Association of livestock ownership and household dietary quality: results from a cross-sectional survey from rural India

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Abstract

Background

Studies from India and Africa found that the impact of dairy animal ownership on household nutrition varied greatly, depending on the social and geographic context. There is a paucity of studies from semi-arid rural districts in southern India where livestock rearing is being promoted to improve household income and nutrition as part of watershed development (WSD) projects. The purpose of this study was to (i) assess socio-demographic factors and health determinants of households based on dairy animal ownership; (ii) determine the correlation between milk consumption and other sources of nutrition; and (iii) examine the association between livestock ownership and milk consumption.

Methods

We collected data from an exhaustive household survey in four study villages of Kolar district, applying a cross-sectional design. Kendall's rank correlation coefficient was employed to determine the correlation between milk consumption and other dietary variables. Multivariable logistic regression was used to describe the relationship between dairy animal ownership and household milk consumption.

Results

Full data records were available from 195 households. Less than half of the households (43.1%) owned dairy animals. Households owning dairy animals more often had access to irrigation (58.3% vs 25.2%) and were less often woman-headed (2.4% vs 22.5%). Household milk consumption was significantly correlated with consumption of vegetable variety, egg and meat (all p-values < 0.05). After adjusting for multiple confounders, the odds of dairy animal-owning households consuming milk was 2.11 (95% confidence interval 0.85, 5.45) compared to households not owning dairy animals.

Conclusion

While dairy animal ownership was found to be associated with improved dietary quality, larger households were in a better position to adopt dairy animals, which, in turn, might contribute to better household nutrition. Our study added to the evidence on health inequity in semi-arid rural areas and the importance of socio-geographical context in determining nutritional impacts of developmental interventions.

Background

The period 2016–2025 has been declared the Decade of Action on Nutrition by the United Nations [1]. The underlying reason is that child and maternal malnutrition continues to be a major global challenge as...
a top risk factor for morbidity and mortality worldwide [2], including India [3]. Although considerable progress has been made over the past several years, in 2016, high prevalence of stunting (38%), wasting (21%) and undernutrition (36%) among children under 5 years of age were recorded in India [4]. Dietary diversity is an important determinant of nutritional status of children [5, 6]. Milk is an important source of animal protein, especially for under 5-year-old children [7, 8]. However, analysis of nationally representative data revealed that 5–15% of children in rural areas were at risk of quality protein deficiency, worsening to up-to 42% among adults in poor households [9]. Livestock ownership, especially dairy animals, has been promoted in rural India to support livelihood and nutrition [10].

Literature on the impact of dairy animal ownership on diet and nutrition is available from India and several African countries. Livestock ownership was estimated at 59.7% for households across rural households in India in 2016 [4], and was deemed an important factor determining consumption of animal-sourced foods [5]. The linkage between dairy animal ownership and milk consumption was specifically emphasised [11]. This was corroborated by studies from Ethiopia [8] and Uganda [12]. However, several factors such as globalisation, urbanisation, changing access to education, livelihood and progressive reduction in farm sizes are impacting agriculture as a viable livelihood option, complicating its linkages with food security and dietary quality in rural areas, as was found in a study in northern India [7]. Also, little is known regarding the association between dairy animal ownership and household milk consumption in villages in southern India.

When we recently conducted a qualitative study in Kolar district, a rural semi-arid area in southern India, we found that households that adopted dairy animals for livelihood through the support of watershed development (WSD) projects perceived positive impacts on milk consumption and dietary quality [13]. This pointed to a need for additional quantitative research to deepen the understanding of context-relevant factors, especially keeping in mind the planned promotion of livestock rearing as part of WSD projects in India [14, 15]. Hence, the basis for the current paper was set, and the opportunity for this analysis presented itself when we conducted a cross-sectional baseline survey as part of a health impact assessment (HIA) of a planned WSD project in four villages of Kolar district [15, 16]. The specific objectives of this paper were to (i) assess the baseline status of socio-demographic factors and health determinants of households based on dairy animal ownership; (ii) determine the correlation of milk consumption with other sources of nutrition; and (iii) examine the association between livestock ownership and milk consumption in the designated project area.

**Methods**

**Study design**

A cross-sectional survey was conducted in the study area during April to July 2019 to characterise socio-demographic factors and health determinants. As the number of people living in each village was relatively small, all households were invited to participate. Data from the cross-sectional survey were used for multivariable logistic regression analysis.
Study settings

The study was conducted in four neighbouring villages in Malur sub-district of Kolar district in Karnataka state, India (geographic coordinates: 12°53’–12°54 N latitude and 78°3’–78°6’ E longitude). The total population of these villages was enumerated at 1,340 individuals in 2011 [17]. The main economic activity is agriculture, with finger millet being the most important crop [17]. The region is drought-prone and vulnerable to climate change [18].

