Do Infant Feeding Practices Differ Between Grandmothers and Mothers in Rural China? Evidence From Rural Shaanxi Province

Ai Yue, PhD; Nianrui Zhang, MA; Xueyang Liu, MA; Lei Tang, PhD; Renfu Luo, PhD; Meredith Yang, BA; Scott Rozelle, PhD; Alexis Medina, MA

The overall goal of this study is to examine whether infant feeding practices differ between mothers and grandmothers in rural China. We randomly sampled 1383 caregivers of infants aged 18 to 30 months living in 351 villages across 174 townships in nationally designated poverty counties in rural areas. Results show that a high fraction of caregivers of 18- to 30-month-old children living in low-income areas of rural China do not regularly engage in positive infant feeding practices. Only 30% of children in our sample achieved adequate dietary diversity. Only 49% of children in our sample were fed meat in the day prior to survey administration. Few caregivers reported giving any vitamin supplements (such as calcium or iron supplements) to their children. We find that 33% of the children were cared for by grandmothers rather than mothers, and that grandmothers feed a less diversified diet to children than do mothers. Most (84%) caregivers rely solely on their own experiences, friends, and family members in shaping their feeding behaviors. Overall infant feeding practices are poor in rural China. Grandmothers engage in poorer feeding practices than do mothers. Grandmothers have improved their feeding practices compared to when their own children were young. Our results suggest shortcomings in the quality of infant feeding practices, at least in part due to an absence of reliable information sources.

Key words: child development, feeding practices, information sources, rural China

DEVELOPMENT during the first 2 years of life is critical and has a lasting impact on a child's health.[1] Poor infant and child nutrition can lead to deficiencies in essential micronutrients, which may lead to a weakened immune system and have lasting effects on children's growth and development, human capital accumulation, and even lifetime earnings.[2-4] Iron deficiency and anemia in the first years of life are major risk factors for cognitive, physical, and emotional delays that can affect long-term development.[5-8]

Recent studies have found that malnutrition among infants remains a serious problem in rural China. Although a recent study conducted in rural Shaanxi found that stunting, underweight, and wasting were much less common among infants, ranging between 1.2% and 3.7%, the high prevalence of anemia (48.8%) classifies sample areas as one with a "severe public health problem" according to the World Health Organization.[9,10] Although children could develop anemia for a number of reasons, it has been postulated from a nearly nationally representative study that 90% of anemia in children younger than 6 years in China results from iron deficiency.[11] Despite the fact that these 2 samples varied slightly in age, this evidence suggests that one of the main problems facing poor rural children in China is malnutrition arising from micronutrient-deficient diets.

To a large extent, poor nutritional outcomes may be associated with insufficient diets arising from inadequate complementary feeding practices. Complementary feeding commences at weaning, when infants progress from exclusive breast milk or formula diets to eating solid foods. This process typically occurs between the ages of 6 and 24 months, a time that has been highlighted as one of the most critical developmental periods for preventing malnutrition.[12] The World Health Organization recommends that children begin to be introduced to

Author Affiliations: *Center for Experimental Economics in Education (CEEE), Shaanxi Normal University, Xi'an, Shaanxi, China (Drs Yue and Tang, Mr Zhang, and Ms Liu); China Center for Agricultural Policy, School of Advanced Agricultural Sciences, Peking University, Beijing, China (Dr Luo); and Rural Education Action Program (REAP), Freeman Spogli Institute for International Studies, Stanford University, Stanford, California (Mss Yang and Medina and Dr Rozelle).*

The authors thank the dedicated leaders and local cadres at the National Health and Family Planning Commission for their unparalleled assistance in implementing this study.

The authors are grateful for 111 project (grant number: B16031), National Natural Science Foundation of China (grant number: 71703083), the International Initiative for Impact Evaluation (3ie), Bill & Melinda Gates Foundation-HBGDki Initiative.

The authors declare no conflict of interest.

Correspondence: *Ai Yue, PhD, Center for Experimental Economics in Education, Shaanxi Normal University, No. 620, West Chang'an Avenue, Chang'an District, Xi'an 710119, Shaanxi, China (yueai@163.com).*

DOI: 10.1097/FCH.0000000000000198

complementary foods starting at 6 months of age, and that children eat some form of meat, poultry, fish, or eggs, as well as some form of fruit or vegetable daily. The World Health Organization also encourages caregivers to provide children with vitamin supplements in order to support and maintain adequate levels of micronutrients, especially during early childhood.[13]

While undernutrition and early feeding practices have been fairly well documented in developing settings, these topics have been less researched in middle-income countries, despite the fact that childhood undernutrition remains a serious problem.[14-16] In many cases, the robustness of the economy in these countries masks lagging health outcomes and household behaviors that have not kept up with economic development.[15] However, there has been less research into the pattern of undernutrition in these settings and its relationship with local feeding practices.

