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Social support, nutrition and health among women in rural Bangladesh: complex tradeoffs in allocare, kin proximity and support network size

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Malnutrition among women of reproductive age is a significant public health concern in low- and middle-income countries. Of particular concern are undernutrition from underweight and iron deficiency, along with overweight and obesity, all of which have negative health consequences for mothers and children. Accumulating evidence suggests that risk for poor nutritional outcomes may be mitigated by social support, yet how social support is measured varies tremendously and its effects likely vary by age, kinship and reproductive status. We examine the effects of different measures of social support on weight and iron nutrition among 677 randomly sampled women from rural Bangladesh. While we find that total support network size mitigates risk for underweight, other results point to a potential tradeoff in the effects of kin proximity, with nearby adult children associated with both lower risk for underweight and obesity and higher risk for iron deficiency and anaemia. Social support from kin may then enhance energy balance but not diet quality. Results also suggest that a woman's network of caregivers might reflect their greater need for help, as those who received more help with childcare and housework had worse iron nutrition. Overall, although some findings support the hypothesis that social support can be protective, others emphasize that social relationships often have neutral or negative effects, illustrating the kinds of tradeoffs expected from an evolutionary perspective. The complexities of these effects deserve attention in future work, particularly within public health, where what is defined as 'social support' is often assumed to be positive.

This article is part of the theme issue 'Multidisciplinary perspectives on social support and maternal–child health'.

1. Introduction

Undernutrition among women of reproductive age is a leading public health concern in many low- and middle-income countries (LMIC), particularly undernutrition from underweight (body mass index, BMI < 18.5) and iron deficiency anaemia[1], both of which increase the risk that infants will be born

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preterm and small for gestational age [3–6]. Iron deficiency anaemia during pregnancy also increases the risk for perinatal death of both the mother and infant [7–9]. Undernutrition in adult caregivers, such as mothers, grandmothers and others who care for children, may also adversely affect responsiveness to infants [10] and work capacity [11]. Iron nutrition, including both anaemia and iron deficiency, may also serve as markers of general health, as both are affected by inflammation as well as diets, and thus tend to occur in the presence of chronic or infectious disease [12].

Under conditions of market integration (increasing economic development and local integration with the market economy; following Lu [13]) in LMIC, the risk for undernutrition may coexist with rising rates of overweight and obesity, leading to increased risks for chronic disease outcomes including type 2 diabetes (T2D) and cardiovascular disease (CVD) [14]. Obesity and T2D entail several risks for mothers, including gestational diabetes, pre-eclampsia, preterm birth, stillbirth, complications during labour and delivery, postpartum haemorrhage, and birth defects [15–20]. Obesity and chronic diseases may pose even greater risks to older caregivers, especially grandmothers, whose health may be compromised at a time of life when the need to care for young relatives is high.

Thus, in the context of rapid market integration, women of reproductive and post-reproductive age face dual threats to their health from undernutrition and overweight/obesity. It is critical to evaluate factors that may buffer women against these multiple facets of nutritional stress. Social support, which has been shown in many contexts to benefit both general health (e.g. [21,22]) and maternal health, may be one such factor.

Social support likely buffers women against nutritional shortfalls (e.g. [23,24]). This could arise via direct sharing of food to increase food security, or via indirect investments in activities such as childcare that contribute to positive energy balance in mothers (e.g. [25–28]). Social support may also lower psychosocial stress [29], which has been shown to be an important risk factor for obesity across multiple settings [30,31]. However, there is a limited empirical investigation of the impact of social support on undernutrition or obesity in LMIC. Here, we investigate whether several measures of social support protect reproductive and post-reproductive-aged women against underweight, overweight, obesity and iron deficiency anaemia in rural Bangladesh.

How social support is characterized varies tremendously in the literature. Measures that elucidate actual sources of support, such as nearby kin or social network members, have benefits over measures that rely on ratings of, for example, community engagement or trust, since they are less likely to reflect differences in perception. However, the assumption that kin and other network members are a de facto source of social support (e.g. proximity of kin as a proxy for kin support) is inconsistent with evolutionary perspectives which highlight the cooperative and conflictual nature of social networks particularly among those in close residential proximity (e.g. [32–35]). Because kin often share resources, larger groups of locally resident kin may increase competition for family resources [36]. If there are more people to feed, for instance, some may need to go without or sacrifice diet quality. Resource competition may also result over money to pay school fees or medical bills if expenses are higher than the number of earners can easily contribute (e.g. [37]). Or, more generally, a central position in social networks may come with both benefits and costs across different domains [33]. It is thus important to differentiate the effects of proximity from the direct effects of parenting or allocare[2] (e.g. [35]). Age is also an important consideration: younger kin may be particularly demanding of attention and resources [38], and thus, more likely to compete for resources compared to adult kin, including adult children, who can act as sources of support and resource competition. Consequently, we considered the impacts of young and adult kin separately.

