should be considered when designing policies to increase the consumption of specific, nutritious foods, particularly ASFs, more so than price volatility and affordability. Given the importance of interethnic exchange, religion, and schooling in shaping food choice preferences, programs should consider more diverse platforms for community entry to influence community diets and nutrition. Livelihoods are changing rapidly due to climate, political, and sociocultural pressures with increased fluidity in gendered roles and responsibilities. Agriculture- and livestock-focused safety net programs are needed that both recognize these trends while also providing pastoralists with the economic, livelihood, and social supports necessary to sustain the livelihoods of their choice while ensuring the climate impacts of those choices are minimized.

3.2.7 Drivers of demand for ASFs in low-income household in Nairobi

Project description The Drivers of Demand for ASFs in Low-Income Households in Nairobi study used mixed methods to investigate causes of variability in ASF intake within and between low-income households in informal settlements by collecting information on demand-side and supply-side factors that influence ASF purchase and consumption (Bukachi et al., 2021). The study focused on the income and women's empowerment pathways. The closest and preferred beef retailers were identified through surveys of households with a child 6–59 months and mapped. The qualitative data showed that food safety related to ASF consumption and possible effects on health were a major concern, more so for women than men. Participants worried that ASFs could not be traced to a reliable source, were sold in unhygienic environments, and could lead to health risks if eaten in large quantities or if improperly prepared for consumption. Strategies to address these risks included boiling milk or cooking other ASFs prior to consumption, buying

ASFs from trusted retailers, avoiding vendors in open air or unhygienic settings, and reducing or avoiding ASF consumption. The results from a bargaining power game showed that women's empowerment was associated with increased hemoglobin in women and increased child growth, most likely because women with greater control over decision-making were able to consume more iron-rich foods, such as ASFs. An intrahousehold allocation game showed that there was a tendency to protect the amount of meat and milk for children. In cooperative couples, the woman was willing to take away some meat from her husband to provide more to her children. When the perceived quality of the retailer was better, the participant gave more of her meat and milk to her husband. When beef prices were high, women provided more beef to their children at their own expense.

Lessons learned Several lessons related to measurement were learned in the Drivers of Demand for ASFs study. During the market survey, enumerators were asked to objectively measure hygiene at beef vendors. Researchers found that the assessments by enumerators were still very subjective, even after training, and that without intense training, including standardization exercises, they might not be sufficiently reliable. Further, researchers discovered that consumers' perceptions of the hygiene or cleanliness of a vendor's operation, although subjective, can be very powerful when choosing a retailer and that these perceptions should be considered, even if they might not reflect the objectively measured hygiene level. The intrahousehold ASF allocation game provided rich insights into decision-making about ASF use. Researchers found that it was difficult to analyze the data with different family member structures across households and suggested that future studies use a game with a hypothetical family structure to facilitate analysis, although this approach has other biases so it might require further testing and adaptation.

3.2.8 Improving dietary and health data for decision-making in agriculture and nutrition actions in Africa

Project description The Improving Dietary and Health Data for Decision-Making study aimed to improve access to information on dietary intake, human health, and human nutritional status from and for individuals for whom such information is currently unavailable. To do so, the program developed and tested a smartphone app to be used by caregivers in remote settings to record and receive feedback on their health and nutritional information and that of their children (Jensen et al., 2020). The app was designed for individuals who had never used a phone and are illiterate and innumerate, so it uses pictures and recordings to take women through the steps of collecting the information. Women were provided with training and smartphones, and compensated for the costs of sending the information. The women could participate as little or as much as they liked, up to a maximum of two surveys, one on themselves and one on the participating child, each day. The app also provided the participants with customized messaging on health and nutrition in response to the information that they recorded on themselves and their children. The app was piloted among pastoral women in Samburu County, Kenya for 12 months in 2018-2019. The participants submitted an average of six surveys each week over the 54 weeks that the project was fully active. CHVs were recruited and hired to collect parallel data from the mothers for benchmarking. The app provided feedback on nutrition progress. For example, if children's mid-upper arm circumference was declining or they had morbidity over time, the app told mothers to contact their CHV. Based on the data they submitted, they also received customized recommendations about consumption of specific critical food groups for themselves and their children. These recommendations provided through the app successfully increased consumption of target foods by mothers and children. Analysis of data quality was promising (Jensen et al., 2023). The app was then piloted in three new locations in Kenya, one in collaboration with the Ministry of Health. While not enough is yet known about the data quality or consistency to start integrating it into national health system databases, there is hope that the recent pilots will provide such evidence and integration is a key goal. The project was not designed to study livestock-to-nutrition pathways, but the initial data measured some elements within the pathways.