In China, proper complementary feeding practices and knowledge of vitamin supplementation continue to be lacking in rural areas. Previous research on complementary feeding practices of young children in rural China demonstrates that children's diets lack variety and seldom include iron-rich foods, such as meat.[17] A study of 6- to 11-month-old infants in rural Shaanxi province revealed that only 23.7% of infants surveyed had consumed meat and only 54.6% had consumed vegetables in the past week.[18] In-depth interviews with caregivers in rural China revealed that the majority of caregivers had little knowledge of the importance of vitamins or micronutrient supplementation; most caregivers were hesitant to provide infants with vitamins or supplements due to the belief that such products could not be given to young children.[17]

Could poor feeding practices depend on the type of caregiver? In China, while the majority of infants and toddlers are cared for by their mothers, paternal grandmothers are most likely to act as primary caregivers when the mother leaves her infant or toddler in her home village and migrates to the city to work.[19] Previous studies on infant feeding practices, however, have not distinguished whether feeding practices depend on the type of caregiver. Given the poor quality of feeding practices in rural areas, could grandmother feeding practices be even worse than mothers and account for the poor micronutrient realizations? Studies have suggested that grandparents are less knowledgeable or less attentive to the nutritional quality of children's diets.[20] With unprecedented urban-to-rural migration occurring over the last few years,[21] the rise of left behind children often cared for by grandparents (typically paternal grandmothers) in rural China can be a potential problem.[22]

The literature is unclear about whether different caregivers—mothers or grandmothers—differ in their understanding and nutritious feeding behavior for their children and grandchildren. Grandparents may not understand the importance of good nutrition (in a modern sense) due to more traditional concepts of parenting and their own early experiences with food.[23] There are also studies that claim that they have identified differences in feeding practices between grandparent (providing their grandchildren with a poorer diet) and parent caregivers.[24] However, the problem may not be limited to grandmothers. Zhang et al[25] found that while grandparents emphasized the importance of starchy foods in their children's diets, migrant parents (when they returned home) were also just as likely to offer their child starch-based foods and other foods with little nutritional value.

If grandmothers were found to be delivering poorer feeding practices, it might be because grandparents have failed to keep up with new sources of information about diets, health, and infant nutrition. The penetration of the Internet and cable in rural villages may have affected young people differently than older generations. Research shows that mothers were more willing to seek infant feeding information from outside sources (eg, friends, relatives, television, and the Internet) while grandmothers frequently did not, citing their own experiences as adequate knowledge.[17] Given the restricted nature of information sources in the remote villages in many areas of China (especially if one does not have access to the Internet or social media), it might be that the knowledge of grandmothers about child feeding practices has not changed over time (and grandmothers may be still feeding young children the same way that they fed their own children—at a time when China was very poor). Have the feeding practices of grandmothers changed? If so, in what ways did they change?

In this study, we sought to empirically identify differences in feeding practices of infants between grandmothers and mothers in rural China. We also sought to understand why feeding practices may or may not differ. To meet this overall goal, we have 3 specific objectives. First, we aim to describe and compare the feeding practices of mothers and grandmothers of 18- to 30-month-old infants in a sample of mothers who live in the Qinling Mountain region of Western China. Second, we sought to understand how the feeding practices of grandmothers have changed over time—comparing their understanding of nutritional needs when they were raising their own children and now. Third, we

explore sources of information of mothers and grandmothers in an attempt to understand from where do grandmothers and mothers get their information.

STUDY SAMPLE AND METHODS

Sample selection

Our study was conducted in 2014 in 11 nationally designated poverty counties located in Shaanxi Province. From each of these 11 counties, all townships (the middle level of administration between county and village) were selected to participate in the study. There were 2 exceptions to this rule: we excluded the 1 township in each county that housed the county seat, and we excluded any townships that did not have any villages with a population of 800 or more. In total, according to these criteria, 174 townships were included in the study.

The sample villages were selected in a way such that in each village cluster (1 per township), there was a minimum of 5 children. To do so, we first randomly selected 1 village from each township to participate. A list of all registered births over the past 12 months was obtained from the local family planning official in each village. All children in our desired age range (6-12 months) were enrolled in the study. If a village had fewer than 5 children in our desired age range, we randomly selected an additional village in the same township for inclusion in the study.

The data used in this study were collected from sample households over a 4-week period in October 2014. At this time, the sample children were aged 18 to 30 months. Overall, our study used data from 1383 households in 351 villages across 174 townships. This sample excludes 6% of children whose primary caregivers are not mothers or grandmothers.

Data collection

Ethical approval for this study was granted by the Stanford University Institutional Review Board (protocol ID 25734). All participants provided informed consent prior to the start of any study activities.

Teams of trained enumerators collected socioeconomic information from households participating in the study. During the interview, each infant's primary caregiver was identified and administered a detailed survey. The primary caregiver was identified in each sample household by asking which family member was most responsible for the infant's care. In 94% of the cases, the primary caregiver was either the infant's mother or the paternal grandmother.

The survey included a detailed module on feeding practices. This module was developed on the basis of the "Indicators for assessing infant and young child feeding practices" compiled by UNICEF, USAID, the World Health Organization, and others in the international community.[26,27] Specifically, the survey asked whether the child was fed staple foods, vegetables, fruits, meats, and eggs in the previous day. In our sample area, "staple foods" refers primarily to rice, noodles, and steamed buns. Minimum dietary diversity is achieved if the infant received food from at least 4 or more food groups. Enumerators also documented at what age (in months) solid, semisolid, or soft foods were introduced into the child's diet. This module has been used elsewhere in the empirical literature.[28]

The survey also collected information from the caregiver about vitamin supplementation. Specifically, we asked whether the child was given calcium, vitamin A, vitamin D, iron, or zinc at least once in the last week. We also asked whether the child had been given any other supplements since the child's birth. For caregivers who were grandmothers, we asked whether or not they had given their child vitamin supplements in the past (ie, when they were mothers).

Additional details on parental and household characteristics were also asked, including each child's gender and birth order, maternal age and education, and whether the family was receiving Minimum Living Standard Guarantee Payments (a poverty indicator). The exact age of each child was obtained from his or her birth certificate. Importantly, the final part of the survey collected information about where primary caregivers obtained information about child feeding, nutrition, and health.

