ORIGINAL ARTICLE

Premastication and length for age among children under 24 months in Laos

Joel Conkle¹ | Sengchanh Kounnavong² | Melissa Young³ | Aryeh D. Stein^{3,4}

¹Nutrition and Health Sciences, Emory University, Atlanta, Georgia, USA

²Division of Health System Research, National Institute of Public Health, The Ministry of Health, Vientiane, Laos

³Hubert Department of Global Health, Emory University, Atlanta, Georgia, USA

⁴Department of Epidemiology, Rollins School of Public Health, Emory University, Atlanta, Georgia, USA

Correspondence

Joel Conkle, Nutrition and Health Sciences, Emory University, 1518 Clifton Road, Atlanta, Georgia 30322, USA.
Email: joelconkle@gmail.com

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Abstract

Premastication of infant food by caregivers is common in Laos. Premastication is hypothesized to have both positive and negative implications for children, but the net effect of premastication on child health and nutrition is largely unknown because of a lack of research. This study quantitatively describes premastication in 5 provinces of Laos and examines the associations between premastication and the length of young children. We analyzed cross-sectional data from the Laos 2015 Food and Nutrition Security Survey to characterize premastication among children under 2 years of age ($n = 1,661$) and to test associations between premastication and child length-for-age z-score. We explored associations using multilevel mixed effects linear regression. Among children 0–23 months, 27.2% of mothers reported giving premasticated food in the past week. Receipt of premasticated food was inversely associated with length-for-age z-score after controlling for potential confounders (child's age, ethno-linguistic group, wealth, and parity) among children 6–13 months ($\beta -0.36$, CI $[-0.68, -0.04]$) and among children 14–23 months ($\beta -0.43$, CI $[-0.81, -0.05]$). For breastfed children 0–5 months who received complementary food, the coefficient was similar, but the association was not statistically significant ($\beta -0.42$, CI $[-1.2, 0.37]$). Premastication is a common feeding practice for children 0–23 months of age, and many infants consume premasticated food on a daily basis. There was a negative relationship between premastication and child length. However, given the cross-sectional nature of this study and potential unmeasured confounding factors, reverse causality or confounding cannot be ruled out. Longitudinal studies are needed to develop recommendations on premastication.

KEYWORDS

anthropometry, child feeding, complementary feeding, infant feeding, prechewing, premastication

1 | INTRODUCTION

By 6 months of age, infants need food other than breast milk to satisfy the nutrient demands of rapid growth (Butte, Lopez-Alarcon, & Garza, 2002), yet infants do not have the ability to chew solid foods (Le Révérend, Edelson, & Loret, 2014). Animal-source foods and wild fruits and vegetables were regularly consumed by the hunter-gatherer, providing a diet high in fiber, protein, and micronutrients (Eaton, 2000; Eaton & Konner, 1997; Kuipers, Joordens, & Muskiet, 2012). Paleolithic peoples needed a strategy for feeding solids to infants. Premastication of infant food, also known as prechewing or kiss-feeding when practiced mouth to mouth (Eibl-Eibesfeldt, 2007), has been documented among both preagricultural peoples (Eibl-Eibesfeldt, 2007; Konner, 2010, p. 386) and nonhuman primates (gorillas,

orangutans, and chimpanzees; Eibl-Eibesfeldt, 2007, p. 138; Goodall, 1968). Estimating infant nutrient intakes based on adult diet, Dewey (2013) concluded that infants in preagricultural societies had a better diet than infants in present-day, low-income countries because infants could meet their micronutrient needs before the introduction of agriculture resulted in a higher consumption of relatively nutrient-poor staples.