Lessons learned Mothers were very enthusiastic about collecting data and using the app. Assessments of data quality suggest that there are errors in both the CHV- and caregiver-submitted data but that reasonably simple protocols could be used to dramatically increase data quality and screen out low-quality data. Collecting high frequency—daily and sometimes weekly—data in this manner, proved to be lower cost than collecting monthly data using conventional methods in a pastoral setting in the Kenya arid and semi-arid lands (e.g., where the terrain is challenging and distances between households and communities are often vast). Further, the app provides a channel for communicating customized recommendations directly to the caregivers based on their submitted measurements and offers an important way to get nutrition messages to hard-to-reach pastoral mothers and families.

4 Discussion

4.1 Livestock-to-nutrition framework and the livestock CRP

Several of the projects discussed here explicitly described or even mapped livestock-to-nutrition pathways of interest to form the basis for intervention design by following principles that the nutrition community has adopted for implementation research (Tumilowicz et al., 2018), including using formative research, developing strategies in collaboration with government and other local structures, integrating nutrition messaging from the outset and not just through the usual health and nutrition channels, and incorporating advocacy (AVCD, 2016; Flax et al., 2021; Flax et al., 2023; Webb Girard et al., 2021). Other researchers have specifically studied program impact pathways from agriculture and livestock program inputs to nutrition outcomes (Olney et al., 2009, 2013; Sharma et al., 2021). To improve the feasibility of generating evidence on the pathways, it is essential that nutrition-sensitive livestock programs and researchers explicitly articulate which livestock-to-nutrition pathways they are addressing, how they are addressing the pathways using evidence-based strategies, and how they are evaluating impacts along the selected pathway(s). The new livestock-to-nutrition framework presented in this paper can facilitate the process of mapping pathways of interest in future programs and research.

A major gap that emerged from our mapping of the Livestock CRP projects to the livestock-to-nutrition framework is that the projects tended to focus on own-consumption, income, and empowerment pathways with little to no data collection on livestock productivity practices, livestock production, workload, physical activity, or natural resources-related pathways. In addition, the projects had disparate aims. Some projects focused on small segments of livestock-to-nutrition pathways and others did not define the pathways of interest. Explicit articulation of the pathways targeted in nutrition-sensitive livestock programs and research is needed across future ILRI livestock-to-nutrition projects. Selection of target pathways should be guided by evidence gaps and research or programs designed to address and examine those pathways. This would facilitate building the evidence base and increasing understanding of the importance of different pathways, and how they differ by species (dairy, poultry, pigs, etc.) and livestock systems (pastoral, agropastoral, mixed crop livestock, emerging commercial, etc.).

4.2 Lessons learned across livestock CRP projects

This analysis gleaned specific lessons learned from nutrition-related projects implemented by the Livestock CRP but also gathered overarching lessons learned.

4.2.1 Women's empowerment and involvement of key influencers

Evidence is mounting on the importance of women's empowerment and women's control over assets and decision-making for increasing household consumption of ASFs and equitable intrahousehold ASF allocation and for improving other nutrition outcomes in livestock-keeping households (Galiè et al., 2019a; Jones et al., 2019; Kumar et al., 2018; Miller et al., 2014; Mullins et al., 1996; Murty et al., 2016; Nielsen et al., 2003; van den Bold et al., 2015). However, further research is needed to understand the relative importance of the domains of women's empowerment (e.g., decision-making and control of resources) in driving changes in nutritional outcomes from livestock keeping. Many livestock projects do not measure empowerment in a standard way or do not incorporate it at all. Validated tools, such as WELI, should be used in more studies. With respect to WELI, researchers should design and test a shorter version that can be incorporated into other surveys and develop guidance on whether it should be adapted in different contexts (Galiè et al., 2019b). To accompany WELI, additional tools are needed to measure how empowerment improves purchase and consumption of ASFs and to fill other gaps in the link between empowerment and nutrition.