Statistical analysis

All statistical analyses were performed using STATA 12.0. *P* values below .05 were considered statistically significant. The statistical significance of differences in the feeding practices between grandmother and mother was assessed using both analysis of variance for comparisons of simple differences and multiple regression analysis to control for confounding variables. We included the following variables as potential confounders in the multivariate analysis: child's gender, child's age, whether the child was born prematurely, whether the child is an only child, whether the child's mother was identified as the primary caregiver, maternal educational level and age, and whether the family received Minimum Living Standard Guarantee Payments. We also ran a supplementary set of analyses substituting caregiver education for maternal education in the list of controls. Caregiver

education differs from maternal education in that it takes on the value of the mother's education level if the mother is the primary caregiver and takes on the value of the grandmother's education level if the grandmother is the primary caregiver.

RESULTS

Basic socioeconomic and demographic characteristics of study participants are reported in Table 1. Of the 1383 households, 923 (or 67%) of primary caregivers were mothers. The remaining 460 (or 33%) of primary caregivers were grandmothers.

Socioeconomic characteristics differ between mother primary caregivers and grandmother primary caregivers. We find that, while majority of primary caregivers had less than 9 years of education, mothers are significantly more educated than grandmothers ($P < .01$). About 13% of mothers completed more than 9 years of schooling compared with 3% of grandmothers in our sample. Another difference is in the birth order of children. Most (79%) children who were cared for by grandmothers were the first child in the family. When mothers were primary caregivers, however, the child that they were caring for had a higher probability of being a higher-order-born child (ie, there was a balanced number of first-born and higher-order-born children when the mother was the primary caregiver). Regarding the age distribution of the caregiver, slightly less than half of all mothers (42%) in our sample were 25 years of age or younger, and about 58% of mothers were between 25 and 50 years of age. Grandmothers were all older than 40 years; 47% were between the ages of 40 and 50 years; the rest were between the ages of 50 and 70 years. We also found that household in which the primary caregiver is the mother was significantly more likely to report receiving Minimum Living Standard Guarantee Payments, a form of government welfare for the lowest income families nationwide ($P < .01$). A quarter of mothers in our sample (26%) reported receiving this benefit compared with 14% of grandmothers.

Feeding practices and vitamin supplementation

Feeding practices of sample children are shown in Table 2. Of the full sample, a large proportion of caregivers (82%) reported that they introduced solid, semisolid, or soft foods to their child at least at 6 months of age. Almost all caregivers (97%) reported that they fed staple food to their children yesterday, compared with 68% of caregivers who reported that they fed vegetables to their children yesterday. A little more than a third of caregivers (37%) reported feeding their children fruits

TABLE 1. Basic Household Characteristics of Sample in Rural Shaanxi Province (n =1384)[a]

Characteristics	Full Sample (n = 1383)	Mothers (n = 923, 67%)	Grandmothers (n = 460, 33%)	*P*
Gender				
Male	721 (52%)	494 (54%)	227 (49%)	.1386
Female	662 (48%)	429 (46%)	233 (51%)	
The infant is premature				
No	1235 (89%)	818 (89%)	417 (89%)	.2533
Yes	148 (11%)	105 (11%)	148 (11%)	
Birth order of infant				
First	824 (60%)	462 (50%)	362 (79%)	.000
Second or higher	559 (40%)	461 (50%)	98 (21%)	
Primary caregiver education level, y				
≤9	1252 (91%)	805 (87%)	447 (97%)	.000
>9	131 (9%)	118 (13%)	13 (3%)	
Primary caregiver age, y				
≤25	388 (28.1%)	388 (42.1%)	0	.000
26 to ≤50	750 (54.2%)	534 (57.8%)	216 (47.1%)	
51 to ≤75	241 (17.4%)	1 (0.1%)	240 (52.3%)	
>75	3 (0.3%)	0	3 (0.6)	
Families received social security support				
No	1054 (76%)	682 (74%)	371 (81%)	.005
Yes	329 (24%)	241 (26%)	88 (19%)	

[a]Data are presented as frequency and percentage for all children.

TABLE 2. Comparison of Feeding Practices Between Grandmothers and Mothers (n = 1383)[a]

Feeding Practices	Full Sample (n = 1383)	Mother's Feeding Practices Now (n = 924)	Grandmother's Feeding Practices Now (n = 459)	*P*	95% CI
(1) Complementary feeding and diet diversity					
Introduction of solid, semisolid, or soft foods, months ≥6 mo (1 = yes; 0 = no)	1137 (82%)	756 (82%)	381 (83%)	.587	−0.03 to 0.05
Fed staple food yesterday? (1 = yes; 0 = no)	1343 (97%)	902 (98%)	441 (96%)	.108	−0.03 to 0.003
Fed vegetables yesterday? (1 = yes; 0 = no)	934 (68%)	658 (71%)	276 (60%)	.000	−0.16 to 0.06
Fed fruits yesterday? (1 = yes; 0 = no)	516 (37%)	363 (39%)	153 (33%)	.031	−0.11 to 0.005
Fed meat yesterday? (1 = yes; 0 = no)	683 (49%)	498 (54%)	185 (40%)	.000	−0.19 to 0.08
Fed eggs yesterday? (1 = yes; 0 = no)	564 (41%)	371 (40%)	193 (42%)	.500	−0.04 to 0.07
Minimum diet diversity (4 or more food categories)	417 (30%)	305 (33%)	112 (24%)	.001	−0.14 to 0.03
(2) Vitamin supplementation (at least once last week)					
Calcium supplement last week? (1 = yes; 0 = no)	340 (25%)	230 (25%)	110 (24%)	.707	−0.06 to 0.04
Vitamin AD supplement last week? (1 = yes; 0 = no)	110 (8%)	84 (9%)	26 (6%)	.027	−0.06 to 0.004
Iron supplement last week? (1 = yes; 0 = no)	82 (5.9%)	60 (6%)	22 (5%)	.208	−0.04 to 0.01
Zinc supplement last week? (1 = yes; 0 = no)	168 (12%)	117 (13%)	51 (11%)	.406	−0.05 to 0.02
Other vitamins after birth? (1 = yes; 0 = no)	156 (11%)	99 (11%)	57 (12%)	.346	−0.02 to 0.05

