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Social networks and infant feeding in Oaxaca, Mexico

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Abstract

The health benefits of delaying the introduction of complementary foods to infants' diets are widely known. Many studies have shown that mothers with the support of close social network members are more compliant with medical recommendations for infant feeding. In our study, we examine the effects of a broader spectrum of network members (40 people) on mothers' infant feeding decisions. The survey was conducted in Oaxaca, Mexico as part of a follow-up to a nationwide Mexican Social Security Institute survey of infant health. Sixty mothers were interviewed from a stratified random sample of the original respondents. Multivariate tests were used to compare the efficacy of network-level variables for predicting the introduction of 36 foods into infants' diets, when compared with respondent-level variables. The study yields four findings. First, network-level variables were better predictors of the timing of food introduction than socio-demographic variables. Second, mothers with more indigenous networks delayed the introduction of some grains (oatmeal, cereal, noodle soup, rice) and processed pork products (sausage and ham) to the infant's diet longer than mothers with less indigenous networks. Third, mothers who had stronger ties to their networks delayed the introduction of rice and processed pork products (sausage and ham) to the infant's diet longer than mothers who had weaker ties to their networks. Fourth, mothers who heeded the advice of distant network members introduced some grains (rice and cereal) earlier than mothers who did not heed the advice of distant network members.

Keywords: social network, personal network, complementary feeding, infant feeding, weaning, Mexico.

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The health benefits of delaying the introduction of complementary foods, or foods used in the transition from breast or bottle feeding to family foods, to infants' diets in the first 6 months of life are widely known. Previous studies have shown that mothers with the support of close social network members are more compliant with medical recommendations for infant feeding. In this study, we examine the effects of a broader spectrum of network members (40 people) on mothers' infant feeding decisions. Our analysis is focused on determining whether network-level variables perform better in explaining variability in the early introduction of 36 complementary foods to infants' diets, when compared with more conventional respondent-level socio-demographic variables.

Infant feeding: timing and socio-demographic predictors

The timely introduction of appropriate foods into infants' diets is the key to balancing the benefits of enhanced nutrition and calories with protection from infection. Early weaning makes infants vulnerable to infections, allergens and malnutrition (Lanigan *et al.* 2001; WHO 2002). Early introduction of complementary foods can cause gastrointestinal problems, infections, malnutrition and increased risk for chronic disease in later life (Dettwyler 1992; von Kries *et al.* 1999; Dennison 1996; Gluckman *et al.* 2005). However, delaying the introduction of complementary foods too long can also be harmful to an infant's health. Breast milk and formula are insufficient to provide for older children's nutritional needs, and their exclusive use can cause malnutrition after the child reaches 6 months of age (McDade & Worthman 1998). To support infant nutrition, the World Health Organization (WHO) publishes a set of principles designed to guide the introduction of complementary foods into infants' diets (Dewey 2002; WHO 2002). Additionally, the global public health community is working to set new policies and programmes to improve infant nutrition (Solomons 2005).

A number of studies have been conducted to determine what conditions encourage new mothers to comply with infant feeding recommendations. Several of the mother's socio-demographic characteristics –

greater maternal age, greater maternal education, the absence of employment outside of the home, and multiparity (i.e. having born a child previously) – are associated with the duration of breastfeeding (Scott & Binns 1999). While the cessation of breastfeeding does not necessarily mean that mothers will introduce family foods into the infants' diet, these findings may provide some insight into the less-studied phenomenon of the timing of complementary feeding. Socio-demographic predictors of infant feeding, although fairly easy to study, are not easily affected by intervention or educational programmes. An alternative approach, which has been shown to be more responsive to interventions, is to examine the effects of the mother's social context on her infant feeding decisions (Bryant *et al.* 1992; Losch *et al.* 1995).

Social network approaches to studying infant feeding

Studies of social context often employ a 'social network' approach, which examines webs of social connections among people. Studies of mothers' infant feeding decisions generally examine 'personal networks', a subset of social networks that comprises the people (what social network researchers call *alters*) that a person (referred to as *ego*) knows. Ego's personal network may include alters such as spouses, children, cousins, co-workers, church members, neighbours – in other words, any alter that ego knows. Statistics summarizing the composition or structure of the personal network are used as a proxy measure of ego's social context (McCarty & Wutich 2005). Personal network analysis is concerned with making generalizations about the features of personal networks that explain outcomes such as ego's income, health status, or behaviour (McCarty 2002).

In studies of personal networks and infant feeding, researchers generally examine the influence of just a few of the closest alters on the mother's decision to initiate or continue breastfeeding. Mothers who have the support of close alters (such as a male partner, the grandmother, or a close friend) are more likely to begin breastfeeding and to breastfeed for a longer duration of time in compliance with medical recommendations (Baranowski *et al.* 1983; Kaufman & Hall

1989; Scott & Binns 1999). Of these close alters, the infant's father is the most influential (Gugliani *et al.* 1994; Kessler *et al.* 1994; Bar-Yam & Darby 1997). Personal network studies found that close alters encourage mothers to comply with infant feeding recommendations through the provision of informational, emotional and tangible support (Raj & Plichta 1998). Following Fonseca-Becker & Valente's (2006) study of personal networks and breastfeeding, we are particularly interested in the ways in which personal networks mediate to flow of informational support, which includes advice and instruction, to mothers.