Agriculturalists removed the requirement to prechew food by feeding infants porridge. Porridge is easily consumed by infants with few or no teeth, but the unfortified, porridge-based diet common in agricultural societies today does not satisfy infant micronutrient needs (Dewey, 2013). Infants, despite small stomach capacity and high nutrient needs, consume a bulky, low-energy density food that inhibits iron and zinc absorption (Dewey, 2013). The immature infant immune

system (Simon, Hollander, & McMichael, 2015) presents another challenge to complementary feeding, in particular feeding improperly stored porridge, because feeding can introduce pathogens that when coupled with an insufficient diet lead the infant into a malnutrition-infection cycle (McDade & Worthman, 1998; Rowland, Barrell, & Whitehead, 1978). Insufficient diet and infection can go a long way to explain why in recent history, and currently, infants in low-and middle-income countries around the world experience growth faltering and suffer from micronutrient deficiencies, particularly iron deficiency, while weaning (Black et al., 2008; de Onis & Branca, 2016). The agricultural revolution increased human reproduction, but from a health and nutrition perspective, it can be viewed as a shock that resulted in reduced height and lower life expectancy (Eaton & Konner, 1997; Kuipers et al., 2012). In more recent times, higher income households and communities have overcome these limitations through sanitation, hygiene, vaccination, and fortification of infant porridges with micronutrients (Dewey, 2013), but much of the world has not rebounded from the growth faltering that resulted from the introduction of agriculture.

Globally, human premastication appears to have survived the agricultural revolution and is still practiced across many different cultures and countries (Conkle, Ramakrishnan, & Freeman, 2016; Peltó, Zhang, & Habicht, 2010), including some industrialized nations (Conkle et al., 2016). Surprisingly, the impact of the practice on child growth has not been studied in hunter-gatherer or agricultural settings. There is clearly a nutritional benefit to starting complementary feeding by 6 months, especially with nutritious foods, and premastication facilitates the introduction of solid foods. In hunter-gatherer societies, premastication was necessary for feeding infants because many foods required mastication, but agricultural societies developed the option of turning staple grains into porridge. It has been hypothesized that premastication improves nutritional status through dietary diversification (Conkle et al., 2016) and that saliva transfer occurring with premastication could itself be advantageous (Konner, 2010, p. 406; Peltó et al., 2010). There is some evidence that saliva transfer from adult to infant can improve the digestion of starches (Humphrey & Williamson, 2001; Karlsson & Svanberg, 1982). However, research has also directly linked premastication to contamination of food (Imong et al., 1995; Ogunshe et al., 2013), and the practice has been associated with the transfer of pathogens to the child (Conkle et al., 2016; Gaur et al., 2009; Huang, 1990; Mbulaiteye et al., 2003; Mbulaiteye et al., 2006; Pattanaporn et al., 2013; Steinkuller, Chan, & Rinehouse, 1992; Taylor & Blaser, 1991; Zhou, Qian, Lu, & Guan, 2009). Thus, premastication may have net nutritional benefit in hunter-gatherer societies, where complementary food is nutritious and population density low, but in agricultural and industrial settings, the effect of the practice on child nutrition is less clear.

Premastication of infant food is a common infant and young child feeding practice in the Lao People's Democratic Republic (PDR; Ministry of Health and the Ministry of Planning and Investment Lao Statistics Bureau, 2016), a country that while experiencing rapid economic development and industrialization remains primarily agricultural, with the majority of the population engaged in subsistence farming (Setboonsarng, Leung, & Stefan, 2008). Caretakers in

Key messages

- Our study showed a negative association between premastication and linear growth, but mixed methods, longitudinal studies are needed to establish causality.
- Future studies should take into account what food was premasticated and how premasticated food was prepared and delivered to the child. There is a need for qualitative research on premastication among the Lao-Tai, an ethno-linguistic group with a high prevalence of premastication.
- Additional qualitative and quantitative research is needed to determine if reverse causality is responsible for the negative association with LAZ found in our study.

Laos use the agriculturalist strategy of porridge, along with the traditional practice of premastication of solids, for feeding infants (Holmes et al., 2007). In this paper, we further characterize premastication practices and examine associations between premastication and length-for-age z-score (LAZ) in Lao PDR, a country whose staple food for adults and infants is glutinous rice (Soukaloun et al., 2003) and where more than 1/3 of children under 5 years of age are stunted (Lao Statistics Bureau, 2016).