Abbreviation: CI, confidence interval.
[a]Data are presented as frequency and percentage for all children. Dietary diversity is the number of the following food categories fed to the child the previous day: staple food, vegetables, fruits, meat, and eggs. Minimum diversity is 1 if dietary diversity is 4 or more.

yesterday, while only half (49%) reported that their children were fed meat yesterday. Less than half (41%) of the caregivers fed their children eggs yesterday. Overall, less than one-third of the children in the sample (31%) achieved minimum dietary diversity, receiving food from at least 4 or more food groups.

In Table 2, we also present data on vitamin supplementation practices. When we asked whether caregivers had given any vitamin supplements to their children (at least once in the last week), few caregivers reported doing so. Only 25% of caregivers reported providing their child a calcium supplement. Other types of vitamin supplements were also less likely to be provided: only 8% of caregivers reported giving vitamin AD supplements. Even fewer caregivers (6%) provided iron supplements to their child; 12% of caregivers gave zinc supplements to their children last week.

Links between caregiver type, feeding practices, and vitamin supplementation

The second and third columns of Table 2 compare feeding practices by caregiver type (mothers and grandmothers). We find that there are no significant differences between grandmothers and mothers in terms of the timing of the introduction of complementary feeding (solid, semisolid, or soft foods) and the proportion of children who were fed staple food. In addition, we find no statistically significant differences between grandmothers and mothers in terms of vitamin supplementation practices, except that there were significant but small differences in terms of providing vitamin A, vitamin D, and iron supplements. There are, however, significantly more mothers than grandmothers who fed their children vegetables, fruits, and meat the day before the survey. Specifically, the proportions were 71% versus 60%; 39% versus 33%; and 54% versus 40%, respectively.

Table 3 shows the results of multiple regression analysis measuring the association between caregiver type, feeding practices, and vitamin supplementation practices after adjusting for potential confounders. We find that the results of the multivariate analysis are consistent with our descriptive findings as in Table 2. In general, (aside from feeding eggs) there are significant links between feeding practices/vitamin supplementation and caregiver type even when we control for confounding factors, such as maternal age and education. In households where the mother is the primary caregiver, children are significantly more likely to be fed vegetables, fruits, and meat than in households where the primary caregiver is the grandmother ($P < .05$). The child is also 11% more likely to meet minimum diet diversity requirements (ie, 4 or more categories) and 3% to 4% more likely to be provided iron and vitamin A and vitamin D supplements.

When we control for caregiver education rather than maternal education, the results are largely consistent, though some of the weaker correlations disappear: we no longer see significant differences between caregivers in the likelihood of feeding their child fruit, vitamin A and D supplements, or iron supplements (Appendix Table 1). More surprisingly, after controlling for caregiver education, we no longer observe differences in caregiver's likelihood of meeting the minimum dietary diversity standards.

Comparing feeding practices of grandmothers over time

Table 4 compares the feeding practices of grandmothers in the past (when they were mothers) and present (when they are grandmothers). In general, we find that some of the feeding practices of grandmother have improved largely over time, while others have improved slightly. Specifically, in terms of vitamin supplementation behavior, grandmothers today provide more vitamin supplements to their grandchildren than they provided to their own children as mothers. The difference is significantly different ($P < .01$) and the improvement is in very large scale. For example, 76% of grandmothers reported giving calcium supplements to their grandchild, compared with just 11% of grandmothers who reported that they did so a generation earlier, when their own children were young. In contrast, we find significant but small differences in the introduction of complementary foods at or after 6 months between grandmothers before and now; 73% of grandmothers reported doing so in the past, compared to 82% of grandmothers who reported doing so now.

TABLE 3. Association Between Caregiver Type (Grandmother or Mother) and Feeding Practices of Sample Children (n = 1383)[a]

Feeding practices	Primary Caregiver (1 = Grandmother; 0 = Mother)	95% CI
(1) Complementary feeding practices and diet diversity		
Introduction of complementary (solid, semisolid, or soft) foods at or after 6 mo (1 = yes; 0 = no)	0.015	−0.03 to 0.06
Fed staple food yesterday? (1 = yes; 0 = no)	−0.022[b]	−0.04 to 0.002
Fed vegetables yesterday? (1 = yes; 0 = no)	−0.116[c]	−0.17 to 0.06
Fed fruits yesterday? (1 = yes; 0 = no)	−0.060[a]	−0.12 to 0.003
Fed meats yesterday? (1 = yes; 0 = no)	−0.165[c]	−0.22 to 0.11
Fed eggs yesterday? (1 = yes; 0 = no)	−0.002	−0.06 to 0.06
Minimum diet diversity (4 or more categories)	−0.107[c]	−0.16 to 0.05
(2) Vitamin supplementation (at least once last week)		
Calcium (1 = yes; 0 = no)	−0.031	−0.08 to 0.02
Vitamin AD (1 = yes; 0 = no)	−0.0437[d]	−0.08 to 0.01
Iron (1 = yes; 0 = no)	−0.0296[a]	−0.06 to 0.002
Zinc (1 = yes; 0 = no)	−0.035	−0.07 to 0.003
Other vitamins (1 = yes; 0 = no)	0.012	−0.02 to 0.05

Abbreviation: CI, confidence interval.
[a]Regression estimates from multiple linear models adjusted for gender, birth order, premature birth, maternal educational level, maternal age, and whether the family received social security support.
[b]$P < .05$.
[c]$P < .001$.
[d]$P < .01$.