The majority of research on social support and maternal health has focused on women of reproductive age, but there are good reasons to also consider the effects of social support on the health of post-reproductive-aged women. Cross-culturally, a significant amount of allocare is done by post-reproductive women (e.g. [39,40]), including but not limited to grandmothers, whose allocare efforts likely affect child health (e.g. [41,42]) and whose own health is likely impacted by their investment in allocare. Older women may sacrifice their own nutrition to preserve food for younger relatives, and custodial childcare by grandparents and older adults has been found to increase their mortality risk [43,44]. However, other research—mostly in high-income contexts—has found that there may be health benefits to allocare, including enhanced cognitive functioning [45], improved psychosocial and overall health [44,46], reduced stress [47], and lower mortality [47,48]. Interestingly, some authors find that providing allocare has beneficial effects while receiving help does not (e.g. [49] found this effect for longevity). Such health benefits may come via social support or through the act of helping itself. We thus included in our analysis women of both reproductive and post-reproductive age, and evaluate multiple measures of social support—including giving and receiving assistance in childcare—as predictors of malnutrition outcomes.

Based on the existing literature, we predict that social support will be broadly related to improvements in maternal nutrition; however, different types of measures of 'support' may highlight different effects, and women of reproductive and post-reproductive age may experience different outcomes relevant to either age or kin dynamics.

2. Sample and methods

(a) Study population

Matlab, Bangladesh, is a rural area located around 60 km from the capital city Dhaka, though accessing the region can be challenging due to flooding and difficult road conditions. Women in the area are primarily housewives (94.2% of women interviewed in 2018), whose major work entails cooking, housework and childcare; housewives may also engage in subsistence tasks including harvesting or processing of agricultural products, caring for chickens or ducks, or making handicrafts, though these tasks vary greatly across women.

Families live in close proximity to each other in residential complexes called *baris* which often include families related patrilocally but may also include unrelated individuals. Patrilocal postmarital residence norms mean that young women are much more likely to live close to their in-laws than their natal kin, but as they age and their children mature, they become increasingly socially integrated with, as well as related to, the other members of their residential area [50]. Related households are often economically inter-reliant; loans of

money and sharing of useful objects are common, and the land is often jointly owned by men in the same family until the death of the father, at which point the land may be divided. Interactions are generally cooperative but may also be competitive, especially in the context of poverty or resource stress (e.g. [51]).

It is common for women to live with or near their in-laws and other relatives, and for paternal grandmothers and aunts to take on significant roles in childcare. Maternal grandmothers and aunts may also help with childcare, especially if they live nearby, and neighbouring women frequently engage in reciprocal childcare regardless of whether they are related. While women generally feed and bathe and perform intensive care tasks primarily for their own children or the children of close relatives, women often share in the duties of watching children with older children and other women in the *bari*. Women in rural Bangladesh have only entered the labour market in small numbers, so most women stay at home with their children. Women with higher socioeconomic status (SES) may be able to pay others to help with children, or to trade with their neighbours for needed help.

Less market-integrated women often have a more traditional, healthier whole food diet but may face risks of undernutrition due to low-calorie intake or a lack of high-quality, iron-rich foods. By contrast, more market-integrated women may have access to higher quality, iron-rich foods but are more likely to have higher caloric intake and are also likely to eat larger quantities of processed foods with added sugars [52,53].

Anaemia is common among women of reproductive age in Matlab and other rural areas of Bangladesh [54–56]. Although less frequently investigated, high rates of iron deficiency have also been observed among pregnant and non-pregnant women of reproductive age, particularly in areas with low ground water iron content [57]. Underweight is common among women of reproductive age in Matlab [54,58], as, increasingly, are overweight and obesity, although more so in urban than rural settings [59,60].

(b) Sample and data

Data were collected in rural Matlab, Bangladesh, by Shenk in collaboration with Alam and the International Centre for Diarrhoeal Disease Research, Bangladesh (icddr,b) in 2017–2018. Icddr,b has run a large Health and Demographic Surveillance System (HDSS) site in Matlab since the late 1960s documenting demographic events (births, deaths, marriages, migrations) on an ongoing basis and collecting periodic socioeconomic survey data for a current population of approximately 200 000 people.