While previous social network studies provided strong evidence that the support of *close* alters exerts positive influences on mothers' infant feeding habits, they did not provide any information about the effects of *distant* alters, also known as 'weak ties'. However, ethnographic descriptions from three studies indicate that extended personal networks can have deleterious effects on mothers' infant feeding decisions. Distant alters (like friends, neighbours and relatives) have been found to encourage mothers to introduce family foods earlier than medical professionals recommend (Bryant 1982; McLorg & Bryant 1989; Muñiz Viveros *et al.* 2003). This is because many people believe that milk and formula are insufficient to meet the caloric needs of fast-growing infants and because the early introduction of solid foods is seen as an accomplishment or indicator of maturity for the infant. Distant alters may advise mothers to begin introducing complementary foods early or pressure mothers to 'catch up' with other mothers who have done so (Bryant 1982, p 1764; Muñiz Viveros *et al.* 2003, p 346). Conformity with social norms for child feeding is an important component of women's perception that they are 'good mothers' (Attree 2005). To accommodate conflicting views of appropriate infant feeding, some mothers discount medical advice, introduce family foods before the recommended period, strike a compromise, or conform to alters' advice in public and medical advice in private (McLorg & Bryant 1989, p 272).

The descriptive findings presented in these studies are intriguing because they demonstrate the potential value of measuring the effect of distant alters (weak ties) as well as close alters (strong ties). The idea that

weak ties (that is, the social effect of distant alters) have a significant effect on ego's beliefs and behaviours is grounded in the social network literature (Granovetter 1973). Indeed, several studies suggest that it is through weak ties that people often get new information (e.g. Granovetter 1973; Johnson 1986; Burt 1992, 2004). We expect this assumption to carry over to the formation of cultural beliefs and behaviours regarding infant feeding practices. In this paper, we systematically test the relationship between extended personal networks and infant feeding practices using personal network analysis. By quantifying the effect that distant alters have on a respondent, we explore how cultural beliefs about infant feeding are created and maintained in a social context. By sampling a wider array of alters, we explain a unique portion of the variability in complementary feeding practices.

Infant nutrition and feeding in Mexico

The Mexican Social Security Institute (IMSS) is the organization responsible for public health and health care in Mexico. IMSS translates the WHO child feeding principles into culturally appropriate recommendations for healthcare providers and mothers in Mexico. Until March 2001, the WHO recommended that complementary foods be introduced into infants' diets between 4 and 6 months of age (WHO 2000). In agreement with the WHO guidelines, IMSS recommended that fruit and vegetable juices be introduced at 4 months, cereals at 5 months, white meat at 6 months, red meat and fish at 7 months, and legumes at 8 to 9 months (IMSS 1998). Between 10 and 12 months, IMSS recommended that children's meals be integrated in the family diet. IMSS food introduction recommendations are designed to reflect national food preferences. Common elements of Mexican food culture include tortillas, rice, maize, beans, fruit and spicy flavoring (Menella *et al.* 2005). It should be noted that, in April 2001, the WHO issued a new recommendation that solid foods be introduced to infants' diets at 6 months (WHO 2001). IMSS has since revised their child feeding recommendations to

comply with new WHO guidelines (Homero Martínez personal communication).

There is a high incidence of initial breastfeeding among Mexican mothers. The majority of Mexican infants (86%) are breastfed in the first month of life, though only about a quarter of them (26%) are breastfed exclusively (Gonzalez-Cossio *et al.* 2006). Despite the good nutritional start that most Mexican infants receive, 92% are fed complementary foods before they reach the recommended weaning age (Gonzalez-Cossio *et al.* 2006). Among the nutritional problems prevalent among Mexican children under the age of 5 years are malnutrition, stunting and deficiencies of vitamin A, vitamin C, zinc and iron, particularly in the Southern region of Mexico, among impoverished families, and in the indigenous population (Rivera and Sepulveda Amor 2003; Barquera *et al.* 2003; Chavez Zuniga *et al.* 2003; Avila-Curiel *et al.* 2004).

In Mexico, several studies have been conducted to determine the factors that contribute to the appropriate introduction of complementary foods into infants' diets. An association between the appropriate delay of complementary feeding and socio-demographic variables (lack of maternal employment, greater maternal education, greater maternal age and multiparity) has been found for certain samples of mothers in Mexico and other Latin American countries (Perez Escamilla *et al.* 1995; Gonzalez-Perez *et al.* 2001; Flores *et al.* 2005). The provision of support by close network alters, particularly family members, has been found to facilitate appropriate infant feeding practices for Mexican mothers (Lipsky *et al.* 1994; Turnbull-Plaza *et al.* 2006). Additionally, indigenous Mexican mothers have been found to be more compliant with WHO infant feeding recommendations than non-indigenous mothers (Gonzalez-Cossio *et al.* 2006). Non-indigenous mothers are more likely to introduce cereals, legumes, animal products (except milk) and nutritive liquids early, while indigenous mothers are not (Long-Dunlap *et al.* 1995; Gonzalez-Cossio *et al.* 2006). Our research examines the extent to which these socio-demographic and network factors are associated with the time of complementary feeding for a sample of mothers in Oaxaca, Mexico.

Materials and methods

During June and July of 2001, we conducted follow-up interviews with mothers who participated in the IMSS Nationwide Survey on the Health and Nutritional Status of Children under Two Years of Age in Oaxaca, Mexico. Participating mothers had already allowed interviewers to collect demographic data, anthropometric measures and developmental assessments of their infants. Mothers who provided contact information in the first survey were eligible to participate in the follow-up study. The research design and protocol for the follow-up study were approved by the Institutional Review Board of the University of Florida prior to the start of the research.