TABLE 4. Comparison of Grandmother's Feeding Practices in the Past and Now (n = 353)[a]

Feeding Practices	Grandmother's Feeding Practices (Past), %	Grandmother's Feeding Practices (Now), %	*P*	95% CI
Introduction of complementary feeding (solid, semisolid, or soft foods), ≥6 mo (1 = yes; 0 = no)	73.1	81.9	.001	0.04-0.14
Calcium supplement after birth? (1 = yes; 0 = no)	10.5	75.6	.000	0.60-0.71
Vitamin AD supplement after birth? (1 = yes; 0 = no)	4.0	32.6	.000	0.23-0.34
Iron supplement after birth? (1 = yes; 0 = no)	2.0	28.1	.00	0.21-0.31
Zinc supplement after birth? (1 = yes; 0 = no)	2.0	50.1	.00	0.43-0.54
Other vitamins after birth? (1 = yes; 0 = no)	1.4	12.5	.00	0.07-0.15

Abbreviation: CI, confidence interval.
[a]We compare only when complementary foods were introduced to the infant, and whether or not infants were given vitamin supplements at least once since birth; information on food groups and diet diversity was not solicited. Standard errors within parentheses.

Sources of information about feeding practices

The survey also asked caregivers about the sources of their knowledge about feeding practices (Table 5). According to the findings, the majority of caregivers (83%) reported obtaining information from their own experiences, families, or friends. Fewer than 15% of all caregivers in our sample received information from their local doctor, local bureaus of family planning, or women's representatives. Less than half (45%) of the caregivers in our sample received any information from books, TV, or the Internet.

Mothers and grandmothers differed in terms of where they received their information on feeding practices. Mothers were significantly more likely to report obtaining information from official sources: 19% of mothers reported receiving information from the local doctor, local bureaus of family planning, or the women's representative, compared with 10% of grandmothers. Likewise, 52% of mothers reported receiving information from popular media (books, TV, or the Internet) compared with 31% of grandmothers. In both of these cases, we find that these differences are statistically significant at the 1% level.

DISCUSSION

We find that even in a nation that has been classified as a "middle-income" economy, nutritional deficits

TABLE 5. Sources of Information About Feeding Practices (n = 1383)[a]

Information Sources	Total (n = 1383)	Mothers (n = 924)	Grandmothers (n = 459)	Comparison Between Grandmothers and Mothers (n = 1383)	
				P	95% CI
Family members, friends, own experience	1151 (83%)	762 (83%)	389 (85%)	.285	−0.02 to 0.06
Local doctor, local bureaus of family planning, or women's representative	221 (16%)	177 (19%)	44 (10%)	.000	−0.14 to 0.05
Books, TV, Internet	619 (45%)	476 (52%)	143 (31%)	.000	−0.26 to 0.15

Abbreviation: CI, confidence interval.
[a]Note that respondents were allowed to select more than 1 information source.

among children are still widespread and feeding practices are poor, suggesting that human behaviors have not kept up with the pace of economic change. Moreover, we find that generational differences in feeding practices exist, with caregivers from an older generation (grandmothers) slow to adopt informed best practices and potentially contributing to the lag in behavioral change. Our results point to the importance of sustained information campaigns in growing economies, even when economic benchmarks have been met, and to targeted efforts to reach older, less educated members of the household, who still have important decision-making power.

In this article, we show that a high fraction of caregivers of 18- to 30-month-old children living in low-income areas of rural China do not regularly engage in positive infant feeding practices. While the majority of caregivers reported timely introduction of semisolid or soft foods to their child following 6 months of age, the overall lack of quality in the children's diet remains notable. Only a third of caregivers reported feeding children fruit, while just half of the caregivers fed meat to their child in the previous day. The remaining 50% of sample children are, in essence, consuming a diet that does not contain meat. Only 30% of children in our sample achieved adequate dietary diversity (a minimum of 4 food groups or more in the last 24 hours), an important indicator that has been linked to infant nutritional status and dietary quality.[29,30] In addition, few caregivers reported giving any vitamin supplements to their children in the last week. The World Health Organization advises that a meatless diet is insufficient to support the micronutrient levels necessary for child development and encourages micronutrient supplements or vitamin-fortified food to make up the difference.[31] What our data show is that babies in our sample are consuming neither meat nor supplements on a regular basis. Given previous research that has shown the high prevalence of anemia among infants in this population,[18] it is concerning that only 5.6% of caregivers supplemented their children's diets with iron. In short, the quality of the diets of young children in rural China is generally poor.