Subsample survey data focused on fertility, fertility transition and marriage were first collected in 2010 by Shenk and Alam from an age-stratified random sample of 944 female HDSS participants aged 20–64. A second wave of data was collected from the same women in 2017–2018 focusing on market integration, wealth, social networks and health. Seven hundred and sixty-five of the original 944 women were re-interviewed in the second wave. Attrition was primarily due to families moving out of the area ($N = 154$), with a limited number of cases attributable to death ($N = 4$), disability ($N = 14$), refusal ($N = 4$, typically due to illness or pressing obligations) or prolonged travel outside of Matlab ($N = 3$). Data in this paper are exclusively from the women followed up in 2018.

(c) Specimen collection and laboratory analyses

Capillary whole blood was collected via finger stick using a sterile lancet. Using a point-of-care haemoglobinometer (HemoCue 201+), haemoglobin concentration (gram per deciliter, g dl^{-1}) was estimated in a single drop of whole blood. Up to five additional drops of whole blood were allowed to fall freely onto Whatman #903 filter paper cards for dried blood spot (DBS) specimens. DBS were allowed to dry for up to 24 h and were then transferred to freezer storage (−20C) until analysis.

We selected soluble transferrin receptor (TfR) as a biomarker of iron deficiency because it is robust to inflammation and has been validated for measurement in DBS [61]. In populations with a high infectious disease burden, biomarkers of iron deficiency that have a physiological role in iron sequestration and inflammation, such as ferritin, become difficult to interpret in a large number of participants; TfR is free of this limitation [61,62]. TfR was estimated using an enzyme immunoassay (Ramco Laboratories), adapted for use with DBS [61]. One 3.2 mm disc of DBS specimen, equivalent to 1.5 µl serum, was removed with a hole punch and eluted in assay buffer overnight. The eluent was assayed without further dilution. For the 35 plates of sTfR evaluated for this project, the intra-assay coefficient of variation (CV) was 3.48%, and the inter-assay CV was 14.8% at low concentration and 9.5% at high concentration.

(d) Anthropometry

Height was measured with a stadiometer (Seca 213) and weight with a digital scale (Tanita BC-545) validated for similar work [63]. BMI was calculated as weight (kg)/height $(m)^2$.

(e) Dependent variables

We used BMI to classify women as underweight (BMI < 18.5), lean (18.5 ≤ BMI < 25), overweight (25 ≤ BMI < 30) and obese (BMI ≥ 30) [64].

There is currently a lack of consensus around precise TfR cutpoints for the identification of iron deficiency [2]. In the light of this, we considered two definitions of iron deficiency: TfR ≥ 8.3 mg l^{-1} (suggested by the assay manufacturer) and TfR > 5.0 mg l^{-1} (validated in DBS against the gold standard of zinc protoporphyrin:heme; [62]). Anaemia was defined as haemoglobin < 12 g dl^{-1} [1]. We classified women as 'iron replete' if they were neither iron deficient nor anaemic, having 'mild-to-moderate iron deficiency' if they were iron deficient but not anaemic, having 'iron deficiency anaemia' (sometimes also referred to as severe iron deficiency) if they were iron deficient and anaemic, and having 'non-iron deficiency anaemia' if they were anaemic but not iron deficient.

Underweight and both iron deficiency anaemia and non-iron deficiency anaemia co-occur more than predicted by chance (Pearson's chi-squared = 6.3058, $p = 0.012$), but not dramatically so, and otherwise there are no clear associations between weight and iron status. This suggests that the two sets of measures used in this study are capturing distinct aspects of nutrition and health, though a deficient diet is likely to be deficient in multiple ways.

(f) Independent variables

We focused on two distinct, but potentially overlapping, measures of social support: social support network members

and family members living nearby. Social support network members are people with whom a person reports regular and meaningful social interaction. Nearby family members have the potential to be sources of social support yet may also compete for resources. Considering both of these measures allows us to separate the effects of the proximity of kin—who may be supportive, competitive (particularly when in need), or both—from actual reported support.

The social network items were collected using the 'name generator' method, which explicitly asked participants to list people who either provided the participant with assistance in various domains or whom the participant provided assistance to. We considered three variables from these items: the total number of unique social support network members nominated in response to all 12 name generator questions asked in our 2018 survey was used as a measure of participants' 'total support network size'. In addition, we considered participants' social support network members named in relation to childcare and housework: 'Who helps you with childcare or housework when you need it?' and 'Who do you help with childcare or housework?' These provided the number of the 'childcare/housework network helpers' and 'help recipients', respectively. See electronic supplementary material for further details.