2 | METHODS

2.1 | Dataset

We analyzed data from the 2015 Food and Nutrition Security Survey (FNSS), a cross-sectional, cluster-based household survey carried out by the Lao Statistics Bureau in five provinces. The FNSS questionnaires and survey methods were approved by the Lao National Ethics Committee for Health Research. Survey participants gave informed consent, and the National Ethics Committee for Health Research approved secondary analysis and was informed about our study before it was carried out. The 2015 FNSS completed interviews in 6,387 households, achieving a household response rate of 97.5%. Weighted estimates from the survey are representative at the provincial level. Additional details on the 2015 FNSS sample design are available in the main survey report (Ministry of Health and the Ministry of Planning and Investment Lao Statistics Bureau, 2016).

2.2 | Inclusion/exclusion criteria

Before exploring the relationship between premastication and length, we calculated basic statistics on current premastication and premastication frequency to complement statistics available in the FNSS report. The FNSS report included an indicator on whether a child "ever received" premasticated food, which includes children that received premasticated food at any point in their life. FNSS data on

premastication at the time of the survey and on premastication frequency were not previously analyzed, and indicators for these variables were not published in the FNSS report. In our study, basic statistics included all children under 2 years of age whose mother responded to questions on current premastication, resulting in a weighted sample size of 1,661.

We divided the sample into three age groups: 0–5, 6–13, and 14–23 months. We decided on 13 months as an age group cutoff considering dentition (Le Révérend et al., 2014) and on the basis of the high prevalence of premastication from 6 to 13 months in Laos. We hypothesized that premastication could have a different association with LAZ in each of the age groups because of varying nutrient needs, gut development, and ability to masticate.

To explore the relationship between premastication and length, we analyzed descriptive statistics and association tests with sampling weights removed. We also added additional inclusion criteria. For all age groups, we restricted analysis to breastfed children, and for the 0–5 months age group, we only considered breastfed children who received complementary food. Our research question did not require analyzing associations with exclusive breastfeeding or early cessation of breastfeeding, and we adopted additional inclusion criteria to isolate the relationship with premastication. For all age groups, we excluded children with implausible measurements (<6 SD or >6 SD LAZ).

2.3 | Definition of key variables

Our exposure of interest was “current” premastication. We defined current premastication as a binary variable of feeding with premasticated food at least once in the previous week. The daily frequency of premastication is an average, based on the number of times the child received premasticated food in the past week as reported by the mother. Two percent of children were excluded because of nonresponse to premastication. We categorized daily frequency into less than one time per day, one to less than two times per day, and two or more times per day. We used terms borrowed from the infant and young child feeding literature to categorize premastication as prelacteal (premastication feeding before feeding breast milk in the first 3 days of life), early (premastication feeding before 6 months of age), and timely (premastication feeding from 6 to 23 months of age).

Our outcome of interest was child LAZ, calculated using the 2006 World Health Organization Growth Standards as a reference population (de Onis et al., 2004; Ministry of Health and the Ministry of Planning and Investment Lao Statistics Bureau, 2016). We excluded 6.7% of the children because of implausible measurements.

We selected cluster-, household-, and individual-level covariates presumed a priori to be associated with LAZ to control for potential confounding. At the cluster level, we used the categorical variable for residence type as defined by the Lao Statistics Bureau: urban, rural, and rural without road. For access and utilization of health services, we created a proxy variable of the percent of women in the cluster taking at least 90 iron–folic acid tablets during their last pregnancy.

At the household level, we used the combined wealth score calculated for the FNSS. Because water and sanitation infrastructure are included in the wealth score (Ministry of Health and the Ministry of Planning and Investment Lao Statistics Bureau, 2016), we did not include separate variables on water and sanitation infrastructure. The food insecurity variable is a binary question asking if the family had enough food over the last year. For ethnicity, we combined two groups because of small sample size, resulting in three ethno-linguistic groups: Lao-Tai, Mon-Khmer, and other (made up of Hmong-Mien and Chinese-Tibetan).