Our findings are consistent with the previous literature that also found poor infant feeding practices in other parts of rural China. A study conducted in 2014 in rural Hebei reported that only 32.5% of children were given iron-rich or iron-fortified food.[32] This supports the notion that the problem of poor infant nutrition in rural areas of China more likely stems from poor-quality diets rather than insufficient energy intake. Despite China's dramatic reduction of the stunting rate (by two-thirds between 1990 and 2010),[33] the prevalence (and persistence) of poor infant feeding practices in rural areas more so resembles countries earlier in their economic development. National data have revealed that the prevalence of stunting in infants 6 to 12 months has actually increased in poorer rural areas from 2008 to 2009, a trend that has continued post-2010.[33] Given the strong link between poor infant nutritional status and long-term child development,[34] the prevalence of poor feeding practices is certainly worrisome.

Given that parenting largely falls on either mothers or grandmothers in rural China (as in 97% of caregivers in our sample) and many children are cared by grandmothers even when they are very young, we analyzed whether infant feeding practices vary by these 2 types of caregivers. While the literature is unclear about whether we should expect differences in feeding practices between mothers and grandmothers, our results demonstrated that the quality of infant feeding practices does differ significantly between grandmothers and mothers in rural China. While we found no significant differences between grandmothers and mothers in terms of timely introduction of complementary feeding and whether or not the child was fed staple food, we do find significant differences in the feeding of vegetables, fruits, and meat in the previous day. There were also significant, albeit small differences between mother and grandmothers in terms of vitamin supplementation practices.

We also looked at the change in grandmother's feeding practices from when she was a young mother, to now, when she is a grandmother. In fact, despite the generally poor nature of feeding practices today, there has been measurable improvement in feeding practices. Specifically, in the case of many important feeding practices, such as the timing of the introduction of complementary foods and the provision of vitamin, calcium, iron, and zinc supplements, grandmothers have improved over time. However, it is important to note that even after we have measured improvements in the feeding practices of grandmothers, key practices, such as vitamin supplementation, are still low (28%—Table 5).

Why do we find low quality of feeding practices by both mothers and grandmothers and why is it that mothers only have slightly better feeding practices than grandmothers? We know from previous surveys of household diets that a typical primary school child in rural China eats meat an average of 4 times per week at home.[35] Moreover, in-depth interviews with caregivers of infants and toddlers conducted as part of another study have indicated that all caregivers have plans to introduce meat into their child's diet eventually but believe that this

should occur when the child is older.[17] The cost of meat does not appear to be an important factor limiting consumption, again because data show that older children in rural households eat meat regularly. Ready access to farmland paired with high rates of off-farm employment (above 80% for young male adults) and wages that are relatively high for a still-developing economy (well more than US $2 per hour) together mean that access to meat is not a problem of affordability.[36] Moreover, other researchers have shown that the price of pork (the primary source of meat protein in China) is not correlated with anemia levels among adults.[37] Together with the results from the current study, these findings suggest that perhaps the main obstacle to meat consumption among babies in rural areas may be a lack of information about when to introduce meat into a child's diet. The empirical results of our study support this. More than 80% of caregivers in our sample (both mothers and grandmothers) reported that their main source of information for feeding their child/grandchild was that of their own experience, friends, and family members. However, we do find that mothers are significantly more likely than grandmothers to get information from local doctors, local bureaus of family planning, women's representatives, books, TV or the Internet, which may possibly explain why mothers have better feeding practices than grandmothers. However, even though mothers feed better, they are feeding their child only marginally better. This suggests that even if mothers are more likely to consult external sources of information, these sources are possibly of low quality (or their messages are not salient).

Education is another possible explanation for the differences in feeding practices that we observe. When we control for caregiver education, some of the smaller differences between mother and grandmother caregivers disappear. We also lose any significant differences in the likelihood of the child meeting minimum dietary diversity standards. Together, these findings suggest that caregiver education may explain some of the observed differences in caregiver feeding. Because grandmothers are significantly less educated than mothers (97% of grandmothers have a middle school education or less, compared with only 87% of mothers), they may be less able to access, understand, and/or put into practice new information on best feeding practices for children.

A final possibility that merits consideration is that caregivers in rural areas, particularly mothers, do not have a large degree of control in the family. In rural areas, mothers generally live with the husband's families and are not seen as significant figures in the household, particularly in relation to the mother-in-law. In households where mothers live with their mother-in-law, it is easy to imagine a scenario where new mothers rely primarily on the mother-in-law for guidance on how to feed and raise a child. This may lead mothers to treat "other" information sources from the community (local doctors, local bureaus of family planning) and popular media (books, TV, and the Internet) as secondary sources of information. (It should be noted that popular media may also provide conflicting and inaccurate information.) While we did not collect this specific information, we can presume that there is a high likelihood that the mothers in our sample live together with their mother-in-law. According to census data in 2010, the proportion of 3-generation families in rural areas is nearly double that of urban areas.[38] Further study would be needed to verify whether there is indeed an impact on the mother's infant feeding behavior via the mother-in-law in order to better tailor policy interventions for this group.

Study limitations

The current study has several limitations. One limitation of the study is its cross-sectional design, which does not allow us to identify causal relationships. Moreover, we cannot rule out the possibility of recall bias. Data collected on infant feeding practices in the past were based on the recall of grandmothers of their experiences as a young mother. Another possible source of bias stems from the fact that our study children were identified on the basis of a list of registered children provided by the village family planning officially, systematically excluding unregistered children. This bias is negligible, however, given evidence that the number of unregistered children has declined in recent years: a 2010 survey found the rate of unregistered children to be only around 0.12%.[39]

CONCLUSIONS

Our results suggest shortcomings in the quality of infant feeding practices, possibly due to a lack of reliable information sources in rural villages in Shaanxi. We also suggest possible constraints that may prevent caregivers, particularly young mothers, from applying newly learned infant feeding information in the household.