Because of the time involved in conducting face-to-face follow-up interviews in a large city, we chose to focus on a subset of 28 neighbourhoods represented in the original IMSS study. These twenty-eight neighbourhoods were chosen to represent a range of ethnic enclaves and income groups in Oaxaca. Within each of these neighbourhoods, mothers who participated in the original IMSS study were randomly selected to participate in the follow-up study. Of the 742 respondents who participated in the first IMSS study, 99 mothers were randomly selected and contacted. Thirty-three mothers had moved or were never home (only address contacts were available) and six refused to participate or failed to keep interview appointments. Sixty mothers participated in the follow-up study, 47 of whom completed the entire personal network section of the survey. The mean number of days that elapsed between the initial and follow-up survey was 251 days ($SD = 79$), or about 8 months. The mean age of children at the time of the follow-up survey was 15 months ($SD = 4.4$). While the follow-up study's sample was designed to be generalizable to the initial IMSS study respondents, it is not necessarily generalizable to the general population of Oaxaca.

The initial IMSS survey included family demographics and information about child feeding, and these data were added to the follow-up data that we collected. The follow-up survey consisted of three sections: verification of household demographics, personal network questions and a food introduction chart. The face-to-face interviews were conducted in

Spanish and took approximately one hour. To improve respondent accuracy, appropriate memory prompts were used during the interviews (Bernard *et al.* 1984; Brewer 2002). Additionally, mothers were permitted to consult with family members to improve their recall of factual data, such as the timing of food introductions and alter demographics (e.g. age and education). Despite the efforts that were made to improve respondent accuracy, we must assume that mothers' faulty recall threatens the validity of the recall data to an unknown degree (as is the case for all studies that rely on respondent recall data).

In the personal network section, we asked mothers to name 40 people that they knew. We chose forty alters because previous research determined that this number maximizes the tradeoff between the utility of the information collected and burden placed on respondents (McCarty *et al.* 2000). The definition of knowing used in this study was that 'you know them and they know you by sight or by name, you could contact them, and that there has been some contact (in person, by telephone, by mail or e-mail) in the last two years' (Bernard *et al.* 1990). Mothers reported on each alter's sex, age, number of children, level of education and ability to speak an indigenous language (a proxy measure of indigenous knowledge). Mothers reported how close they were to each alter on a 1 to 5 scale (where 5 is closest), whether they had ever discussed weaning or infant feeding with each alter and whether they valued the advice of each alter regarding infant feeding issues. For the interval and ordinal network variables, we calculated the alters' average score in each mother's network. While performing statistical routines (such as averages) that assume interval scales with ordinal level can be problematic, this approach is generally considered acceptable for 5-to-7-point Likert-type scales (Labovitz 1967; Kim 1975). For nominal network variables, we calculated the 'percentage of alters' possessing a characteristic in each mother's network. For instance, if the percentage of adults in a mother's network is 25%, then 10 of the 40 alters she named were adults. To summarize nominal variables across multiple mothers' networks, we present the 'average percentage of alters' possessing a characteristic in all of the mothers' networks. For instance, if two mothers have 10% and 90% adults in

their networks, respectively, then the average percentage of adults in the two networks is 50%.

In the food introduction section, we asked mothers to report at what month of age, if at all, they had introduced 36 foods to their infant's diet. This questionnaire was designed to replicate another IMSS-sponsored study of 36 foods used for complementary feeding in Mexico. We then used the 2001 IMSS child feeding recommendations to create a list of ages at which foods could safely be introduced to children's diets. While some of the 36 foods were not specifically named in the 2001 IMSS guidelines, we were able to infer the correct introduction age and our list was later validated by a former IMSS director. The resulting recommendation schedule is as follows. Foods that could be safely introduced at 4 months or later were: vegetables, fruit, juice and smoothies (*aguas de fruta*). Foods that could safely be introduced at 5 months or later were: chicken soup, oatmeal, sweet corn drink (*atole*), sweet corn drink with milk (*atole con leche*), cereals and rice. Foods that could be safely introduced at 6 months or later were: chicken, chicken liver and noodle soup. Foods that could be safely introduced at 7 months or later were: crackers, bread, tortillas, yogurt, beef, beef liver, ham, pork, fish and mutton. Foods that could be safely introduced at 8.5 months or later were: sweet potatoes, pinto beans, bean soup, bread beans, lentils, garbanzo beans, *alverjon* beans and eggs. Foods that could be safely introduced at 11 months or later were: milk, cheese, sausage, coffee and soft drinks. The deviation from the recommended age was calculated by subtracting the actual month from the recommended month. For cases where the difference was negative (i.e. the food was introduced later than recommended), the difference was set to zero. We made this choice because the WHO and IMSS child feeding recommendations are primarily concerned with preventing the early introduction of specific foods, and do not provide the information needed to draw justifiable conclusions about the late introduction of specific foods.

Our analysis was focused on determining whether network-level variables perform better than respondent-level variables in explaining the variability of the early introduction of 36 foods to infants' diets. As Fig. 1 demonstrates, we developed two

Fig. 1. Model for explaining introduction of specific complementary foods.

