Received: 18 August 2021 | Revised: 17 March 2022 | Accepted: 30 March 2022

DOI: 10.1111/mcn.13363

ORIGINAL ARTICLE

Maternal & Child Nutrition WILEY

The seasonal relationships between household dietary diversity and child growth in a rural Timor-Leste community

Gabriela Guizzo Dri[1,2] | Phoebe R. Spencer[1] | Raimundo da Costa[3] | Katherine A. Sanders[1] | Debra S. Judge[1]

[1]School of Human Sciences, The University of Western Australia, Crawley, Western Australia, Australia

[2]Global Studies Institute, The University of Geneva, Geneva, Switzerland

[3]Family Ecology & Child Growth in Rural Timor-Leste Project, Natarbora, Manatuto, Timor-Leste

Correspondence
Debra S. Judge, Department of Anatomy, Physiology and Human Biology, School of Human Sciences, The University of Western Australia, 35 Stirling Hwy, Crawley 6009, WA, Australia.
Email: debra.judge@uwa.edu.au

Funding information
Margaret-Loman Hall Scholarship Fund; School of Human Sciences of the University of Western Australia; Claremont-Nedlands Lions Club; The Australian Department of Foreign Affairs and Trade's New Colombo Plan

Abstract

Both child growth and dietary diversity are poor in rural Timor-Leste. The rainy season is associated with food scarcity, yet the association between seasonal scarcity, food diversity, and child growth is underdocumented. This study assesses the relationship between household dietary diversity and children's standardized growth across the 2018 food-scarce (April–May; post-rainy period) and post-harvest (October) seasons in the agricultural community of Natarbora, on the south-coastal plains of Timor-Leste. We conducted household interviews and collected anthropometric data across 98 and 93 households in the post-rainy and post-harvest periods, respectively. Consumed household foods were obtained via 24-h diet recalls and were subsequently categorized into a nine-food-group dietary diversity score (DDS; number of different food groups consumed). The DDS was related to children's standardized short-term growth (z-weight, z-body mass index [BMI] and percent change in weight over the harvest season) via linear mixed models. Across seasons, DDS increased from 3.9 (standard deviation [SD] = 1.0) to 4.3 (SD = 1.4; $p < 0.05$). In the post-rainy season, children in high DDS households had higher z-weight than those in low DDS households and higher z-BMI than children in medium and low DDS households. In the post-harvest period, household DDS did not predict children's z-weight but predicted z-BMI. Consumption of protein-rich foods, particularly animal-source foods and legumes, in low- and medium-DDS households may be associated with improved child growth. While consuming more animal-source foods in the post-rainy season would be ideal, promoting the consumption of locally grown legumes, such as beans and pulses, may facilitate better nutritional outcomes for more children in rural Timor-Leste.

KEYWORDS
child growth, dietary assessment, dietary diversity, DDS, 24-h recall, seasonality, Timor-Leste

1 | INTRODUCTION

Children need a diet of sufficient energy and nutritional diversity for healthy development and optimal growth (Arimond & Ruel, 2004; International Food Policy Research Institute [IFPRI], 2016). In rural Timor-Leste, child growth is below international standards (Spencer et al., 2018a); nationally, 47% of children under 5 years of age are moderately or severely stunted (height-for-age >2 standard deviation [SD] below the international median), 40% are underweight (weight-for-age) and 24% are wasted (weight-for-height or body mass index [BMI]-for-age; General Directorate of Statistic [GDS] Ministry of Planning and Finance [MoPF] & Ministry of Health [MoH], 2018). Low weight-for-age and BMI-for-age are indicators of short-term undernutrition and reflect a child's current nutritional status, while stunting is an indicator of chronic undernutrition, demonstrating an accumulation of poor growth over years. Persistent poor child growth in all three metrics can arise due to the combined effects of poverty, food insecurity and low dietary diversity (Prentice et al., 2013).