Possible nutritional campaigns targeted at caregivers of young children in rural China that focus on promoting adequate feeding practices can be considered. Training local village doctors, women's representatives, and local cadres may be an efficient way to disseminate information about quality infant feeding practices. Additional study could look into the specific content of infant feeding

information currently being disseminated in rural areas, as well as factors affecting its uptake among mother and grandmother caregivers.

Further studies can also investigate whether grandmothers and mothers differ in other aspects of parenting behavior. Differences in parenting behaviors by caregiver could have important implications for a child's cognitive and social emotional development.

We believe that researchers and policy makers working in middle-income economies can learn from our findings and may be interested in our conclusions. We hope that by identifying the hitherto understudied phenomenon of intergenerational caregiving as a potential factor contributing to child undernutrition, our work will trigger additional research among other middle-income populations, including those in Latin America, Turkey, and Thailand, among others.

REFERENCES

1. Currie J, Almond D. Chapter 15—human capital development before age five. *Handbook Labor Economics*. 2011;4:1315-1486.
2. Caulfield LE., Stephanie AR, Juan R, Philip M, Robert EB. Stunting, wasting and micronutrient deficiency disorders. *Dis Control Priorities Dev Countries*. 2006;870:551-567.
3. Engle PL, Fernald LC, Alderman H, et al. Strategies for reducing inequalities and improving developmental outcomes for young children in low-income and middle-income countries. *Lancet*. 2011;378(9799):1339-1353.
4. Campbell F, Conti G, Heckman JJ, et al. Early childhood investments substantially boost adult health. *Science*. 2014;343:(6178) 1478-1485.
5. Walter T, De Andraca I, Chadud P, Perales CG. Iron deficiency anemia: adverse effects on infant psychomotor development. *Pediatrics*. 1989;84:7-17.
6. Grantham-McGregor S, Ani C. A review of studies on the effect of iron deficiency on cognitive development in children. *J Nutr*. 2001;131:649S-668S.
7. Iannotti LL, Tielsch JM, Black MM, Black RE. Iron supplementation in early childhood: health benefits and risks. *Am J Clin Nutr*. 2006;84:1261-1276.
8. Lozoff B, Jimenez E, Smith JB. Double burden of iron deficiency in infancy and low socioeconomic status: a longitudinal analysis of cognitive test scores to age 19 years. *Arch Pediatr Adolesc Med*. 2006;160:1108-1113.
9. Luo RF, Shi YJ, Zhou H, et al. Micronutrient deficiencies and developmental delays among infants: evidence from a cross-sectional survey in rural China. *BMJ Open*. 2005;5:e008400.
10. World Health Organization. *Iron Deficiency Anaemia: Assessment, Prevention and Control: A Guide for Programme Managers*. Geneva, Switzerland: World Health Organization; 2001.
11. Lin LM, Song XF, Liu YL, et al. Relationship between vitamin A deficiency and anemia for Chinese children [in Chinese]. *Chin J Child Health Care*. 2003;11:242-244.
12. Martorell R, Kettel Khan L, Schroeder DG. Reversibility of stunting: epidemiological findings in children from developing countries. *Eur J Clin Nutr*. 1994;48(suppl 1): S45-S57.
13. World Health Organization. *Diet, Nutrition and the Prevention of Chronic Diseases.* Joint WHO/FAO Expert Consultation. WHO Technical Report Series no. 916. Geneva, Switzerland: World Health Organization; 2003.
14. Attanasio OP, Fernandez C, Fitzsimons EO, Grantham-McGregor SM, Meghir C, Rubio-Codina M. Using the infrastructure of a conditional cash transfer program to deliver a scalable integrated early child development program in Colombia: cluster randomized controlled trial. *BMJ*. 2014;349:g5785.
15. Rozelle S, Huang J, Wang X. The food security roots of the middle-income trap. In: Naylor R, ed. *The Evolving Sphere of Food Security*. Oxford, England: Oxford University Press; 2014:64-86.
16. World Health Organization. *The Global Prevalence of Anaemia in 2011*. Geneva, Switzerland: World Health Organization; 2015.
17. Yue A, Marsh L, Zhou H, et al. Nutritional deficiencies, the absence of information and caregiver shortcomings: a qualitative analysis of infant feeding practices in rural China. *PLoS One*. 2016;11(4): e0153385.
18. Luo RF, Shi YJ, Zhou H, et al. Anemia and feeding practices among infants in rural Shaanxi Province in China. *Nutrients*. 2014;6(12):5975-5991.
19. Ban L, Guo SF, Scherpbier WR, Wang XL, Zhou H, Tata LJ. Child feeding and stunting prevalence in left-behind children: a descriptive analysis of data from a central and western Chinese population. *Int J Public Health*. 2017;62(1):143-151.
20. Tan C, Luo JY, Zong R, et al. Nutrition knowledge, attitudes, behaviors and the influencing factors among non-parent caregivers of rural left-behind children under 7 years old in China. *Public Health Nutr*. 2010;13(10):1663-1668.
21. Chan KW. China: internal migration. In: *The Encyclopedia of Global Human Migration*. Oxford, England: Blackwell Publishing Ltd; 2013.
22. Yue A, Shi YJ, Luo RF, et al. China's invisible crisis: cognitive delays among rural toddlers and the absence of modern parenting. *China J*. 2017;78:50-78.
23. Jingzhong Y, Lu P. Differentiated childhoods: impacts of rural labor migration on left-behind children in China. *J Peasant Stud*. 2011;38(2):355-377.
24. Su P, Hu C, Li L, et al. Study on dietary patterns and its effect on infant health among left-behind children aged 1-4 years old with both parents working out in rural Anhui [in Chinese]. *Wei Sheng Yan Jiu*. 2012;41(5):754-759.
25. Zhang N, Bécares L, Chandola T, Callery P. Intergenerational differences in beliefs about healthy eating among carers of left-behind children in rural China: a qualitative study. *Appetite*. 2015;95:484-491.
26. WHO; UNICEF; USAID, et al. Indicators for assessing infant and young child feeding practices (part I—definitions). In: *Proceedings of WHO Global Consensus Meeting on Indicators of Infant and Young Child Feeding*; November 6-November 8, 2007; Washington, DC; Geneva, Switzerland: World Health Organization; 2008.
27. WHO; UNICEF; USAID, et al. Indicators for assessing infant and young child feeding practices (part II—measurement). In: *Proceedings of WHO Global Consensus Meeting on Indicators of Infant and Young Child Feeding*; November 6-November 8, 2007; Washington, DC; Geneva, Switzerland: World Health Organization; 2010.
28. Mallard SR, Houghton LA, Filteau S, et al. Dietary diversity at 6 months of age is associated with subsequent growth and mediates the effect of maternal education on infant growth in urban Zambia. *J Nutr*. 2014;144(11):1818-1825.
29. Moursi MM, Arimond M, Dewey KG, Trèche S, Ruel MT, Delpeuch F. Dietary diversity is a good predictor of the