Livestock programs and intervention studies that want to impact human diets and nutritional status also need to move away from focusing nutrition interventions solely on women and determine how to involve male partners and other key household decision-makers and behavior influencers. In the nutrition literature, there is growing evidence that involving men, grandmothers, and other key influencers is essential for achieving nutrition behavior change and better nutrition outcomes (Aubel, 2012; Bezner Kerr et al., 2008; Martin et al., 2020; Thuita et al., 2015). This experience could be transferred and applied to nutrition-sensitive livestock programming. Mapping out in advance how livestock programs may have unintended negative consequences for women (e.g., increased milk production leading to men taking control of milk sales and household milk use) is essential so that they can be avoided.

4.2.2 Working with governments and community-based organizations

Some projects described here purposefully worked with government structures, community-based organizations, CHWs, CHVs, extension workers, and others. Working with local governments is often challenging and slows down implementation, but it is essential for uptake and sustainability of interventions.

4.2.3 Rapid data collection systems for accurate and timely information

The Improving Dietary and Health Data study showed that new data collection techniques that involve women or caregivers collecting and reporting on their own and their child's nutrition are feasible. This is an important finding for data collection among pastoralists, who are often difficult to reach with surveys and who constitute an important livelihood group for livestock-to-nutrition research. The study demonstrated that the data were useful for government, researchers, and mothers or other caregivers, who received timely and tailored feedback. Further pilots in collaboration with the Ministry of Health indicate the potential for incorporating the data into government systems.

4.2.4 Livestock keeping does not equal production and access to ASFs

The review of Livestock CRP nutrition projects showed that studies and projects should not assume that livestock keeping means that households have adequate ASF production, especially if they are poor or land-poor households or pastoralists affected by climate change (Flax et al., 2021; Ripkey et al., 2021). This points to the need to integrate livestock productivity activities aimed at increasing production in nutrition SBCC interventions and to measure production in studies and projects that are trying to improve nutrition among livestock-keeping households. Few studies on nutrition-sensitive livestock programs sufficiently describe livestock productivity activities or report on changes in livestock production (Alderman, 1987; Berti & Cossio, 2017; McKune et al., 2020; Olney et al., 2009) and, similarly, few of the Livestock CRP projects supported livestock productivity or measured production.

4.2.5 Contexts and livelihoods are not static

Climate change, globalization, and other factors are influencing livelihoods of livestock-keeping households and subsequently leading to changes in gender roles, social norms, and availability and accessibility of ASFs (Ripkey et al., 2021). Nutrition-sensitive livestock programs and research need to take changing contexts and livelihoods into consideration in the design of programs and when identifying pathways to target. To facilitate this process, researchers and program implementers should develop a decision-support tool that accompanies the livestock-to-nutrition framework and that takes the local context into consideration in order to identify and prioritize nutrition interventions.

4.3 Missed opportunities

Four main missed opportunities were identified through the review of Livestock CRP projects. First, the projects did not have an overarching goal with respect to nutrition or evidence-generation related to livestock-to-nutrition pathways. As a result, the projects were quite diverse, which limits the ability of the Livestock CRP to make a stronger contribution to the literature. Second, most studies and projects described here lacked attention to governance issues. This may be important in contexts where land is communally held for livestock grazing or where there is intense land pressure and livestock grazing areas are unavailable. Governance should be incorporated into formative research, program design, and sustainability planning. Third, most projects reviewed included a human nutrition expert, but those that did not felt that it would be helpful to involve a nutritionist when collecting nutrition data or incorporating human nutrition components into a livestock program. Fourth, the Livestock CRP projects tended to focus on large ruminants, rather than smaller livestock, such as poultry or cavies, that women may have more control over, and additional evidence is needed to understand livestock-to-nutrition pathways across livestock species.

5 Conclusions

Nutrition-sensitive Livestock CRP projects have contributed evidence on design and evaluation of SBCC in livestock programs, the importance of women's empowerment and engaging male partners, implementation through existing structures, the role of climate change and shifting livelihoods in relation to gender and nutrition among livestock-keeping households, and the potential benefits of rapid nutrition data collection and feedback loops. Key gaps in nutrition-sensitive livestock research and programming include measurement challenges and research on livestock-to-nutrition pathways. We encourage researchers to use standard tools, such as WELI; adapt existing tools and scales so they are shorter to reduce participant burden; and develop tools to measure parts of the pathways where no tools currently exist. In addition, as complexity of programs and pathways increases, alternative tools and evaluation approaches, such as outcome harvesting and most significant change (Davies & Dart, 2005; Wilson-Grau & Britt, 2013), may be needed. The other key gap is related to research on pathways from livestock keeping to nutrition. We recommend that program implementers and researchers use the livestock-to-nutrition framework to be intentional about selecting pathways and be explicit about why they were selected and how their design and evaluation link to the pathways. More research should include pathways analysis, when possible,