Data collection and tools

A structured questionnaire covering topics of household demography, occupation, agriculture, diet, sanitation and access to healthcare was used. The questionnaire was administered by trained field enumerators, and data were directly entered into electronic tablets on the Open Data Kit (ODK) platform [19]. An adult woman (aged ≥ 15 years) of the household was requested to be the respondent, and the alternative was an adult man. Details on the recruitment of field staff and pilot testing of the questionnaire have been described elsewhere [15, 16].

Statistical analysis

Data were downloaded from the ODK Aggregate platform and read into R statistical software version 3.5.1 (on RStudio Version 1.1.456) [20]. Variables were summarised to find missing and inappropriate values. Categorical variables were checked for small cell sizes. We examined the associations of socio-demographic factors and health determinants with ownership of dairy animals; the main explanatory variable, defined as high-yielding variety cows, local variety cows and buffaloes. Because all households in the study area were included, statistical testing for between-group comparisons was not done. Kendall’s rank correlation coefficient (tau) was used to calculate the correlation between milk consumption (binary) and other dietary variables (i.e. vegetable consumption, fruit consumption, egg consumption and meat consumption; each with four ordered categories).

Crude odds ratios (ORs) and 95% confidence intervals (CIs) were calculated for describing the relationship between household milk consumption (the main outcome; binary variable) and a set of predetermined covariates (i.e. ownership of dairy animal, household size, sex of household head, existence of children in household, caste (scheduled caste or SC, scheduled tribe or ST and other; with SC and ST considered as marginalised groups in most regions in India), land ownership, access to irrigation, self-help group (SHG) membership and a dummy variable for wage labour as main income source. Household income (self-reported) data were available but not used as a covariate in our analysis because of high potential for measurement errors, and literature from India suggesting that income was an unsuitable predictor of nutrition in rural areas [11]. Several included covariates are proxies for income, for instance, land ownership, access to irrigation and ownership of motorised vehicles. The covariates were based on a hypothesised causal model of household milk consumption in rural areas in southern India, as ascertained from literature [5, 7, 8, 11, 12, 21] and knowledge of the local context (Fig. 1).
A multivariable logistic regression model adjusting for various covariates was fitted to the data to better understand the causal relationship between dairy animal ownership and household milk consumption. Variables (ownership of other livestock) showing high correlation with the main explanatory variable were eliminated from the final model (Phi coefficient = 0.69). The ORs and 95% CIs were reported and interpreted. Results were considered significant at p < 0.05. CIs were reported only for the ORs despite having conducted a census, to provide an impression of the uncertainty around the estimate, especially keeping in mind the small population size, to aid in generalisability of study results outside of the study population.

Sensitivity analysis was performed by using propensity score matching (PSM) through nearest neighbour matching (NNM) with replacement, using the Matchit package in R statistical software, to increase the comparability of the two groups based on the following covariates: household size, sex of household head, child in household, caste, land ownership, access to irrigation, SHG membership and wage labour. The quality of matching was assessed through quantile-quantile (QQ) plots and two sample t-tests for each covariate. As the matching was deemed to have improved comparability (though having expectedly reduced the sample size), multivariate logistic regression was carried out on this data subset to better understand the association between dairy animal ownership and household milk consumption.

Results

Study population

A total of 195 households were included in the four project villages (response rate: 100%). Over 93% of the respondents were adult women. The median age of all respondents was 35 years (25th – 75th percentile: 27–45 years). Most of the respondents were illiterate (56.9%). Characteristics of the respondents are summarised in Table 1. Less than half of the households (43.1%; n = 84) owned at least one dairy animal. Households owning dairy animal(s) were more often larger than households not owning a dairy animal (median of 5 persons vs 4), had greater land-holdings (2.75 acres vs 2.09 acres), increased access to irrigation (58.3% vs 25.2%), more frequent ownership of a motorised vehicle (92.9% vs 81.1%) and higher ownership of other livestock (95.2% vs 26.1%). Households owning dairy animal(s) were also less likely to be woman-headed (2.4% vs 22.5%), SC (2.4% vs 11.7%) or have recent history of seasonal migration (2.4% against 9.0%).