Fig. 2. Graph shows the average month at which mothers in the sample introduced the foods (■), the range of introduction ages for each food (represented by bars) and the average deviation from the IMSS recommendation (◆).

models, one for the respondent-level characteristics and one for the network-level characteristics in the models. We decided against including all variables in a single model for two reasons. One is the potential for multi-colinearity by combining correlated variables in the model. For example, average alter age and mother's age are correlated, although not perfectly. Another problem was the additional degrees of freedom introduced relative to the low number of

observations. Given that our aim was specifically to test whether a model comprised of network variables worked better than a model with respondent-level characteristics, we decided it was better to keep them separate. There are strong methodological reasons related to data collection for doing this. Network variables are far more difficult to collect and analyse than respondent-level characteristics. Therefore, we wanted to test these separately to see whether the

added respondent and research burdens introduced by the network variables were offset by increased explanatory power. We believe that, if network-level variables do not perform better than respondent-level variables, the pursuit of future research in this vein would be inadvisable given the difficulties involved in collecting and analysing network data.

We ran multiple regressions using four respondent-level variables (respondent age, education, whether the respondent was employed and whether the respondent was a first time mother) as independent variables against a set of dependent variables representing the month at which each food was introduced. These four independent variables were selected from the literature on the socio-demographic determinants of mothers' infant feeding decisions. We also ran multiple regressions using four network-level variables (alter age, per cent of alters that speak an indigenous language, per cent of alters whose weaning advice the respondent values and mean tie strength) as independent variables against the same set of dependent variables. For the respondent-level and network-level predictors, we tested for multicollinearity and found that there were no large and significant associations among the variables within each of the models. We use both models to predict the age at introduction for the 36 foods discussed above. We plotted the residuals for each regression, and in all cases they appear as a horizontal band. This suggests that the models fit the data. In our analyses, we compare the results to determine which set of measures better predicts the age at which complementary foods are introduced into the infants' diets. This approach is similar to the one used by Fonseca-Becker & Valente (2006) to demonstrate that network-level characteristics add to the predictive value of respondent-level characteristics in a study of Bolivian mothers' breastfeeding practices.

Results

Demographics

As Table 1 indicates, the mean age of mothers in the sample was 26.0 years ($SD = 4.8$). About half of the women (53.3%) were first-time mothers. All of the

Table 1. Description of Oaxacan mothers

Respondent-level variables	Value
Mean age	26.0 (SD 4.8)
Mean education (in years)	11.3 (SD 4.0)
Per cent in poverty	1.7
Per cent first time mother	53.3
Per cent mother has stable partner	95
Per cent mother works outside home	38.3
Per cent mother speaks indigenous language	7.1
Per cent that breastfeed until 4 months ($n = 30$)	80
Per cent that breastfeed until 6 months ($n = 30$)	33
Age in days of child when breast-feeding stops ($n = 30$)	Mean 137.0 (SD 47.0)

Table 2. Description of alter characteristics

Personal network variables	Value	SD
Average age of alters	32.5	4.29
Average closeness between mothers and alters (scale: 1–5)	3.7	0.59
Average percentage of alters with at least one child	0.56	0.26
Average percentage of alters with education above high school	0.18	0.15
Average percentage of alters who speak an indigenous language	0.08	0.14
Average percentage of alters with valued child feeding advice	0.47	0.26

mothers (100%) breastfed their infants at least once. The mean number of days that mothers breastfed was 137 ($SD = 47$). In compliance with IMSS recommendations, most mothers (80%) breastfed for four or more months. A third of the mothers (33%) breastfed for six or more months. Most of the mothers (95%) had a stable partner, and less than half (38.3%) worked outside of the home. Mothers' mean years of education was 11.3 years ($SD = 4.8$). A small minority of the mothers (7.1%) spoke an indigenous language.

Each of the mothers provided a list of 40 alters with whom they had had contact in the last 2 years. Table 2 illustrates the characteristics of the mothers' alters. Mothers' average closeness to alters was 3.7 ($SD = 0.59$). The average age of mother's personal network alters was 32.5 ($SD = 4.29$). The average

percentage of network alters with at least one child was 56% (SD = 26%). The average percentage of alters with education beyond high school was relatively low at 18% (SD = 15%). The average percentage of alters who speak an indigenous language was quite low, only 8% (SD = 14%). The average percentage of network alters with valued child feeding advice was about half, or 47% (SD = 26%).

Child feeding

Figure 2 illustrates the data for the introduction of 36 foods into Oaxacan infants' diets. Five trends can be identified in Fig. 2. First, there is variability across foods as to when they are introduced into children's diets. Second, many of the foods are introduced at or after the time recommended by IMSS. Third, when foods are introduced early, they are introduced, on average, between 1 and 2 months earlier than recommended. Fourth, compliance with recommendations is highest for foods that are introduced earliest (4–5 months) and latest (11 months). Fifth, variability in age at food introduction appears to grow for foods introduced later, with some foods (such as sausage, soft drinks and coffee) exhibiting wide variability.

Models

In this section, we use the Proportionate Reduction of Error (PRE), represented by r^2 , to summarize the goodness of fit of the multiple regression models. This class of statistics measures the degree to which the error in predicting the value of the dependent variable for a given case will be reduced by having knowledge of the independent variable(s), compared with the situation where you guess the mean. This statistic is often described as the percentage of variance in the dependent variables explained by the independent variable(s).

As Table 3 indicates, respondent-level variables proved to be poor predictors of the age of introduction of complementary foods. In fact, only the month at which pork was introduced into the infants' diet was significantly associated with the respondent-level model. In that model, just one of the three respondent-level variables, mother's education, had a

significant positive association with the month at which pork was introduced in the infant's diet. The other three respondent-level variables – mother's age, employment and first-time mother status – were not significantly associated with the month at which pork was introduced. The model accounted for 81% of the variation in the introduction of pork to infants' diets. None of the 35 other foods were significantly associated with the respondent-level variables.