Nearby family members were considered as both potential sources (adult kin) and recipients (young kin) of social support. Separate survey items asked respondents about their family members, including their relationship, age and current location. From these questions, we created the predictor variable 'nearby young kin', a count of the relatives, other than the respondent's own children, who were (i) in early childhood (age $\leq \sim$5 years at the time of the survey, born in the year 2012 or later) and (ii) living in the respondent's household (*khana*) or neighbourhood (*bari*). We also created the predictor variable 'nearby adult children', a count of the relatives who were (i) adult (age $\geq \sim$18 years at the time of the survey, born in 1999 or earlier), (ii) the respondent's child and (iii) living in the respondent's *khana* or *bari*. Adult children were the focus here as we had clear data on their location and because their status as close kin is unambiguous, whereas cooperation with other kin may be more variable across families or contexts.

Respondent age at the time of the survey was considered as a continuous variable, but was replaced by a dichotomous variable of reproductive (age 20–49 years) and post-reproductive (age $\geq$ 50 years). Reproductive/post-reproductive status was considered as both a predictor and an interaction effect with other predictors of interest.

Several additional variables were considered to control for aspects of socioeconomic status (education, income, MacArthur Ladder, marital status) and exposures likely to be associated with nutritional outcomes and predictors of interest (food insecurity, smoking, betelnut use). These variables are described in detail in the electronic supplementary material, where relevant results and discussion for these variables is also included.

(g) Modelling

We used multinomial logistic regression analysis. The reference category for BMI was lean and for iron deficiency was iron replete. We estimated both relative risk ratios (RRRs) and average marginal effects (AMEs) to describe effect sizes, as RRR or odds ratios can overstate the magnitude of an effect for outcomes that are not rare. Although we present *p*-values for both RRR and AME estimates, *p*-values for RRR were emphasized in interpreting results. All data analyses were conducted with Stata 16.

Network variables (total support network size, childcare/housework network helpers, childcare/housework network help recipients) and nearby kin variables (nearby young kin and nearby adult children) were examined with respect to each outcome variable. Interactions between reproductive/post-reproductive age and predictors of interest were assessed. We considered F statistics, deviance and Bayesian information criterion to compare nested models and to select the SES control variables included in final models.

3. Results

(a) Descriptives

While a total of 765 women participated in the study, complete information on the variables of interest was available for 677 women (the final sample; electronic supplementary material, table S1A); these women were similar to the full sample (electronic supplementary material, table S1B). These women's childcare/housework networks included on average 1.98 (s.d. = 1.17) helpers and 1.49 (s.d. = 1.09) help recipients. Participants total support network size ranged from 0 to 25, with an average of 8.86 (s.d. = 3.16) individuals. Participants had on average 0.85 (s.d. = 1.09) nearby adult children and 0.16 (s.d. = 0.41) nearby young kin.

The prevalence of underweight was 10.19%, overweight was 29.84% and obesity was 7.24%. Anaemia was identified among 48.01% of participants. The sTfR cutpoint of 8.3 mg l^{-1} identified iron deficiency among 4.73% of participants (electronic supplementary material, table S1B); this is an implausibly low rate of iron deficiency for the rate of anaemia we identified (e.g. [57,65]). The sTfR cutpoint 5.0 mg l^{-1} [62] identified iron deficiency among 52.73% of participants, which better matches our understanding of women's health in this region; thus, we used the 5.0 mg l^{-1} cutpoint to identify iron deficiency in all subsequent analyses. About 24.96% of participating women were iron replete, 27.03% had mild-to-moderate iron deficiency, 25.70% had iron deficiency anaemia and 22.30% had non-iron deficiency anaemia.

(b) Body mass index: underweight, overweight and obesity

Total support network size was inversely associated with underweight (RRR: 0.91; 95% CI: 0.82, 1.01): each additional person in a woman's network was associated with an AME of −0.01 (95% CI: −0.02, 0.00) or a 1% lower probability of underweight (electronic supplementary material, table S2). Total support network size was positively associated with overweight (RRR: 1.05; 95% CI: 0.99, 1.12), but not obesity. Neither childcare/housework network helpers nor help recipients significantly predicted BMI. The effects of nearby adult children differed substantially for women of reproductive and post-reproductive age. For those of reproductive age (20–49 years), each adult child living nearby was associated with a lower probability of underweight (RRR: 0.26; 95% CI: 0.07, 1.02). For women of post-reproductive age (over 50 years), the number of nearby adult children was weakly positively associated with underweight (RRR: 1.08; 95% CI: 0.82, 1.41).