Details on ownership of livestock in the study population are shown in Fig. 2. Those owning dairy animals more often had greater variety of livestock.
Table 1
Socio-demographic characteristics of the study population of the household survey conducted between April and July 2019 in four villages in Kolar district, India

| Variable                                | Owns dairy animal(s) (n = 84) | Does not own dairy animal(s) (n = 111) | Total (n = 195) |
|-----------------------------------------|-------------------------------|---------------------------------------|-----------------|
| **Respondent details**                  |                               |                                       |                 |
| Age (median [P25–75])^a in years       | 34.5 [26–41.3]                | 35 [28–47]                            | 35 [27–45]      |
| Respondent is female                    | 75 (89.3%)                    | 107 (96.4%)                           | 182 (93.3%)     |
| Respondent is illiterate                | 42 (50.0%)                    | 69 (62.2%)                            | 111 (56.9%)     |
| **Household characteristics**           |                               |                                       |                 |
| Household size (median [P25–75])        | 5 [4.8–7]                     | 4 [3–5]                               | 5 [4–6]         |
| Under-5 child in household              | 23 (27.4%)                    | 22 (19.8%)                            | 45 (23.1%)      |
| Woman-headed household                  | 2 (2.4%)                      | 25 (22.5%)                            | 27 (13.8%)      |
| **Caste**                               |                               |                                       |                 |
| *General category*                      | 52 (61.9%)                    | 68 (61.3%)                            | 120 (61.5%)     |
| *Scheduled caste (SC)*                  | 2 (2.4%)                      | 13 (11.7%)                            | 15 (7.7%)       |
| *Scheduled tribe (ST)*                  | 30 (35.7%)                    | 30 (27.0%)                            | 60 (30.8%)      |
| **Primary income source**               |                               |                                       |                 |
| *Agriculture*                           | 61 (72.6%)                    | 70 (63.1%)                            | 131 (67.2%)     |
| *Daily wage*                            | 14 (16.7%)                    | 24 (21.6%)                            | 38 (19.5%)      |
| *Livestock rearing*                     | 3 (3.6%)                      | 2 (1.8%)                              | 5 (2.6%)        |
| *Other*                                 | 6 (7.2%)                      | 15 (13.5%)                            | 21 (10.8%)      |
| Land ownership in acres^b (mean [standard deviation]) | 2.75 [1.47] | 2.09 [1.46] | 2.37 [1.49] |

^a 25th and 75th percentile; ^b one acre = 4046.86 m²
| Variable                              | Owns dairy animal(s) (n = 84) | Does not own dairy animal(s) (n = 111) | Total (n = 195) |
|--------------------------------------|------------------------------|---------------------------------------|----------------|
| Access to irrigation                 | 49 (58.3%)                   | 28 (25.2%)                            | 77 (39.5%)     |
| Owns non-dairy livestock             | 80 (95.2%)                   | 29 (26.1%)                            | 109 (55.9%)    |
| Regular travel for wage labour       | 33 (39.3%)                   | 49 (44.1%)                            | 82 (42.1%)     |
| Undertook seasonal migration         | 2 (2.4%)                     | 10 (9.0%)                             | 12 (6.2%)      |
| SHG membership                       | 35 (41.7%)                   | 37 (33.3%)                            | 72 (36.9%)     |
| Owning a motorised vehicle           | 78 (92.9%)                   | 90 (81.1%)                            | 168 (86.2%)    |
| Social welfare card                  |                              |                                       |                |
| Below poverty line                   | 77 (91.7%)                   | 105 (94.6%)                           | 182 (93.3%)    |
| Antyodaya scheme                     | 7 (8.3%)                     | 5 (4.5%)                              | 12 (6.2%)      |

* 25th and 75th percentile; one acre = 4046.86 m²

**Status of health determinants**

The status of health determinants is summarised in Table 2. One in five households (20.5%) have experienced food insecurity during the past two years. A higher proportion of households owning dairy animal(s) consumed milk (88.6% vs 62.2%). Latrine ownership was high across both groups (92.8%). Dairy animal-owning households more commonly opted for private healthcare services in case a household member had fever (38.1% vs 15.3%). Health insurance coverage was only reported by 44.1% households. Milk consumption was significantly correlated with vegetable consumption (Kendall’s tau = 0.16, p = 0.017), egg consumption (Kendall’s tau = 0.27, p < 0.001) and meat consumption (Kendall’s tau = 0.14, p = 0.049). The correlation statistics are summarised in Table 3.
Table 2
Select health determinants in the study population based on a survey conducted between April and July 2019 in four villages in Kolar district, India