Household food insecurity in rural Timor-Leste is high; 75% of Timorese households are food insecure year-round (Integrated Food Security Phase Classification [IPC], 2019). During times of increased food availability (May–October), 80% of children under 2 years of age met the recommended meal frequencies, but 70% did not meet nutritional requirements, eating fewer than the recommended minimum of four food groups per day (MoH, 2015). Dietary diversity (the number of different food groups consumed over a given reference period; Ruel, 2003a) is often low. A typical Timorese meal entails large quantities of purchased rice accompanied by small servings of home-grown vitamin A-rich leafy greens or vegetables (MoH, 2015). When rice is not available, roots and tubers, such as cassava and taro, are substituted (da Costa et al., 2013). Infants and young children miss out on important growth-promoting nutrients as they commonly are fed watery rice porridge, a filling dish of little nutritional value (Fidalgo Castro, 2013; Provo et al., 2017). Despite various studies on household dietary practices in Timor-Leste (Bonis-Profumo et al., 2021; Fidalgo Castro, 2013; Spencer et al., 2017a; Wong et al., 2018), evidence for the association between dietary diversity and child growth remains mixed (Spencer et al., 2018b). In 2016, dietary diversity scores (DDS), collected via 24-h recalls in the early harvest period in rural Natarbora, were low and not associated with child growth. This may have been due to limited interhousehold variation (Spencer et al., 2018b) caused by the El Niño drought over the 2015–2016 crop-growing season (Seeds of Life, 2016).

Timor-Leste's rainy season (November–late March) and extreme climatic events (such as the 2015/2016 El Niño drought) further exacerbate household food insecurity (Andersen et al., 2013). This is of particular concern for the 80% of rural Timorese who rely on subsistence farming as their main source of food (GDS Food and Agriculture Organization [FAO] & United Nations Population Fund [UNPFA], 2018). Subsistence households report significantly less food available and poorer dietary diversity during the crop-growing, food-insecure, rainy season than during the harvest season (May–October; IPC, 2019). Child growth in rural Timor-Leste is influenced by seasonal variations (Sanders et al., 2014). Children's standardized weight and standardized BMI decline over the rainy season (Judge et al., 2012; Sanders et al., 2014; Spencer et al., 2017b), demonstrating that children face developmental constraints over the food insecure period. Multivariate analyses of child growth across two ecologically different field sites (controlling for sex and mother's height) demonstrate that older children have poorer standardized height-for-age (*z*-height), weight-for-age (*z*-weight) and BMI-for-age (*z*-BMI) than younger children, indicating that recurring ecological pressures throughout development contribute to growth faltering (Spencer et al., 2018a). Household ecological models can be used to demonstrate how variation in household composition, kinship, construction materials and resources (economic and agricultural) influences children's growth (Spencer et al., 2017b, 2018b). As dietary diversity is a function of the household (Swindale & Bilinsky, 2006), it would be valuable to explore what household foods are available for children to consume during the food insecure and harvest seasons and explore the seasonal influence of dietary diversity on Timorese children's growth measures. This paper assesses the influence of seasonal dietary conditions on child growth in the rural subdistrict of Natarbora, Timor-Leste. We compare household dietary diversity in the food-insecure, early post-rainy season and in the post-harvest seasons of 2018 and, utilizing a household ecology model, examine the relationship between seasonal household diets and children's short-term growth (*z*-weight, *z*-BMI and percent change in weight over the harvest season).

Key messages

- Household dietary diversity in rural Timor-Leste is poor in both the post-rainy and post-harvest periods. Most households consumed four or fewer food groups in both seasons.
- Dietary diversity increased slightly in the post-harvest compared with the post-rainy season due to the increased consumption of vegetables and animal-source foods.
- Increased dietary diversity (along with pig husbandry and water treatment) predicts better children's growth. Dietary diversity had a stronger relationship to both *z*-weight and *z*-body mass index in the post-rainy season than in the post-harvest season.
- Increasing the consumption of locally grown legumes year-round, particularly in the post-rainy season, may improve household dietary diversity and protein consumption, thus facilitating better nutritional and anthropometric outcomes for children in rural Timor-Leste.

2 | METHODS

Household interviews were conducted in the subdistrict of Natarbora, situated on the southern coastal plains of Timor-Leste. These households have been involved in a longitudinal study of growth by Judge and colleagues since 2012. Households were originally selected to include

TABLE 1 Categories of DDS food groups.