In comparison, Table 4 indicates that network-level variables performed better as predictors of the timing of the introduction of complementary foods. The network-level model was significantly associated with the month at which seven foods were introduced into infants' diets (oatmeal, cereals, rice, noodle soup, ham, sausage and soft drinks), and accounted for between 23% and 41% of the variance in the introduction of these seven foods. Network-level variables predicted 41% of the variance in the introduction of ham. Two of the variables, per cent alters who speak an indigenous language and average strength of ties, were significantly positively associated with ham introduction. Network-level variables explained 40% of the variance in the introduction of soft drinks. One variable, average alter age, had a marginally significant negative association with soft drink introduction. Network-level variables explained 39% of the variation in the introduction of rice. The per cent of alters with trusted advice had a significant negative association with rice introduction, while the average strength of ties had a significant positive association. Per cent alters who speak an indigenous language also had a marginally significant positive association with rice introduction. Network-level variables accounted for 35% of the variance in the introduction of sausage. As with ham, two variables, per cent alters who speak an indigenous language and average strength of ties, were significantly positively associated with sausage introduction. Network-level variables explained 25% of the variance in the introduction of oatmeal. One variable, per cent alters who speak an indigenous language, was significantly positively associated with oatmeal introduction. Network-level variables explained 24% of the variance in the introduction of noodle soup. As with oatmeal, one variable, per cent alters who speak an indigenous language, was signifi-

Table 3. Regression results for each food using respondent characteristics

Dependent variables Foods	Independent variables: mother's characteristics				Model parameters	
	Age β (p)	Education β (p)	Employment β (p)	First birth β (p)	Prob > <i>F</i>	<i>r</i> ²
Vegetables	-0.04 (0.5581)	-0.02 (0.7927)	0.27 (0.6306)	-0.68 (0.1754)	0.186	0.14
Fruit	-0.04 (0.5935)	-0.03 (0.6492)	0.29 (0.5918)	-0.67 (0.1609)	0.1937	0.13
Smoothie	-0.11 (0.1521)	-0.0001 (0.9963)	-0.32 (0.6270)	0.13 (0.8213)	0.5119	0.07
Chicken broth	-0.16 (0.0139)	0.009 (0.8836)	-0.61 (0.2422)	0.41 (0.3589)	0.1045	0.17
Juice	-0.16 (0.1076)	-0.04 (0.7170)	0.28 (0.7389)	0.09 (0.8928)	0.2557	0.12
Chicken liver	0.10 (0.2513)	0.002 (0.9858)	0.53 (0.4458)	-0.18 (0.7862)	0.6819	0.06
Oatmeal	-0.12 (0.2410)	-0.01 (0.9770)	0.87 (0.3095)	-0.03 (0.9712)	0.3621	0.12
Sweet corn drink	-0.17 (0.3425)	-0.08 (0.5986)	-2.79 (0.0430)	1.39 (0.2903)	0.205	0.17
Sweet potatoes	0.14 (0.2173)	-0.24 (0.0290)	1.03 (0.2600)	-1.47 (0.0717)	0.1643	0.17
Sweet corn drink with milk	-0.29 (0.0436)	0.02 (0.8614)	-2.24 (0.0943)	1.24 (0.2209)	0.2616	0.16
Cereals	-0.11 (0.4209)	-0.10 (0.4685)	-0.59 (0.5888)	-0.22 (0.8266)	0.5762	0.07
Rice	-0.06 (0.5144)	0.03 (0.6801)	-0.08 (0.9137)	0.40 (0.5797)	0.9688	0.01
Yogurt	-0.05 (0.6887)	0.02 (0.8759)	0.40 (0.6891)	-0.16 (0.8546)	0.9308	0.02
Beans	-0.16 (0.2232)	0.15 (0.2388)	-0.77 (0.4747)	0.50 (0.5923)	0.6218	0.06
Bean soup	-0.16 (0.2232)	0.15 (0.2388)	-0.77 (0.4747)	0.50 (0.5923)	0.6218	0.06
Noodle soup	-0.06 (0.5532)	0.04 (0.6980)	-0.02 (0.9776)	-0.85 (0.2100)	0.1998	0.14
Milk	-0.18 (0.2978)	-0.19 (0.2509)	-0.62 (0.6582)	0.68 (0.6054)	0.4236	0.13
Tortillas	0.05 (0.7124)	-0.09 (0.4644)	0.55 (0.5781)	-0.02 (0.9811)	0.9186	0.03
Chicken	-0.13 (0.2902)	-0.06 (0.6151)	0.84 (0.4162)	-0.07 (0.9337)	0.3974	0.1
Crackers	0.12 (0.3239)	-0.08 (0.4764)	1.08 (0.2976)	-1.16 (0.2185)	0.724	0.06
Bread	-0.09 (0.4419)	0.003 (0.9770)	0.22 (0.8257)	-0.16 (0.8499)	0.771	0.05
Bread beans	0.06 (0.7618)	0.05 (0.8260)	0.41 (0.7873)	-0.96 (0.5754)	0.9704	0.03
Lentils	0.12 (0.6306)	-0.03 (0.9130)	-0.67 (0.7354)	-0.25 (0.8862)	0.9785	0.02
Garbanzo beans	0.27 (0.1381)	0.04 (0.7945)	1.71 (0.2014)	-1.69 (0.1481)	0.4245	0.16
Cheese	0.004 (0.9631)	-0.07 (0.5282)	0.37 (0.6926)	-0.20 (0.7917)	0.9617	0.02
Beef	-0.05 (0.7760)	-0.13 (0.4413)	1.44 (0.3221)	-1.79 (0.1790)	0.2044	0.2
Ham	-0.05 (0.7191)	-0.11 (0.5228)	1.17 (0.3496)	-0.23 (0.8286)	0.5728	0.11
Eggs	0.04 (0.7707)	0.04 (0.7742)	1.24 (0.3015)	-1.04 (0.3309)	0.6475	0.07
Alverjon beans	0.03 (0.9155)	0.25 (0.5300)	-1.91 (0.5558)	1.4 (0.5677)	0.6646	0.77
Sausage	0.02 (0.8914)	0.004 (0.9860)	1.73 (0.2361)	-0.64 (0.6067)	0.7873	0.07
Fish	-0.20 (0.2301)	-0.03 (0.8612)	2.06 (0.1480)	-0.04 (0.9699)	0.1388	0.25
Beef liver	-0.31 (0.4307)	-0.83 (0.2384)	0.62 (0.8901)	1.52 (0.5888)	0.5972	0.3
Soft drinks	-0.48 (0.0331)	0.03 (0.8738)	-0.42 (0.7920)	2.24 (0.1455)	0.2012	0.24
Mutton	NA	NA	NA	NA	NA	NA
Pork	-0.45 (0.1154)	1.42 (0.0114)	4.16 (0.1062)	-1.53 (0.4325)	0.0232	0.81
Coffee	-0.09 (0.8190)	0.27 (0.6225)	-1.16 (0.6849)	0.69 (0.8350)	0.9628	0.05