micronutrient density of the diet of 6-to 23-month-old children in Madagascar. *J Nutr*. 2008;138:2448–2453.
30. Rah JH, Akhter N, Semba RD, et al. Low dietary diversity is a predictor of child stunting in rural Bangladesh. *Eur J Clin Nutr*. 2010;64(12):1393-1398.
31. Dewey K. *Guiding Principles for Complementary Feeding of the Breastfed Child*. Washington, DC: Pan American Health Organization; 2003.
32. Wu Q, Scherpbier RW, van Velthoven MH, et al. Poor infant and young child feeding practices and sources of caregivers' feeding knowledge in rural Hebei Province, China: findings from a cross-sectional survey. *BMJ Open*. 2014;4(7):e005108.
33. Chen C, He W, Wang Y, Deng L, Jia F. Nutritional status of children during and post-global economic crisis in China. *Biomed Environ Sci*. 2011;24(4):321-328.
34. Grantham-McGregor S, Cheung YB, Cueto S, et al. Developmental potential in the first 5 years for children in developing countries. *Lancet*. 2007;369(9555): 60-70.
35. Luo R, Miller G, Rozelle S, Sylvia S, Vera-Hernandez M. *Can Bureaucrats Really Be Paid Like CEOs? School Administrator Incentives for Anemia Reduction in Rural China*. NBER Working Paper No. 21302, June 2015. http://www.nber.org/papers/w21302.pdf. Accessed July 27, 2018.
36. Wang X, Huang J, Zhang L, Rozelle S. The rise of migration and the fall of self employment in rural China's labor market. *China Econ Rev*. 2011;4:573-584.
37. Li L, Luo R, Medina A, Rozelle S. The prevalence of anemia in central and eastern China: evidence from the China health and nutrition survey. *Southeast Asian J Trop Med Pub Health*. 2015;46(2):306-321.
38. Hu Z Peng X. Household changes in contemporary China: an analysis based on the four recent censuses. *J Chin Sociol*. 2015;2:9.
39. National Bureau of Statistics. The bulletin of 2010 sixth national census in China (no. 1). http://www.gov.cn/test/2012-04/20/content_2118413.htm. Published 2011. Accessed October 2014.

APPENDIX TABLE 1. Association Between Caregiver Type (Grandmother or Mother) and Feeding Practices of Sample Children (n = 1383)[a]

Feeding Practices	Primary Caregiver (1 = Grandmother; 0 = Mother)	95% CI
(1) Complementary feeding practices and diet diversity		
Introduction of complementary (solid, semisolid, or soft) foods at or after 6 mo (1 = yes; 0 = no)	−0.005	−0.06 to 0.05
Fed staple food yesterday? (1 = yes; 0 = no)	−0.024[b]	−0.05 to 0.002
Fed vegetables yesterday? (1 = yes; 0 = no)	−0.117[c]	−0.18 to 0.06
Fed fruits yesterday? (1 = yes; 0 = no)	−0.031	−0.10 to 0.03
Fed meats yesterday? (1 = yes; 0 = no)	−0.130[c]	−0.20 to 0.06
Fed eggs yesterday? (1 = yes; 0 = no)	0.048	−0.02 to 0.11
Minimum diet diversity (4 or more categories)	−0.053	−0.11 to 0.01
(2) Vitamin supplementation (at least once last week)		
Calcium (1 = yes; 0 = no)	−0.0004	−0.06 to 0.06
Vitamin AD (1 = yes; 0 = no)	−0.031	−0.05 to 0.004
Iron (1 = yes; 0 = no)	−0.028	−0.06 to 0.003
Zinc (1 = yes; 0 = no)	−0.020	−0.06 to 0.02
Other vitamins (1 = yes; 0 = no)	0.020	−0.02 to 0.06

Abbreviation: CI, confidence interval.
[a]Regression estimates from multiple linear models adjusted for gender, birth order, premature birth, caregiver educational level, maternal age, and whether the family received social security support.
[b]$P < .05$.
[c]$P < .001$.