Individual child covariates include age (in months) and sex. For size at birth, we categorized caretaker-reported qualitative size as very small or smaller than average, average, and larger than average or very large. For individual mother covariates, we included mother's height (in centimeters). Mother's smoking status is binary and represents current smoking status. We categorized maternal age as follows: 15–19, 20–29, 30–39, and 40–49 years. For mother's schooling and parity, we created three categories each: no schooling, any primary schooling, and any secondary or higher schooling and one child, two to four children, and five or more children.

2.4 | Data analysis

We used IBM SPSS Statistics 20 to calculate basic statistics on current premastication for children under 2 years of age and for descriptive statistics of children 6–13 months of age. For basic statistics, we used the FNSS child sample weights, and confidence intervals were calculated using SPSS Complex Samples to account for the cluster survey design. We used Stata SE 13.0 (College Station, TX) to test for associations. We used a two sample *t* test with equal variance to explore unadjusted associations. For multilevel regression analysis, we used random-intercept multilevel mixed effects linear regression with restricted maximum likelihood estimation. The regression model consisted of two levels, with individuals nested within clusters. Households were not treated as a level because less than 5% of households had more than one child. We included child's age, ethno-linguistic group, wealth score, and parity in the multilevel regression because they were associated with both premastication and LAZ. Overall, 5.5% of parity values were missing, and we imputed missing values with multiple imputation by chained equations. On the basis of the guidance of White, Royston, and Wood (2011) that the number of imputed datasets be “at least equal to the percentage of incomplete cases,” we produced six imputed datasets, and each dataset was based on 10 iterations. The full model is estimated from all six datasets. For the reduced model, we kept only the covariates that improved model fit, following Singer's advice to add one covariate at a time to the unconditional means model and testing for goodness of fit using the log-likelihood ratio test (Singer, 1998; Singer & Willett, 2003). We also used Akaike's information criteria and Schwarz's Bayesian information criteria to assess model goodness of fit. Goodness-of-fit statistics were not available from Stata for models based on imputed data.

Because caretakers from different ethnic groups practice premastication differently (Holmes et al., 2007), we tested for an interaction between premastication and ethno-linguistic group. Normality

and homoscedasticity were assessed using a normal probability plot of residuals and by plotting residuals against predictor variables. All tests of statistical significance were two sided using $p < .05$ for statistical significance.

3 | RESULTS

Overall, 27.2% of mothers of children 0–23 months reported that they fed their child premasticated food at least once in the past week. Table 1 presents basic statistics of the premastication prevalence and frequency for all children under 2 years of age. The prevalence of premastication was highest at 7 months of age (Figure 1). Premastication was less common for infants below 6 months of age and for those above 13 months of age; notably, 14% of children in their first month of life received premasticated food (Figure 1). The prevalence of premastication was above 20% in all wealth quintiles and all provinces. Premastication was highest among Lao-Tai (33.4%) and Mon-Khmer (27.0%) and lowest among Chinese-Tibetan (11.8%). Among children consuming premasticated food, 36.9% received premasticated food less than once a day over the past week and 45.2% ate premasticated food two or more times daily. Frequent feeding (2+) via premastication was most common in the youngest age group (0–5 months, 63.2%).

Using a t test, the unadjusted LAZ of breastfed children 6–13 months of age who received premasticated food ($n = 189$)

FIGURE 1 Percentage of children 0–23 months of age in five provinces of Laos currently receiving premasticated food by age, Food and Nutrition Security Survey 2015

differed from the z -score of breastfed children who did not receive premasticated food ($n = 252$, $p = .04$). There was also a statistically significant difference in unadjusted mean LAZ for children 14–23 months (received $n = 108$, did not receive $n = 292$, $p = .02$; Figure 2).