| Variable                                                                 | Owns dairy animal(s) (n = 84) | Does not own dairy animal (n = 111) | Total (n = 195) |
|--------------------------------------------------------------------------|-------------------------------|------------------------------------|-----------------|
| Experienced food insecurity in the past two years                        | 15 (17.9%)                   | 25 (22.5%)                         | 40 (20.5%)      |
| Consume any milk regularly                                              | 74 (88.1%)                   | 69 (62.2%)                         | 143 (73.3%)     |
| Variety of vegetables consumed previous week (median [P25 – P75]^a        | 6 [5–7]                      | 6 [4–7]                            | 6 [5–7]         |
| Egg consumption monthly frequency (median [P25 – P75]                    | 2 [2–4]                      | 2 [1–3]                            | 2 [1–4]         |
| Meat consumption frequency monthly                                      | 4 (4–4.3)                    | 4 (3–4)                            | 4 (4–4)         |
| Fruit consumption frequency monthly (median [P25 – P75]                  | 2 [1–3]                      | 1 [0–2]                            | 1 [0–2]         |
| No knowledge of any iron-rich foods                                     | 2 (2.4%)                     | 11 (9.9%)                          | 13 (6.7%)       |
| Latrine ownership                                                        | 79 (94.0%)                   | 102 (91.9%)                        | 181 (92.8%)     |
| Any member consumes alcohol                                             | 7 (8.3%)                     | 20 (18.0%)                         | 27 (13.8%)      |
| Any member smokes                                                        | 11 (13.1%)                   | 20 (18.0%)                         | 31 (15.9%)      |
| Any member chews tobacco                                                | 21 (25.0%)                   | 25 (22.5%)                         | 46 (23.6%)      |
| First choice healthcare provider for fever                               |                              |                                    |                 |
| Local government hospital                                               | 50 (59.5%)                   | 91 (82.0%)                         | 141 (72.3%)     |
| Local private doctor                                                     | 32 (38.1%)                   | 17 (15.3%)                         | 49 (25.1%)      |
| Health insurance cover                                                   |                              |                                    |                 |
| Governmental schemes                                                    | 34 (40.5%)                   | 51 (45.9%)                         | 85 (43.6%)      |
| Private                                                                  | 1 (1.2%)                     | 0 (0.0%)                           | 1 (0.5%)        |
| None                                                                     | 49 (58.3%)                   | 60 (54.1%)                         | 109 (55.9%)     |

^a 25th and 75th percentile
Table 3
Correlation of milk consumption with other dietary variables based on data from survey conducted between April and July 2019 in four villages in Kolar district, India

| Factor related to dietary quality | Kendall’s tau | p-value |
|----------------------------------|---------------|---------|
| Variety of vegetables consumed   | 0.163         | 0.017*  |
| Frequency of fruit consumption   | 0.016         | 0.816   |
| Frequency of egg consumption     | 0.265         | < 0.001*|
| Frequency of meat consumption    | 0.139         | 0.049*  |

*Significant at p-value < 0.05

Association between ownership of dairy animal(s) and milk consumption

Of the 195 households, 52 (26.7%) reported that they did not consume milk. Covariates that showed strong crude associations with milk consumption include owning dairy animal(s) (OR: 4.50, 95% CI: 2.17, 10.14), household size (OR: 2.00, 95% CI: 1.56, 2.66), woman-headed households (OR: 0.19, 95% CI: 0.08, 0.43), land ownership (OR: 1.67, 95% CI: 1.23, 2.35), access to irrigation (OR: 3.19, 95% CI: 1.57, 6.99) and owning a motorised vehicle (OR: 9.72, 95% CI: 4.04, 25.4) (Table 4).

The full model for the relationship between dairy cow ownership (primary explanatory variable) and milk consumption (main outcome) was adjusted by household size (count), woman-headed household (binary), whether general caste (binary), child in household (binary), wage labour as main income source (binary), land owned (continuous), access to irrigation (binary), membership with SHG (binary) and ownership of motorised vehicle (binary). The multivariate logistic regression model output indicated that the adjusted OR for household milk consumption was 2.11 (95% CI: 0.87, 5.45) between households owning and not owning dairy animals. Evidence of association was found for household size (adjusted OR: 1.88, 95% CI: 1.34, 2.77), ownership of motorised vehicle (adjusted OR: 4.08, 95% CI: 1.23, 14.31) and wage labour as primary income source for family (adjusted OR: 2.89, 95% CI: 1.04, 9.03).