which can be used to better understand the linkages in the framework and further refine it. Given the complex natures of the causal chains from livestock keeping to changes in nutritional status, creating evidence for linkages in the framework requires long-term funding, large-scale projects, and strong research designs with the engagement of local and national governments to support the uptake of learning into integrated livestock and nutrition programming.

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Declarations

Conflict of interest The authors have no conflicts of interest.

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Dr. Valerie Flax is a nutrition epidemiologist and evaluator in RTI International's Global Public Health Impact Center. She has 20 years of experience implementing public health programs and conducting research in low- and middle-income countries. Her research includes the evaluation of large-scale nutrition-specific and nutrition-sensitive programs, design and testing of innovative community-based interventions to improve infant and young child feeding practices, and implementation research related to maternal and child nutrition programs. Dr. Flax serves as an Adjunct Assistant Professor in the Department of Nutrition at the University of North Carolina at Chapel Hill.

Dr. Emily Ouma is a Senior Scientist, Agricultural Economist working with the Policies, Institutions and Livelihoods Program at the International Livestock Research Institute (ILRI). She has 15 years post-doctoral experience conducting research and implementing R&D projects in Sub-Saharan Africa. Her research areas and interest are economic analysis of smallholder agri-food systems, consumer economics, and ex-ante and ex-post impactanalyses of agricultural innovations aimed to enhance value chain competitiveness and improve livelihoods of smallholders. Her research also focusses on application of non-market valuation techniques, estimating willingness to pay from random utility models of discrete/continuous choices to assess potential demand for innovations.

Dr. Isabelle Baltenweck is a development economist with twenty years of post-doctoral experience in agricultural systems in Africa, South and South-East Asia, with a focus on livestock value chains, working at the International Livestock Research Institute (Nairobi Kenya). In addition to leading the ILRI research program on 'Policies Institutions and Livelihoods', she leads the CGIAR's Sustainable Animal Productivity for Livelihoods, Nutrition and Gender inclusion (SAPLING) Initiative, that brings together partners from ICARDA and CIAT, in addition to the ILRI researchers.

Dr. Esther Omosa is a nutrition specialist at the International Livestock Research Institute (ILRI). She has over 15 years of experience in food security and nutrition programming in development and humanitarian setting, working in government and non-government organizations. Esther's research interest are in food systems and livestock-nutrition links, for better nutrition outcomes in women of reproductive age and young children.

Dr. Amy Webb Girard is an Associate Professor in the Departments of Global Health and Epidemiology at Emory University. Her research, teaching, and service focus on the structural and social determinants of health applying a nutrition lens. Her research examines community based, food security, and social behavior change approaches to improve maternal and child health in East Africa and in Atlanta, Georgia. Dr. Webb Girard serves as the co-director of the Maternal and Child Health Certificate program at the Rollins School of Public Health and co-directs the Emory Urban Health Initiative.

Dr. Nathaniel Jensen is a development economist working to reduce poverty. Much of his research has focused on understanding welfare dynamics among pastoralists, the impacts of shocks on them, and mechanisms for mitigating those impacts. He received his Master's from the University of Missouri-Columbia and PhD in Applied Economics and Management from Cornell University. He worked as a Peace Corps Volunteer in Mali, as a Postdoctoral Associate at Cornell University, as a Senior Scientist at the International Livestock Research Institute (ILRI), and now as an independent researcher based in upstate New York.

Dr. Paula Dominguez-Salas is an Associate Professor in food-based strategies for nutrition, at the Natural Resources Institute (NRI), University of Greenwich, and at the International Livestock Research Institute (ILRI), Kenya. She is a veterinarian and a human nutritionist, working in public health. She has over 15 years of experience in food and nutrition security in development and humanitarian settings, as well as experience in food safety. Her research focuses on maternal and child nutrition and she is interested in making food systems more nutrition-sensitive and sustainable.