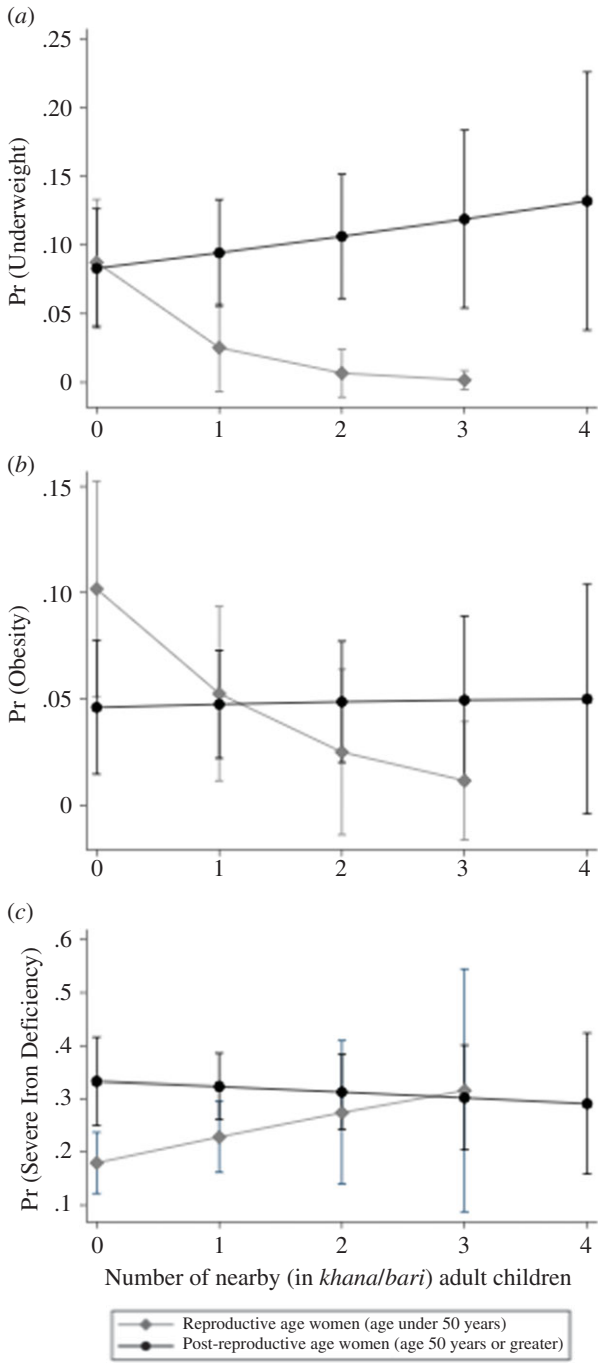

Figure 1. Predicted probabilities of underweight, obesity and anaemia among reproductive- and post-reproductive-age women.

Figure 1*a* shows these divergent associations as predicted probabilities of underweight among reproductive and post-reproductive age women. Similarly divergent effects were apparent for obesity: reproductive-aged women with more nearby adult children were less likely to be obese (RRR: 0.46: 95% CI: 0.19, 1.11), while no effect was apparent for post-reproductive women (figure 1*b*). Nearby young kin (≤ ~5y) were unassociated with underweight, overweight or obesity, regardless of age category. Unmarried women (primarily widows) were not more likely to be underweight (RRR: 1.08; 95% CI: 0.56, 2.09), overweight (RRR: 1.02; 95% CI: 0.60, 1.73) or obese (RRR: 0.42; 95% CI: 0.14, 1.28) when marital status was included in the model in electronic supplementary material, table S2. See electronic supplementary material for effects of socioeconomic and other control variables.

(c) Iron nutrition: iron deficiency and anaemia

Iron deficiency anaemia was associated with childcare/housework network size, and the direction of the association differed by type of help (electronic supplementary material, table S3). Childcare/housework network helpers were positively associated with iron deficiency anaemia (RRR: 1.27; 95% CI: 1.01, 1.60), such that each additional helper was associated with a 3% increase in a woman's probability of iron deficiency anaemia (figure 2). By contrast, in the same model, childcare/housework network help recipients were inversely associated with iron deficiency anaemia (RRR: 0.71; 95% CI: 0.60, 0.90), such that each additional help recipient was associated with a 7% decrease in a woman's probability of iron deficiency anaemia. Total support network size was unassociated with iron deficiency.