The sensitivity analysis included 128 households (84 households owning dairy animals and 44 not owning dairy animals). Previously observed imbalances between households owning and not owning dairy animals were minimised through the matching for all included covariates, except for household size (difference persisted after matching at p = 0.03). The adjusted OR for milk consumption was 2.20 (95% CI: 0.77, 6.45) in this subsample.
Table 4
Crude and adjusted odds ratios and a sensitivity analysis (SA) comparing household milk consumption with the explanatory variables based on data collected between April and July 2019 from four villages in Kolar district, India

| Variable                          | Crude OR (95% CI)  | Adjusted OR (95% CI) | SA: adjusted OR (95% CI) |
|----------------------------------|--------------------|----------------------|--------------------------|
| Owns dairy animal(s)             | 4.50 (2.17–10.14)** | 2.11 (0.87–5.45)     | 2.20 (0.77–6.45)         |
| Household size                   | 2.00 (1.56–2.66)** | 1.88 (1.34–2.77)**   | 1.62 (1.06–2.77)         |
| Woman-headed household           | 0.19 (0.08–0.43)** | 0.78 (0.25–2.58)     | NA                       |
| Whether SC<sup>b</sup>           | 2.50 (0.66–16.35)  | -                    | -                        |
| Whether ST<sup>b</sup>           | 1.13 (0.57–2.32)   | -                    | -                        |
| Whether general caste            | 0.71 (0.36–1.37)   | 0.71 (0.31–1.58)     | 0.36 (0.1–1.14)          |
| Child in household               | 1.92 (0.86–4.73)   | 0.48 (0.16–1.45)     | 0.73 (0.15–4.16)         |
| Wage labour main income source   | 0.87 (0.4–1.97)    | 2.89 (1.04–9.03)     | 2.01 (0.52–9.17)         |
| Land owned                       | 1.67 (1.23–2.35)** | 1.06 (0.8–1.47)      | 1.8 (0.96–3.92)          |
| Irrigation access                | 3.19 (1.57–6.99)** | 1.30 (0.53–3.29)     | 1.75 (0.55–5.74)         |
| SHG member                       | 1.29 (0.67–2.56)   | 1.04 (0.47–2.37)     | 3.38 (0.97–14.98)        |
| Owns motorised vehicle           | 9.72 (4.04–25.4)** | 4.08 (1.23–14.31)*   | 1.21 (0.19–6.53)         |
| Any non-dairy livestock owned<sup>c</sup> | 3.71 (1.92–7.42)** | -                    | -                        |

***p-value < 0.001; **p-value < 0.01; *p-value < 0.05; <sup>a</sup> standard deviation; <sup>b</sup> due to small cell sizes, only dummy variable for general caste was used in final model; <sup>c</sup> highly correlated with ownership of dairy animal, hence not included in final model; NA, not available; SHG, self-help group; SC, scheduled caste, ST, scheduled tribe; SA, sensitivity analysis with data subset determined by propensity score matching

Discussion

Milk consumption was found to be both significantly correlated with other markers of a diverse and high quality diet (i.e. vegetable, egg and meat consumption) and elevated among households owning dairy animal(s) (OR: 2.11), even after controlling for multiple confounders. The association between dairy animal ownership and milk consumption was not statistically significant, which might be explained by the relatively small sample size (n = 195). Of note, we included all households in the four villages that will
be affected by the project. It is conceivable that families owning dairy animals would consume milk when the dairy animal is producing milk. However, families owning dairy animals were, in general, different from those not owning dairy animals. For example, they often owned greater assets (land, access to irrigation and motorised vehicle(s)) than those that did not. This was also consistent with the finding that woman-headed and SC households owned dairy animals far less frequently. This suggests ownership of dairy animals was associated with an overall higher socioeconomic status in the study area. The investment of purchasing and managing a high-yielding dairy animal may be prohibitive to those without assets [7, 12]. However, even after matching for these socioeconomic covariates through PSM, a positive association was found between dairy cow ownership and milk consumption, suggesting that this finding is not entirely dependent on socioeconomic status.

The advantage of owning land and irrigation access for meeting fodder and water needs of dairy animals was reported by other studies [7, 12]. Indeed some local farmers from nearby villages revealed cultivating only fodder crops in their irrigated fields, focusing solely on dairy for livelihood [13]. This indicates that while dairy animals have the potential to contribute dietary quality and diversity, the impact may be disproportionately higher for richer households, as has been shown in an earlier study [12].