Tables 2 and 3 show the characteristics of children 6–13 months of age who received premasticated food and those who did not. Large differences were observed for ethno-linguistic group and parity. Table 4 presents a taxonomy of “multilevel mixed effects linear regression” models on LAZ for the 6–13 months age group. The intraclass correlation coefficient in Model A showed that 90% of

TABLE 1 Current premastication and frequency of feeding among children 0–23 months by ethno-linguistic group, wealth, age group, and province in five Laotian provinces, Food and Nutrition Security Survey 2015

	Number of children	Current premastication %	Number of children	Daily frequency among children currently receiving premasticated food %			
				<1	1 to 2	2+	Don't know/missing
Ethno-linguistic group							
Lao-Tai	517	33.4	173	37.5	12.0	48.5	2.0
Mon-Khmer	939	27.0	254	37.5	10.7	43.0	8.7
Hmong-Mien	26	16.8	4	.	.	.	.
Chinese-Tibetan	178	11.8	21	21.7	23.7	49.4	5.1
Wealth quintile							
Poorest	398	24.4	97	41.8	8.5	39.9	9.7
Second	374	32.5	122	26.8	12.3	53.2	7.7
Middle	334	24.2	81	33.8	15.3	48.0	2.9
Fourth	267	32.8	87	39.8	14.8	43.0	2.4
Richest	288	22.5	65	48.6	8.4	37.7	5.4
Age group (months)							
0 to 5	431	15.1	65	27.3	7.3	63.2	2.2
6 to 13	557	42.1	235	37.4	11.1	47.0	4.5
14 to 23	673	22.6	152	40.3	15.2	34.8	9.7
Province							
Luangnamtha	228	20.4	46	25.3	20.6	49.7	4.4
Oudomxay	453	23.8	108	38.7	9.7	48.4	3.2
Saravane	557	32.6	181	29.4	10.9	53.8	5.8
Sekong	187	27.0	50	55.1	12.1	13.1	19.7
Attapeu	237	27.9	66	48.9	12.2	37.8	1.1

. indicates insufficient sample size.

FIGURE 2 Unadjusted mean length-for-age z-score (LAZ) and 95% confidence interval by current premastication in selected age groups of children under 2 years of age, Food and Nutrition Security Survey 2015

the difference in LAZ was between individuals within a village and that villages did not differ much from each other with respect to child length. Adding covariates in subsequent models reduced inter-individual variance slightly and did not meaningfully alter the intraclass

correlation coefficient. Decreases in deviance and Akaike's information criteria showed that the model fit improved as covariates were added, but Schwarz's Bayesian information criteria did not show improved model fit.

Model B shows the unadjusted association of premastication on LAZ, and as expected, it agreed with the prior *t* test and showed lower LAZ for children who received premasticated food (β -0.34 , CI $[-0.66, -0.02]$). Model C, the full model, includes all covariates in the order that they were added to the model. In the full model, premastication, child's age, and parity were statistically significant predictors of LAZ at $p < .05$. Premastication was associated with a lower LAZ (β -0.36 , CI $[-0.68, -0.04]$) after adjusting for child's age and ethno-linguistic group in Model D, the reduced model. Including the interaction between premastication and ethno-linguistic group for the 6–13 months age group did not improve model fit. Fitting the same final reduced model on the older and younger age groups yielded similar results. Adjusted results for children 14–23 months (β -0.43 , CI $[-0.81, -0.05]$; $n = 400$) and for infants 0–5 months (β -0.42 , CI $[-1.2, 0.37]$; $n = 75$) were similar to each other and to the 6–13 months age group. For infants 0–5 months, the sample size was small ($n = 75$) and results were not statistically significant.

TABLE 2 Selected characteristics by premastication status among 441 breastfed children 6–13 months of age, Food and Nutrition Security Survey 2015