Nearby adult children were associated with iron deficiency anaemia; as above, these associations differed for women of reproductive and post-reproductive age, though in the opposite direction. Among women of reproductive age, each additional nearby adult child was associated with a higher probability of iron deficiency anaemia (RRR: 1.88; 95% CI: 1.09, 3.24); no association was apparent for women over age 50 years (figure 1*c*). Nearby adult children were also positively associated with mild-to-moderate iron deficiency (RRR: 1.70; 95% CI: 1.01, 2.88) and non-iron deficiency anaemia (RRR: 1.64; 95% CI: 0.92, 2.94) among women under age 50 years. Nearby young kin were associated with higher risk for mild-to-moderate iron deficiency (RRR: 1.54; 95% CI: 0.90, 2.67), but not iron deficiency anaemia.

4. Discussion

Whether characterized as social network members or nearby kin, our findings point to complex relationships between social support and nutrition (summarized in table 1) that suggest the importance of tradeoffs in social relationships.

(a) Body mass index

As predicted, and as others have observed in LMIC settings, women with larger social networks were less likely to be underweight, consistent with the hypothesis that social support protects women against undernutrition. These findings are consistent with findings from rural Tanzania that social support protects households against food insecurity [66] and from rural western Uganda that maternal social support improves young children's diet quality [67].

Social network members may reduce women's risk for underweight by buffering them against hunger, through, for example, sharing meals or reducing workloads (and thus improving energy balance). Women with larger social networks were also marginally more likely to be overweight, though not obese, consistent with greater access to food or reduced workloads. Such benefits of cooperation are central to theories that see food sharing and cooperative childrearing as key to human evolution (e.g. [23,68–71]). Yet, we considered multiple measures that should have captured cooperative childrearing—childcare/housework network helpers and help recipients, nearby young kin (other than the respondent's own children), who could potentially represent needed allocare—and these were all unassociated with underweight or obesity. In contrast with the overall

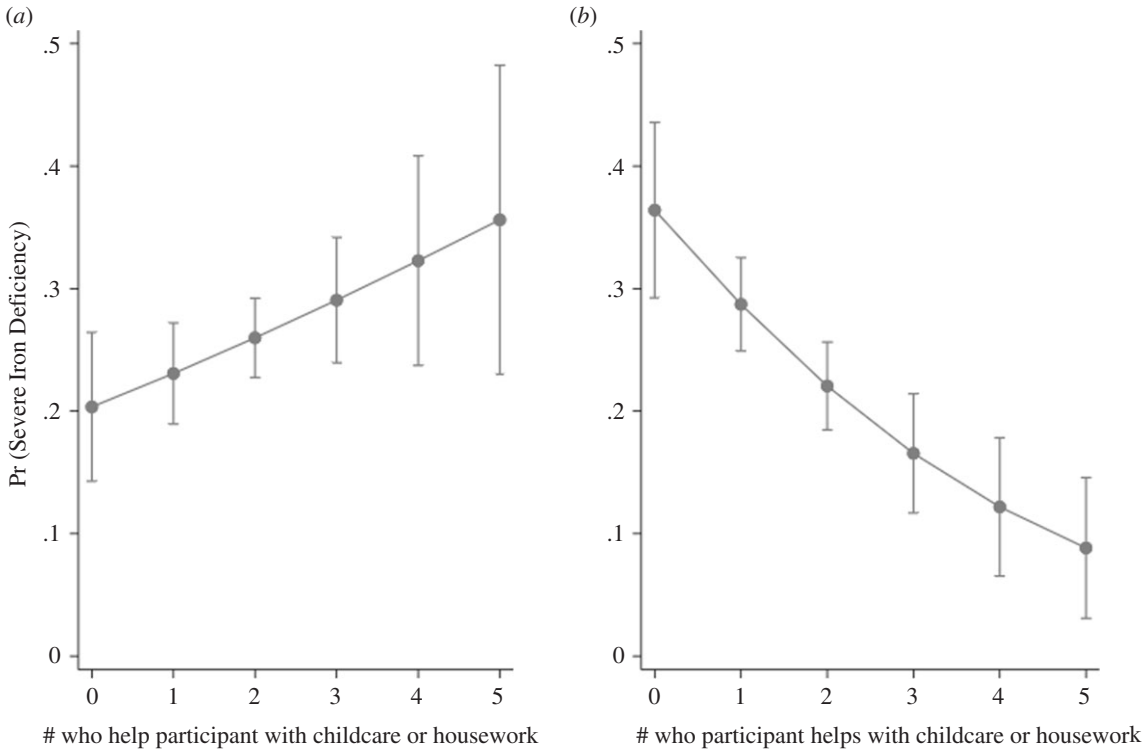

Figure 2. Predicted probabilities of iron deficiency anaemia from individuals who help (*a*) or are helped by (*b*) the respondent (holding other variables at the mean).