**Interpretation from a household nutrition perspective**

The main finding of association between dairy animal ownership and household milk consumption was corroborated by a large study from India [11], and also smaller studies from Ethiopia (23% increased frequency) [8], Uganda [12, 22] and Kenya [23]. This was found to be especially important in areas without access to markets [8], which was not the case in our study area where dairies have been established.

While milk was significantly correlated with other markers of a diverse and high quality diet, it was not the only source of protein and micronutrients in the study area, as has also been reported in literature [9]. There is also consumption of finger millet, pulses (a regular feature in meals), eggs and meat, the latter two being more frequent among households owning dairy animals. These findings are in contrast to what was observed in some villages in northern India where consumption of milk and milk products were found to be more critical to dietary quality [7]. The importance of understanding local context in the contribution towards household nutrition is emphasised [7].

The proportion of households that reported having experienced food insecurity during the last two years was similar for households with or without dairy animal(s) (17.9% vs 22.5%). These percentages do not indicate the frequency and severity of the experienced food insecurity. In addition, it is difficult to draw causal inferences in the context of dairy animal ownership as this is a cross-sectional study.

Food consumption at household level cannot be extrapolated to nutritional status of individuals within the household, as shown before [6, 11]. A study from Ethiopia indicated positive impact on reducing stunting [8]. Studies from Uganda found significant positive impact [12], no impact [22], or even negative impact of dairy animal ownership on child nutrition, and hence, there must be other contextual factors,
such as availability and use of sanitation and intra-household competition for resources. Small ruminants (e.g. goats and sheep) were found to contribute to better nutrition outcomes in Uganda [21] and the poorest households in Kenya [24]. Several other factors complicating this relationship have been elucidated in the literature, including wealth, resource constraints and experience of financial shocks [8].

**Interpretation in the light of WSD projects**

WSD projects locally have helped overcome the obstacle of high initial investment by providing grants and loans to procure livestock, preferentially to poor woman-headed households through SHGs [13]. Currently SHG membership was somewhat lower among households without dairy animals (33.3% against 41.7%), and this can be expected to improve through the planned WSD project [15]. Beneficiaries in earlier local WSD projects perceived financial and nutritional benefits following the adoption of dairy animal(s) [13]. On similar lines, an intervention study in Rwanda on donation of livestock to households was able to demonstrate impact on child nutrition [25]. However, keeping in mind that managing dairy animals also takes a lot of work and harbours various costs [26, 27] – including accessing water and feed [7], all households may not be able to adopt it.

Interventions encouraging dairy animal ownership as part of the WSD project should take into account whether it is feasible for low-income households to maintain a dairy animal long-term. Additionally, challenges of water and feed are worsened during droughts [7], which occur regularly in Kolar district. Local anecdotal evidence (assimilated during a recent study) [13] reported that several households sold their dairy animals a few years ago following a period of intense drought. Financial returns from dairy animals were also reportedly lower in areas with high groundwater exploitation [27], such as in the study area. In addition, promotion of dairy animals comes with health and ethical challenges especially for high-yielding varieties [28]. Therefore this strategy could be reviewed accordingly.

**Interpreting effects of household size and wage labour**

We found a strong association of milk consumption and household size (OR: 1.88, 95% CI: 1.34, 2.77), which is in contrast to findings from a large Indian dataset [11]. Two factors might explain this observation. First, wealthy households in the study area lived as joint families, as they have the financial and human resources to buy and manage dairy animals. Second, the poorest households were those of elderly women living alone. The strong association between wage labour and milk consumption (OR: 2.89, 95% CI 1.04, 9.03) may also be related to few households consisting only of elderly poor women living alone unable to engage in wage labour. Reportedly, regular wage labour in construction industry and domestic work in nearby cities was providing adequate returns to young people from this area [13].

**Limitations of the study**

It is not possible to draw conclusions on causal relationships from cross-sectional data. Reverse causality between household milk consumption and dairy animal ownership is plausible if milk consumption be considered a proxy for wealth/income. However, keeping the literature and context in mind, this is unlikely. However, as ownership of cattle was strongly associated with wealth indicators, the
association with household milk consumption should be interpreted with caution. Another limitation of the analysis was the lack of data on other milk products. In our preceding work in the same region, we found that part of the milk was consumed in fermented form (curd) [13]. As this curd was made from fresh milk within the household, we assumed it was represented within the data on milk consumption. Finally, the findings of the present study mainly apply to the study area, but may also provide insights on what can be expected in the drought-prone rural regions in southern India.