NA, not available. Figures in **bold** indicate statistical significance.

cantly positively associated with noodle soup introduction. Network-level variables explained 23% of the variance in the introduction of cereals. Per cent alters who speak an indigenous language had a significant positive association with cereal introduction, while per cent of alters with trusted advice had a significant negative association with cereal introduction.

The multiple regression models indicate that the network-level variables are better predictors of the

timing of the introduction of foods than the respondent-level variables. However, caution is called for in the interpretation of the findings because the large number of multiple regressions conducted increases the chance for type I errors (or incorrectly concluding that a regression is significant when it is actually due to chance). Even so, when we compare Table 3 to Table 4 (with the same set of regressions), the difference in the number of significant regressions is striking. The fact that Table 3 only has one signifi-

Table 4. Regression results for each food using network characteristics

Dependent variables	Independent variables: mother's network characteristics				Model parameters	
	Average alter age β (p)	Per cent indigenous β (p)	Per cent with valued infant feeding advice β (p)	Average closeness β (p)	Prob > F	r^2
Vegetables	-0.04 (0.4258)	2.31 (0.4223)	-1.83 (0.0750)	0.07 (0.8731)	0.2342	0.13
Fruit	-0.05 (0.3633)	0.62 (0.8220)	-1.89 (0.0557)	-0.15 (0.7215)	0.1945	0.13
Smoothie	-0.05 (0.3968)	-1.69 (0.5959)	-3.15 (0.0067)	0.31 (0.5130)	0.081	0.18
Chicken soup	-0.02 (0.7377)	3.99 (0.1537)	-1.18 (0.2395)	0.05 (0.9071)	0.3027	0.11
Juice	-0.11 (0.1526)	0.88 (0.8303)	-3.06 (0.0463)	-0.22 (0.7152)	0.1072	0.17
Chicken liver	-0.03 (0.7013)	1.06 (0.7745)	-2.17 (0.0836)	0.41 (0.4889)	0.4546	0.09
Oatmeal	0.13 (0.1073)	8.50 (0.0412)	-1.54 (0.3273)	-0.22 (0.7266)	0.0479	0.25
Sweet corn drink	-0.0007 (0.9949)	8.61 (0.1765)	-3.08 (0.1466)	-0.66 (0.4532)	0.1028	0.23
Sweet potatoes	-0.11 (0.2914)	1.22 (0.8073)	-2.01 (0.2577)	0.08 (0.9164)	0.6249	0.07
Sweet corn drink with milk	0.16 (0.1737)	11.35 (0.1556)	-2.76 (0.1799)	-0.10 (0.9082)	0.1731	0.19
Cereals	-0.06 (0.5367)	9.60 (0.0450)	-3.28 (0.0499)	0.33 (0.6481)	0.0458	0.23
Rice	0.04 (0.5601)	6.04 (0.0811)	-4.54 (0.0003)	1.46 (0.0064)	0.0006	0.39
Yogurt	-0.14 (0.1197)	2.27 (0.6560)	-3.31 (0.0501)	1.05 (0.1421)	0.1098	0.18
Beans	-0.15 (0.1425)	0.89 (0.8661)	-3.46 (0.0734)	0.53 (0.5098)	0.2278	0.13
Bean soup	-0.15 (0.1425)	0.89 (0.8661)	-3.46 (0.0734)	0.53 (0.5098)	0.2278	0.13
Noodle soup	-0.11 (0.1907)	11.76 (0.0066)	-1.50 (0.2581)	0.52 (0.3665)	0.0273	0.24
Milk	-0.07 (0.5500)	6.08 (0.3912)	-1.13 (0.6630)	-1.45 (0.1840)	0.2299	0.19
Tortillas	0.16 (0.1016)	0.78 (0.8829)	-3.10 (0.0639)	0.44 (0.5388)	0.1816	0.17
Chicken	-0.08 (0.3929)	-0.009 (0.9985)	-2.60 (0.1349)	-0.78 (0.2848)	0.2071	0.14
Crackers	-0.20 (0.0409)	2.88 (0.5549)	-2.93 (0.0940)	1.18 (0.1167)	0.0688	0.23
Bread	0.018 (0.8626)	2.17 (0.7082)	-1.11 (0.5411)	0.0004 (0.9996)	0.9373	0.02
Bread beans	0.003 (0.9853)	3.72 (0.6720)	-3.02 (0.2596)	0.44 (0.7146)	0.6366	0.17
Lentils	0.07 (0.7280)	-4.20 (0.6861)	-0.39 (0.9161)	-1.13 (0.5164)	0.9678	0.03
Garbanzo beans	-0.02 (0.8712)	13.61 (0.3016)	1.95 (0.4108)	0.64 (0.5208)	0.7993	0.08
Cheese	-0.04 (0.6437)	-0.79 (0.8703)	-1.98 (0.2220)	0.05 (0.9417)	0.7617	0.05
Beef	-0.15 (0.3139)	7.63 (0.3985)	-1.91 (0.4728)	0.57 (0.6290)	0.615	0.1
Ham	-0.09 (0.3481)	16.15 (0.0078)	-2.85 (0.1282)	1.89 (0.0254)	0.0125	0.41
Eggs	-0.05 (0.6395)	-2.58 (0.6962)	-0.16 (0.9397)	-1.17 (0.1995)	0.7041	0.07
Alverjon beans	0.33 (0.1590)	-9.03 (0.6019)	-6.95 (0.2361)	0.57 (0.5806)	0.3271	0.95
Sausage	-0.05 (0.6446)	19.95 (0.0059)	-0.04 (0.9859)	2.75 (0.0211)	0.0482	0.35
Fish	-0.31 (0.0135)	6.14 (0.3998)	-1.85 (0.3836)	0.64 (0.5608)	0.0893	0.3
Beef liver	-0.78 (0.0630)	13.37 (0.2909)	2.36 (0.6760)	1.40 (0.4697)	0.2746	0.44
Soft drinks	-0.25 (0.0666)	6.82 (0.3205)	-4.40 (0.1106)	-0.84 (0.4588)	0.0361	0.40
Mutton	NA	NA	NA	NA	NA	NA
Pork	-0.43 (0.3049)	-18.72 (0.5172)	-0.69 (0.9242)	-8.33 (0.3091)	0.735	0.29
Coffee	0.31 (0.2665)	6.59 (0.7677)	0.75 (0.8625)	-1.98 (0.3764)	0.6895	0.19