Table 1. Summary of results.

	underweight	overweight	obese	mild/moderate iron deficiency	iron deficiency anaemia	non-iron deficiency anaemia
social support network members						
# childcare/housework network helpers					+	
# childcare/housework network help recipients					−	
total support network size	−	+				
nearby family members						
# nearby young kin ≤ ~5 y				+		
# nearby adult children (women < 50)	−		−	+	+	+
# nearby adult children (women 50+)	+					

effects of total support network size, these findings suggest either that help with childcare is not that helpful, or—perhaps more ethnographically plausible—that mothers who have help with childcare are likely to invest the saved energy back into their children and thus experience no net positive outcome from help with childcare alone [27]. This interpretation is especially plausible as some of our findings suggest that help with childcare may be in part need-based (see below).

By contrast, nearby adult children, who could be sources of either social support *or* kin competition, were associated with reduced risks of both underweight and obesity among women of reproductive age, suggesting a social support effect for this outcome. Nearby adult children likely protect women against underweight through kin support, including the provision of food, but potentially also help with childcare/eldercare or other work, leading to positive energy balance [27]. Protection against obesity may similarly be related to reduction of psychosocial stress [72] and/or food sharing (particularly of higher quality foods, such as fish or vegetables, if these replace more obesogenic, processed foods [73]).

For post-reproductive age women, however, we found a modest positive association between nearby adult children and underweight, signalling the potential for kin competition over resources, consistent with effects that have been found in other land-limited agricultural or market-oriented populations in the region and elsewhere (e.g. [32,34]). These effects

could also be driven by an increased motivation for parental investment in which women forgo their own nutritional needs to ensure that their children's and grandchildren's needs are met—a practice commonly reported by our participants. In summary, our findings suggest that women's energy balance benefits from social support through both their total social networks and their nearby adult children.

(b) Iron nutrition

In contrast with results for BMI, iron nutrition does not show a relationship with total support network size, but it does show clear patterns related to allocare—though these were more complex than we had predicted. Receiving childcare/housework help from more social network contacts was associated with a higher risk for iron deficiency anaemia, while providing childcare/housework help to more contacts was associated with a lower risk of iron deficiency anaemia.

A health-protective effect for allocare providers has been described in other populations (e.g. [44,47–49]). For iron deficiency anaemia, a protective effect of providing allocare support to others could manifest through a direct pathway, such as provisioning of iron-rich foods. A further possible explanation is that women with better iron nutrition may be more willing to engage in allocare. For instance, women with iron deficiency anaemia are likely to be fatigued and experience a reduced ability to do work, potentially reducing their ability to provide allocare. This pattern is also in keeping with functional explanations of cooperation based on reciprocity, in which individuals with ample resources may share those additional resources with others now to ensure they receive future, more beneficial, support [74,75].

Women who received support from more social network contacts had a higher rate of iron deficiency anaemia, suggesting social competition for resources which could result in a poorer diet or greater exposure to infectious disease. Reverse causation or selection effects may also be at work here, however, if a mother's need for help inspires people to help her—a pattern consistent with research on need-based sharing (e.g. [76,77]) and kin selection, in which relatives gain increased fitness returns when assistance is directed at the most needy [78–82]. In either case, our results suggest that the support women receive from their childcare/housework networks is often not enough to protect them from iron deficiency—though it is possible that their health would be worse without that help. Need-based helping of resource-stressed women could reduce energy deficits without necessarily improving micronutrient status, consistent with a lack of effect on BMI alongside the increased risk for iron deficiency anaemia for the same predictors.

Nearby young kin were associated with increased risk for mild-to-moderate iron deficiency, consistent with kin competition or women sacrificing the quality of their own diet to benefit young children. In contrast with the effects for underweight, however, the number of nearby adult children showed negative effects on participants' iron nutrition for reproductive-aged women. Post-reproductive women, in contrast, had higher rates of iron deficiency anaemia in both the presence and absence of nearby adult children. Effects of kin competition on iron nutrition may be more apparent among reproductive-age women due to the iron stressors such women face through menstruation, childbirth, and the work burdens of caring for both children and elders; however, the higher risk among post-reproductive women suggest this vulnerability to iron deficiency persists throughout adulthood and may increase with ageing, as well as with chronic and infectious disease, which are more common among older women [83,84]. It is only in reproductive-age women that we see a contrast in the effects of nearby adult children, who protect against underweight, but elevate the risk for iron deficiency and anaemia. Among older women, effects of kin proximity are generally small and unimportant, begging the question of whether this should be termed support.