**Scope for future research and practice**

The data analysed here stem from a baseline survey for a proposed WSD project. We will get further insights on how things changed due to the interventions in 2024–2025. Further research could adopt a prospective mixed-method design, focus on differential benefits experienced by various types of adopting households and also study challenges being faced by each in taking up and managing dairy animals. Adding health outcome measures as part of the survey (e.g. nutritional status among children within the household) and also micronutrients among adults (e.g. haemoglobin levels) would be good to estimate the size and distribution of direct health impacts of these interventions. This kind of evidence is currently lacking [5].

As the data used in this study came from a baseline survey for a HIA, it shows the benefits gained by conducting HIAs, as it fosters empirical research in settings that are usually neglected [29, 30]. Indeed, baseline survey data can be leveraged to better understand about agriculture and nutrition linkages, besides potentially other locally relevant health outcomes.

**Conclusions**

Our study revealed that dairy animal ownership was quite common in the study area, but lower than the average for rural India. We found evidence suggestive of causal relationship between dairy animal ownership and household milk consumption in the four villages in Kolar district. Households consuming milk were found to have a better dietary quality in terms of vegetable variety, frequency of meat consumption and frequency of egg consumption. In terms of the factors in adoption of dairy animals, we found that wealth, household size, land ownership and access to irrigation were important. Our findings also illustrated how context plays a role for determining effects of interventions in rural areas, for instance, the effect of household size.

Health- and equity-sensitive rural development schemes are needed for achieving the Sustainable Development Goals 3 (good health and well-being) and 10 (reduce inequalities). More specifically, a call has been made for development policies to be nutrition-sensitive [31, 32]. As lot of resources are being poured into these initiatives, careful monitoring and evaluation of these interventions and schemes is essential. One-size-fits-all approaches cannot be expected for diverse contexts. We used the opportunity of a baseline survey of a planned project to contribute to literature and local planning, and similar studies from other parts of the country could enhance incorporation of health concerns into local planning towards addressing important health concerns such as undernutrition.
List Of Abbreviations

CI, confidence interval; HIA, health impact assessment; OR, odds ratio; SC, scheduled caste; SD, standard deviation; SHG, self-help group; ST, scheduled tribe; WSD, watershed development

Declarations

• Ethics approval and consent to participate:

  Ethical clearance was obtained from the Padmashree Institute of Clinical Research in Bengaluru, India (reference no. IEC-BIO-004; date of approval: 10 August 2018) and the Ethics Commission of Northwest and Central Switzerland (EKNZ) in Basel, Switzerland (reference no. BASEC Nr Req-2018-00839, date of approval: 19 October 2018). Study details were explained to the participants and written informed consent (in the local language) was taken prior to the interviews and survey. An information sheet prepared in local language with contact details of the researcher was handed over to participants. The data were stored on a server of the Swiss Tropical and Public Health Institute in Basel, Switzerland in an anonymised manner.

  Consent for publication:

  Not applicable

• Availability of data and materials:

  The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

• Competing interests:

  The authors declare that they have no competing interests

• Funding:

  The first author is a doctoral student from India sponsored by the Swiss Government Excellence Scholarships (ESKAS). This paper is part of his doctoral thesis. The Federal Commission for Scholarships for Foreign Students (Switzerland) had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript, or in the decision to publish the results.

• Authors' contributions:
AP, MSW and JU conceptualised the study; AP created tools, managed data collection, performed analysis, prepared first draft; AF guided the study design; MSW and AF reviewed data collection tools, AF advised on the analysis plan and reviewed the analysis at each stage, AF reviewed the initial and advanced drafts of the manuscript, MSW and JU reviewed the advanced drafts.

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References

1. UN. United Nations Decade of Action on Nutrition 2016–2025 - work programme. New York: United Nations; 2017.

2. GBD 2016 Risk Factors Collaborators. Global, regional, and national comparative risk assessment of 84 behavioural, environmental and occupational, and metabolic risks or clusters of risks, 1990–2016: a systematic analysis for the Global Burden of Disease Study 2016. Lancet. 2017;390(10100):1345–422.

3. India State-Level Disease Burden Initiative Collaborators. Nations within a nation: variations in epidemiological transition across the states of India, 1990–2016 in the Global Burden of Disease Study. Lancet. 2017;390(10111):2437–60.

4. IIPS ICF. National family health survey (NFHS-4), 2015-16: India. Mumbai: International Institute for Population Sciences; 2017.

5. Kadiyala S, Harris J, Headey D, Yosef S, Gillespie S. Agriculture and nutrition in India: mapping evidence to pathways. Ann N Y Acad Sci. 2014;1331(1):43–56.