Covariates		Current premastication	
		No (252) % or mean $\pm$ SE	Yes (189) % or mean $\pm$ SE
Cluster-level covariates			
Residence type	Urban	10.7	12.2
	Rural with road	76.6	73.5
	Rural without road	12.7	14.3
Health service access and utilization proxy (coverage of pregnancy 90+ iron-folic acid supplementation)	$\geq 60\%$	19.4	16.5
Household-level covariates			
Wealth	Combined wealth score	-0.21 ± 0.05	-0.25 ± 0.06
Food insecurity in the past year	Food shortage	39.8	45.7
Ethno-linguistic group	Lao-Tai	23.8	23.3
	Mon-Khmer	59.9	69.8
	Other	16.3	6.9
Individual-level covariates			
Child's age (months)		9.57 ± 0.15	9.28 ± 0.17
Child's sex	Female	52.0	49.2
Child's size at birth (reported qualitative)	Large	10.2	9.6
	Average	80.9	80.7
	Small	8.8	9.6
Mother's schooling	None	42.9	37.1
	Primary	35.4	41.6
	Secondary+	21.7	21.3
Mother's age (years)	15–19	11.7	10.7
	20–29	58.8	62.4
	30–39	22.5	23.0
	40–49	7.1	3.9
Mother's parity	1	26.3	30.3
	2 to 4	65.8	56.7
	5+	7.9	12.9
Mother's height		148.6 ± 0.36	148.6 ± 0.39
Mother's smoking status	Smoker	27.5	28.1

TABLE 3 Length-for-age z-score by selected covariates among 441 breastfed children 6–13 months of age, Food and Nutrition Security Survey 2015

		Length/age z-score	
		n	Mean $\pm$ SE
Current premastication	No	252	-0.89 $\pm$ 0.12
	Yes	189	-1.19 $\pm$ 0.11
Cluster-level covariates			
Residence type	Urban	50	-0.88 $\pm$ 0.20
	Rural with road	332	-1.03 $\pm$ 0.10
	Rural without road	59	-1.07 $\pm$ 0.21
Health service access and utilization proxy (coverage of pregnancy 90+ iron-folic acid supplementation)	<60%	357	-1.04 $\pm$ 0.10
	$\geq$ 60%	79	-0.84 $\pm$ 0.18
Household-level covariates			
Food insecurity in past year	No food shortage	253	-0.98 $\pm$ 0.13
	Food shortage	186	-1.06 $\pm$ 0.10
Ethno-linguistic group	Lao-Tai	104	-0.66 $\pm$ 0.16
	Mon-Khmer	283	-1.13 $\pm$ 0.10
	Other	54	-1.09 $\pm$ 0.23
Individual-level covariates			
Child's sex	Male	217	-1.13 $\pm$ 0.12
	Female	224	-0.90 $\pm$ 0.11
Child's size at birth	Large	38	-0.78 $\pm$ 0.21
	Average	308	-0.95 $\pm$ 0.10
	Small	35	-1.68 $\pm$ 0.26
Mother's schooling	None	169	-1.02 $\pm$ 0.14
	Primary	159	-0.99 $\pm$ 0.13
	Secondary+	90	-0.96 $\pm$ 0.17
Mother's age (years)	15–19	47	-1.39 $\pm$ 0.24
	20–29	252	-0.97 $\pm$ 0.11
	30–39	95	-0.86 $\pm$ 0.18
	40–49	24	-1.06 $\pm$ 0.39
Mother's parity	1	117	-1.22 $\pm$ 0.15
	2 to 4	259	-0.85 $\pm$ 0.11
	5+	42	-1.30 $\pm$ 0.26
Mother's smoking status	Nonsmoker	302	-0.91 $\pm$ 0.16
	Smoker	116	-1.22 $\pm$ 0.10

4 | DISCUSSION

Our study is the first to look directly at associations between premastication and child nutritional status in Laos. In addition to examining the relationship between premastication and length, we provided basic statistics on premastication frequency. The high percentage of children that receive premasticated food at least once daily shows that the practice is not rare or isolated; rather, it is a core infant and young child feeding practice in Laos. It is a core infant and young child feeding practice that lacks evidence-based recommendations because the effect of the practice on infant health and nutrition remains unknown.