(c) Complex tradeoffs: improved body mass index *and* worsening iron deficiency?

The relationship between nearby adult children differed for BMI and iron deficiency in reproductive-age women. These divergent findings may relate to the dual burden of malnutrition with rapid market integration. Adult children, particularly in populations with short generation times, will have younger children who require support while the mother is still of reproductive age (i.e. not all grandmothers are post-reproductive, [27]). Therefore, these women may be caught in a bind between caring for younger children and helping to support adult children and their families. Such women may voluntarily share food, and especially high-quality food, with younger relatives, at the expense of their own iron intake. At the same time, food may flow to these women from their adult children, but be of lower quality, particularly in the context of rapid market integration and the high availability of calorically dense but nutrient-poor foods. This is especially likely in the context of dual burden malnutrition in Bangladesh [85] where overweight/obesity are commonly found alongside poor iron nutrition.

Finally, our results highlight the contrasting effects of different types of measures of social support. Direct support with allocare, as measured by childcare/housework network helpers, was generally associated with poor nutrition, reflecting need. By contrast, childcare/housework network help recipients and total support network size were protective against poor nutrition, consistent with general expectations in the literature. Finally, nearby kin appear to demonstrate dual effects of reductions in undernutrition/obesity and increases in iron deficiency and anaemia. This may be indicative of competitive effects or obligations to kin, demonstrating the complex and interdependent nature of social relationships among close kin.

5. Conclusion

Although some of our findings support the hypothesis that social support can protect women in rural Bangladesh against undernutrition and improve their health, others emphasize that social relationships are not always supportive, but may often have neutral or negative effects. Our results additionally suggest that the effects of social relationships are dynamic and may shift over time from reproductive to post-reproductive periods of life. Overall, our results illustrate the kinds of tradeoffs we often see when viewing human social relationships from an evolutionary perspective: the benefits of cooperation are clearly visible alongside the costs of resource limitations and competition. Our results indicate that social support, as measured by adult kin proximity, may serve to enhance energy balance but not dietary quality, indicating that social

relationships have costs to reproductive-age women. Further, social support is a cooperative behaviour and as a result may be dependent on both the mother's need for support, and the cost of providing support to the supporters. Such dynamics produce complex results in which support is not necessarily associated with positive nutritional outcomes.

Regardless of the mechanism involved, our results make it clear that variables chosen as proxies of 'social support', including kin proximity, are not necessarily straightforward measures of help but instead may reflect complex social interactions with both positive and negative outcomes, either exacting costs or—perhaps more likely—ameliorating what could have been even worse states of health [86].

The complexities of these effects require careful attention in future work, particularly in the literature of public health, where 'social support' is often taken in a positive light with less attention to challenging dynamics. Building social support through social networks is an appealing target for public health interventions aimed at promoting maternal health (e.g. [87,88]) among other outcomes. Our findings suggest that this may indeed be an avenue to reduce rates of some forms of malnutrition. However, our findings also suggest that social support has complex effects on women's nutrition, potentially due to the obligations, as well as benefits, that social and kin relationships bring. Nuanced and context-specific information is thus needed to understand how interventions seeking to enhance social support are likely to impact women's nutrition and health.

Ethics. The data analysed in this article were collected under research protocols approved by icddr,b (PR-17062) in Bangladesh and The Pennsylvania State University (STUDY00007821) in the United States.

Data accessibility. Data are available upon request to the first author subject to ethics restrictions on identifiable human subjects data.

Authors' contributions. M.K.S., S.M.M., T.B.K., J.H.S., R.Se. and R.So. obtained funding; M.K.S., S.M.M., N.A. and K.W. designed the study; M.K.S., N.A. and K.W. trained field staff and oversaw data collection; A.K. and F.M. performed laboratory analyses; A.R.M. and K.W. performed statistical analyses; M.K.S., S.M.M., T.B.K., J.H.S., R.Se., R.So. and K.W. contributed to theoretical framing; M.K.S., A.R.M. and K.W. drafted the paper; all authors edited the paper.

Competing interests. We declare we have no competing interests.

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Endnotes

[1]'Iron deficiency' refers to inadequate dietary iron to meet the body's iron needs, which include cellular metabolism and erythropoiesis (red blood cell production). 'Anaemia' refers to oxygen delivery to tissues due to low hemoglobin; anaemia can result from dietary iron deficiency and/or other factors. Iron deficiency that is not severe enough to cause anaemia is considered mild-to-moderate and is understudied compared to iron deficiency anaemia [1,2].
[2]Caretaking of children by people other than their parents.

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