NA, not available. Figures in **bold** indicate statistical significance.

cant regression and Table 4 has seven does not seem entirely because of chance. Additionally, a few trends – the role that indigenous alters, strength of ties and trusted advice play in the introduction of grains and processed pork products to infants' diets – emerge repeatedly across analyses for several specific foods. As a result, we are reasonably confident that they reflect genuine results. We are less confident in our findings regarding the role of network alters' age in

the introduction of soft drinks and the role of mother's education in the introduction of pork. We evaluate each of these findings in light of previous research in the following section.

Discussion

Of the respondent-level and network-level variables tested here, the percentage of indigenous alters in

mothers' networks was found to be the best predictor of the introduction of complementary foods. The indigenous network variable has a positive association with the age at introduction of four foods featuring grains (oatmeal, cereal, noodle soup and marginally rice) and two processed pork products (ham and sausage). Our results support previous findings that indigenous mothers delay the introduction of complementary foods in their own infants' diets (Long-Dunlap *et al.* 1995; Gonzalez-Cossio *et al.* 2006). Our research adds to this literature by demonstrating that the presence of indigenous alters in mothers' networks is associated with delayed complementary feeding, even when the mothers themselves are not necessarily of indigenous descent. While we did not directly test the transfer of knowledge among network alters, we believe that the presence of indigenous alters in a network indicates increased exposure to indigenous cultural constructs. This finding suggests the continued importance of culture, even in a population like IMSS mothers that is highly influenced by a shared biomedical model for the complementary feeding of infants. We also note that our finding does not necessarily support the conclusion that having a higher percentage of indigenous network alters is related to improved infant health. As we mentioned previously, Mexican children of indigenous descent are more likely to suffer from malnutrition; the role that the late introduction of complementary foods may or may not play in causing malnutrition among indigenous Mexican infants is still unknown.

The percentage of network alters whose weaning advice mothers value was negatively associated with the month at which two grains (cereals and rice) were introduced in infants' diets. This indicates that when mothers heed the advice of a wider network of alters, their child feeding practices may be less compliant with medical advice. This finding provides quantitative confirmation of published ethnographic accounts that distant alters encourage mothers to introduce solid foods early to prove that the infant is maturing quickly (Bryant 1982; McLorg & Bryant 1989, Muñoz Viveros *et al.* 2003), at least for the introduction of some grains to infants' diets. Additionally, the strength of ties between mothers and the alters in

their networks was found to have a positive association with the introduction of one grain (rice) and two processed pork products (ham and sausage). This indicates that mothers who are closer to network alters may delay the onset of complementary feeding longer than those with more distant alters. This finding is consistent with previous studies on the positive effects of social support on mothers' infant feeding practices. Taken together, the findings about alters' valued advice and alters' closeness to mothers suggest that close alters and distant alters work at cross purposes. Close alters appear to help mothers delay complementary feeding, while distant alters appear to encourage mothers to speed complementary feeding. This fits into a wider scholarship on social networks, the construction of norms, information flow and innovation. We believe that mother's infant feeding decisions are shaped by the social context in which they are made, including the influences of strong and weak ties. Analysis of extended personal networks provides an important tool for unraveling the effects of strong and weak ties.