6. Kim R, Rajpal S, Joe W, Corsi DJ, Sankar R, Kumar A, et al. Assessing associational strength of 23 correlates of child anthropometric failure: an econometric analysis of the 2015–2016 National Family Health Survey, India. Soc Sci Med. 2019;238:112374.

7. Pritchard B, Rammohan A, Sekher M. Land ownership, agriculture, and household nutrition: a case study of north Indian villages. Geographical Research. 2017;55(2):180–91.

8. Hoddinott J, Headey D, Dereje M. Cows, missing milk markets, and nutrition in rural Ethiopia. J Devel Stud. 2015;51(8):958–75.

9. Minocha S, Thomas T, Kurpad AV. Dietary protein and the health-nutrition-agriculture connection in India. J Nutr. 2017;147(7):1243–50.

10. Government of India. National livestock mission - operational guidelines. New Delhi: Government of India; 2016.

11. Bhagowalia P, Headey D, Kadiyala S. Agriculture, income, and nutrition linkages in India: insights from a nationally representative survey. International Food Policy Research Institute; 2012.
12. Kabunga NS, Ghosh S, Webb P. Does ownership of improved dairy cow breeds improve child nutrition? A pathway analysis for Uganda. PLoS One. 2017;12(11):e0187816.

13. Pradyumna A, Mishra A, Utzinger J, Winkler MS. Perceived health impacts of watershed development projects in southern India – a qualitative study. Int J Environ Res Public Health. 2020;17(10):3448.

14. Government of India. Common guidelines for watershed development projects – 2008 (revised 2011). New Delhi: Government of India; 2011.

15. Pradyumna A, Farnham A, Utzinger J, Winkler MS. Health impact assessment of a watershed development project in southern India: a case study. (Submitted to peer-reviewed journal). 2020.

16. Pradyumna A, Farnham A, Utzinger J, Winkler MS. People's health in villages of Kolar district, India at the outset of a proposed watershed development project. (Submitted to peer-reviewed journal). 2020.

17. Office of the Registrar General &. Census Commissioner. District census hand book: village amenities (for Karnataka). Census of India. New Delhi: Government of India; 2011.

18. Bangalore Climate Change Initiate - Karnataka (BCCI-K). Karnataka climate change action plan - an interim report submitted by 'Bangalore Climate Change Initiate - Karnataka (BCCI-K)' to Government of Karnataka. Bengaluru: BCCI-K; 2011.

19. Hartung C, Lerer A, Anokwa Y, Tseng C, Brunette W, Borriello G. Open Data Kit: tools to build information services for developing regions. Proceedings of the 4th ACM/IEEE International Conference on Information and Communication Technologies and Development; London, United Kingdom. 2369236: ACM; 2010. p. 1–12.

20. R Core Team. R: a language and environment for statistical computing. Version 3.5.1. Vienna. Austria: R Foundation for Statistical Computing; 2018.

21. Azzarri C, Zezza A, Haile B, Cross E. Does livestock ownership affect animal source foods consumption and child nutritional status? Evidence from rural Uganda. J Devel Stud. 2015;51(8):1034–59.

22. Fierstein JL, Eliasziw M, Rogers BL, Forrester JE. Nonnative cattle ownership, diet, and child height-for-age: evidence from the 2011 Uganda Demographic and Health Survey. Am J Trop Med Hyg. 2017;96(1):74–82.

23. Nicholson CF, Thornton PK, Muinga RW. Household-level impacts of dairy cow ownership in coastal Kenya. J Agr Econ. 2004;55(2):175–95.

24. Romeo A, Meerman J, Demeke M, Scognamillo A, Asfaw S. Linking farm diversification to household diet diversification: evidence from a sample of Kenyan ultra-poor farmers. Food Secur. 2016;8(6):1069–85.

25. Rawlins R, Pimkina S, Barrett CB, Pedersen S, Wydick B. Got milk? The impact of Heifer International's livestock donation programs in Rwanda on nutritional outcomes. Food Policy. 2014;44:202–13.

26. Sunil VR, Chandel BS, Makarabbi G. Economics of milk production in Mandya district of Karnataka. Econ Aff. 2016;61(4):659–65.
Figures

Figure 1

Factors potentially influencing milk consumption at the unit of household in the study area (boxed variables have been included in the analysis); SHG, self-help group
Figure 2

Ownership of livestock in the study population based on survey conducted between April and July 2019 in four villages in Kolar district, India