Premastication was documented by development agencies in Lao PDR as early as 1992, when the United Nations Children's Fund (UNICEF)-supported consultants connected the early introduction of complementary food via premastication to "peptic perforation" and "bladder stone disease" (Kachondham & Dhanamitta, 1992). Qualitative studies on child nutrition in the mountainous areas of northern Laos have documented premastication of glutinous rice, meat, and

other foods among some ethnic groups (de Sa et al., 2013; Holmes et al., 2007). Barennes et al. (2009) reported that in a peri-urban area of Vientiane Capital, the early introduction of rice, fed via premastication, was associated with 4% to 75% increased odds of severe stunting. Although Barennes and colleagues provided some information on the relationship between premastication and nutritional status, they could not distinguish between the effect of early introduction of complementary food and that of premastication. We could not identify any studies looking primarily at the effect of premastication on child nutritional status, morbidity, or dietary diversity in Laos.

Our study sample included children from the northern and southern provinces of Laos and from multiple ethno-linguistic groups. Compared to national demographics, Mon-Khmer, an ethnic minority group with high poverty and stunting prevalences (Lao Statistics Bureau, 2016; Ministry of Health and the Ministry of Planning and Investment Lao Statistics Bureau, 2016), were substantially overrepresented, whereas Lao-Tai were underrepresented. The relatively large sample size allowed some disaggregation by age. Our sample criteria limit the findings to children that are currently breastfeeding, and for the youngest age group, we excluded children that were exclusively breastfeeding. The major limitation of our study is that it was cross-sectional. A history of premastication is not available. Premastication was documented to start at 6 months among hunter-gatherers (Konner, 2010), but in Lao PDR, many children receive premasticated food in the first 6 months. The negative association with LAZ found in our study among children 6–23 months of age could be a result of growth faltering related to prelacteal or early premastication.

Reverse causality is also a possibility when testing associations with cross-sectional data. In the late 1990s, longitudinal studies in Peru, Sudan, and Senegal showed that the reason cross-sectional studies on continued breastfeeding routinely found a negative association with child nutritional status is that mothers chose to continue breastfeeding children who were small for their age (Fawzi, Herrera, Nestel, el Amin, & Mohamed, 1998; Marquis, Habicht, Lanata, Black, & Rasmussen, 1997; Simondon & Simondon, 1998). Given that premastication is needed for children who cannot chew themselves, and qualitative research shows that mothers in Laos respond to feeding problems with premastication (Holmes et al., 2007), the negative association between premastication and LAZ could be a result of mothers choosing to initiate or continue premastication for smaller children. In addition, our final reduced model only explained 4% of the variability in LAZ, and premastication could be related to confounding characteristics that we did not measure. Another limitation is that we did not have information on what food was premasticated and how premasticated food was prepared and delivered to the child. Some ethnic groups in Laos feed premasticated food immediately by hand, whereas others roast or bake premasticated food in a banana leaf before feeding the child (Holmes et al., 2007), and premastication by a wide range of providers, including the mother, father, grandmother, siblings, and senior community members, has been documented in Laos (Holmes et al., 2007; Kaufmann, 2009). Cooking premasticated food may prevent pathogen transfer, and family involvement could facilitate more frequent feeding, both of which could affect the relationship between premastication and child growth.

TABLE 4 Results from multilevel linear regression model for length-for-age z-score among children 6–13 months of age in Laos ($n = 441$), Food and Nutrition Security Survey 2015

Parameter	Unconditional means Model A		Primary exposure Model B		Full Model C		Reduced Model D	
	β	95% CI	β	95% CI	β	95% CI	β	95% CI
Fixed effects								
Premastication			−0.34	[−0.66, −0.02]	−0.33	[−0.65, −0.01]	−0.36	[−0.68, −0.04]
Child age (months)					−0.10	[−0.18, −0.03]	−0.11	[−0.18, −0.05]
Child age squared					−0.01	[−0.04, 0.03]		
Ethno-linguistic group								
Lao-Tai					Reference		Reference	
Mon-Khmer					−0.41	[−0.86, 0.04]	−0.44	[−0.83, −0.04]
Other					−0.40	[−1.02, 0.22]	−0.40	[−1.00, 0.20]
Wealth score					0.03	[−0.19, 0.25]		
Parity								
1					Reference			
2 to 4					0.40	[0.03, 0.77]		
5+					0.09	[−0.51, 0.70]		
Variance components								
Between cluster	0.29	[0.09, 0.94]	0.33	[0.11, 0.94]	0.31	[0.11, 0.92]	0.29	[0.09, 0.92]
Within cluster (between child)	2.67	[2.25, 3.16]	2.61	[2.20, 3.10]	2.53	[2.13, 3.01]	2.56	[2.16, 3.04]
Fit statistics								
ICC cluster	0.10		0.11		0.11		0.10	
Deviance	−863.9		−862.7		N/A		−858.3	
AIC	1,733.8		1,733.4		N/A		1,730.6	
BIC	1,746.0		1,749.7		N/A		1,759.2	