The average age of network alters had a strong negative association with just one of the 36 dependent variables – the month at which soft drinks are introduced to the infants' diet. The negative association between average network age and the introduction of soft drinks was not predicted by the literature, and may be the product of a type I error. However, Leathern & Goodman (2005) recently found that Mexicans have become aware of the harmful effects of 'coca-colonization', or the increasing consumption of Coca-Cola and other high-calorie, low-nutrient snack foods, over the last 30 years. It is possible that mothers with younger networks are more likely than mothers with older networks to recognize this problem and react against it by delaying the introduction of soft drinks into their infants' diets.

We were initially also puzzled by the fact that the mother's education has such a strong association with the age of pork introduction. We were inclined to dismiss the finding because, like the average network age finding discussed above, it appeared to be consistent with a type I error given that no association between pork and education was specifically predicted in the literature and none of the other 35 foods'

introductions were significantly associated with mother's education. However, after thorough review of the literature, we discovered that the consumption of pork is a major risk factor for human taeniasis and cysticercosis (*Taenia solium*) infection (Sarti *et al.* 1992) and that cysticercosis is endemic in Oaxaca (Larralde & Sciutto 2006). We also found that education programmes regarding the role of pork in taeniasis/cysticercosis transmission had been conducted in Mexico (e.g. Keilbach *et al.* 1989). As a result, we believe it is possible that more educated mothers are more knowledgeable about the risks associated with the consumption of unprocessed pork, and consequently delay the introduction of unprocessed pork products into infants' diets.

While we have devoted a great deal of space to discussing how and why timing of the introduction of some grains and processed pork products is partially explained by network-level variables, it is equally important to note that the introduction of a large number of foods was not associated with the respondent-level and network-level variables. For foods that are introduced early, particularly fruits, vegetables, smoothies and juice, there was very little variation in the age of introduction, and thus no effect to explain. However, some foods, such as beans, dairy, eggs and other meats, did have a wider variation in the age of introduction and simply were not explained by the respondent-level and network-level variables we studied here. One reason that the respondent-level variables performed so poorly may be that they were identified as predictors of the duration of breastfeeding, at least in the literature on Western mothers, rather than the introduction of complementary foods. The lack of association between mother's age, education, employment, and parity and the introduction of 26 family foods to infants' diets may indicate that there is a need for more research on the socio-demographic predictors of complementary feeding.

Conclusion

In this paper, we demonstrate that analyses of extended personal networks contribute to studies of infant feeding and, more broadly, to studies of mothers' health related decision-making. Previous

literature on infant feeding showed that close alters, such as fathers and grandmothers, encourage mothers to comply with infant feeding recommendations. Our study is the first to systematically test the effects of extended social networks (with 40 alters) on the complementary feeding of infants, and yields four key findings: (1) network-level variables were better predictors of the age at the introduction of foods than respondent-level variables; (2) mothers with more indigenous networks delayed the introduction of some grains and processed pork products to the infant's diet longer than mothers with less indigenous networks; (3) mothers who had stronger ties to alters tended to delay the introduction of rice and processed pork products to the infant's diet longer than mothers with weaker ties; and (4) mothers who heeded the advice of distant alters introduced some grains earlier than mothers who do not heed the advice of distant alters.

Several limitations in the study methodology should be taken into account in the interpretation of results. First, the study was not conducted with a random sample of mothers and thus cannot be generalized to the Mexican population. Furthermore, because interviews were conducted with a sub-sample of respondents to the IMSS Nationwide Survey on the Health and Nutritional Status of Children under Two Years of Age, there may be an unknown bias created by the pattern of refusals during the first IMSS study. Second, the values of the dependent variables were determined by the mothers' recall of the age of introduction of 36 foods. While we used memory prompts and the input of other family members, particularly grandmothers, during the interviews as correctives to faulty recall, it is likely that mothers' responses were to some extent inaccurate. Indeed, recall inaccuracies tend to be reflective of social norms, which may in part explain why there were so few deviations for IMSS recommendations for the reported age of introduction for many foods. Third, no specific data were collected regarding the information and advice provided by network alters. While it is clear that reliance on extended network alters is associated with early introduction of complementary foods, we cannot isolate the social mechanism that causes this phenomenon. Based on previous studies, we suspect that poor

advice and competition to have a mature baby are primary causes, but we cannot rule out other mechanisms (i.e. maternal psychological factors explain why mothers both rely on advice from more alters and why they wean infants too early) without further study. Fourth, because a large number of regression models were run, the statistical significance of some findings should be interpreted with caution, particularly for the associations between mother's education and pork introduction and between alters' age and soft drink introduction.

Because so few studies of extended personal networks have examined infant feeding patterns, we believe that there is an enormous potential for scholars to improve on our methods and findings in future studies. Such research might explore how network-level characteristics affect the introduction of different classes of complementary foods (such as grains, meats, dairy) to infants' diets. Future research might also explore how the influence of social networks with knowledge of indigenous and other non-biomedical models of infant feeding influence mothers' infant feeding practices. Finally, future research might examine whether the varying effects of close and distant alters are related to the transmission of knowledge or of social norms across mothers' networks.

Social networks have been used to design a variety of health interventions, including the promotion of breastfeeding (Bryant *et al.* 1992; Losch *et al.* 1995). Such interventions typically use a 'social marketing' approach intended to broadly educate mothers' social networks. Because the timing of complementary feeding appears to be at least partially explained by network-level characteristics, personal network research may have the potential to improve future educational programmes and interventions designed to promote appropriate infant feeding behaviours.

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