Note. CI = confidence interval; ICC = intraclass correlation coefficient; Deviance = log likelihood; AIC/BIC = Akaike's and Schwarz's Bayesian information criteria; N/A = not applicable.

Nonhuman primates use premastication to expand infant diet, introducing food items that the infant cannot process independently (Silk, 1978). The fact that premastication appears in many distinct cultures around the globe (Pelto et al., 2010) suggests that the behavior was adaptive and conferred survival benefits at some point in human prehistory. However, this evolutionary advantage may have dissipated with the transfer of the practice to energy-poor agricultural staples, rendering it counteradaptive.

Furthermore, the relationship between premastication and child health and nutrition could be complex with a number of possible advantages of the practice that could exist alongside reduced linear growth. Unlike other higher primates, humans continue rapid brain growth after birth, with no slowing of the rate until 1 year of age (Konner, 2010). Premastication of foods rich in omega-3 fatty acids and/or micronutrients important for brain development in the first year may confer an advantage through improved motor development. The timing of complementary feeding via premastication could also impact allergies. Saliva transfer has been linked with the prevention of atopic disease (Hesselmar et al., 2013), and evidence is emerging that earlier introduction of foods can prevent the development of food allergies (Perkin et al., 2016). Premastication could be advantageous because it prevents food allergies, thereby ensuring that infants are able to consume a wider range of foods later in life.

Another possibility is that a premastication survival advantage comes from preventing severe forms of acute infection and malnutrition. Premastication is protective against severe respiratory infection

among Alaskan infants (Bulkow, Singleton, Karron, Harrison, & Group, 2002), which could be explained by the transfer of salivary components and/or improved micronutrient nutrition. Yet another possibility is that the survival advantage of premastication is in the establishment of a protective gut microbiome. Dysbiosis of gut microbiota is a causal factor in kwashiorkor and obesity (Ridaura et al., 2013; Smith et al., 2013). To date, there is no evidence that premastication affects the gut microbiome, but the practice does transfer the maternal oral microbiome to the infant (Han et al., 2014).

5 | CONCLUSIONS

Premastication is common in Laos. Premastication was most common for children 6–13 months of age, but some children continued to receive premasticated food up to 2 years of age. Across all age groups, infants and children that received premasticated food had lower LAZ than those that did not receive premasticated food. The mechanisms for this association remain unclear, and reverse causality cannot be ruled out. From our study alone, we cannot be certain of the effect of premastication on nutritional status because of the limitations of a cross-sectional design, but we do know that if premastication affects infant health and nutrition, it is affecting a large percentage of infants in Laos. More research is needed to qualitatively describe premastication among the majority Lao-Tai ethno-linguistic group and to quantitatively describe the relationship between premastication

and intermediate outcomes such as dietary diversity, infections, and allergies in Laos. Ultimately, in order to provide recommendations on premastication, mixed methods longitudinal studies are needed to determine the effect of premastication on child health and nutrition and findings from our study can be used to help in the design of such studies.

CONFLICTS OF INTEREST

The authors declare that they have no conflicts of interest.

CONTRIBUTIONS

JC was responsible for acquiring data. JC and ADS were responsible for conceptualization and design of the study. JC was responsible for data analysis, initial interpretation of results, and drafting the initial article. JC, ADS, SK and MFY were responsible for further interpretation of results and critical revision of the article. JC was responsible for article finalization and all authors approved the final article for publication.

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