Food group	Example of included foods
1. Staple starches	Rice, corn, bread, taro, cassava
2. Vitamin A-rich foods	Cassava leaf, papaya leaf, water spinach, sweet potato, pumpkin, carrot
3. Vegetables	Eggplant, bitter gourd, banana flower, green beans, tomato
4. Fruit	Mandarins, banana, jackfruit
5. Legumes and nuts	Beans, tempeh, peanuts
6. Meat, poultry and seafood	Beef, pork, chicken, fish, turtle eggs
7. Dairy	Milk (tinned or powdered)
8. Eggs	Eggs
9. Sugar	Tea with sugar, coffee with sugar, biscuits, chocolate

Note: See Table S1 for the categorization of all food items.
Adapted with permission from Spencer et al. (2018b).

adequate representation across Natarbora's four communities: Umaboku, Ai Teka Laran, Abatoan and the Millennium Development Goal neighbourhood. As families grew and households cleaved (i.e., a daughter/son marries into another family and begins to reproduce), newly formed households are incorporated into the longitudinal study. Permission to conduct household interviews was received from the Natarbora-Barique subdistrict administrator and the village chiefs of Umaboku, Abatoan, and Sicone di Ailoli. Household interviews, including the collection of anthropometric data, were conducted from early April to mid-May 2018 (immediately post-rainy season when food is less abundant) and then again in October 2018 (the post-harvest period).

Witnessed, verbal informed consent was obtained from all interviewed participants. Respondents were typically the mother or grandmother in the household. Following established protocol (Reghupathy et al., 2012), information on household composition, kinship, children's education, household resources and sources of income were collected. Interviews also provided information on livestock, water accessibility and household agricultural participation. All interviews were conducted in Tetun (local language) by G. Guizzo Dri or D. Judge and R. da Costa.

Twenty-four-hour food recalls provided information on foods consumed in each household. Prompts referred to food eaten at breakfast, at lunch, at dinner and for snacks. Dietary diversity was measured via the DDS, calculated from the foods reported (Arimond & Ruel, 2004; Ruel, 2003a). The DDS was composed of nine food groups: 'staple starches', 'vitamin-A rich foods', 'vegetables', 'fruit', 'legumes and nuts', 'meat, poultry and seafood', 'dairy', 'eggs' and 'sugar' (Tables 1 and S1). To maintain indicator consistency at the community level (Verger et al., 2019) and compare DDS across years, the DDS groups were based on Spencer et al.'s (2018b) dietary diversity group code; their research group collected dietary data in Natarbora in 2016. Spencer et al. (2018b) did not include the ninth food group (sugar) in their DDS, but it was added for the purpose of this study because sugary tea or coffee was commonly consumed for breakfast. When comparing to Spencer et al.'s DDS, sugar was removed from our DDS.

Households were categorized as low (DDS ≤ 3), medium (DDS = 4) and high (DDS ≥5) dietary diversity for each collection period.

We measured the height, weight and mid-upper arm circumference of all children (aged from birth to 19 years) and the height of mothers according to accepted protocols (World Health Organization [WHO], 2003, 2008). We measured recumbent length for children unable to stand upright. Children's anthropometric measurements were standardized relative to the WHO references for age and sex using Anthroplus 2007 and are reported in standard deviations from the reference median (WHO & de Onis, 2006). Herein, we address short-term growth using standardized weight and BMI. The WHO weight reference includes children through 10 years and z-BMI to 19 years.

2.1 | Data analyses

We calculated DDS for each household in each season from 24-h recalls. We compared DDS within households across seasons using paired **t**-tests.

We first analysed the post-rainy season data (377 children, 98 households and 24 variables). Individual-level variables (age group, sex, mother's height, fostering status and health) and household-level variables were coded as per Spencer et al. (2017b). In this population, there is no correlation between maternal education and child growth (as most mothers have little education) (Judge et al., 2012; Spencer et al., 2017b) and thus it was not included in analyses. Household variables include the presence of income, cultivation of garden plots and/or rice field, crop diversity, livestock ownership, number of household electrical appliances, household wall and floor construction materials, type of toilet, water source and water treatment. Bivariate relationships correlated with growth variables at $p < 0.1$ (Table S2) were included in the initial step of the multivariate linear mixed model (LMM). We use LMM to relate children's standardized growth measures to household DDS, while controlling for individual- and household-level variables (Spencer et al., 2017b).

A DDS by age group interaction was included in the models because we considered it unlikely that children in the 0–2 years age category ate the full variety of foods consumed by the household. Models commenced with all relevant input variables, which were then eliminated sequentially in decreasing order of statistical significance. At each step, change in the Akaike information criterion (AIC) was examined and model simplification continued until the AIC value no longer decreased—identifying the best model (Sakamoto et al., 1986). To compare the post-harvest model with the post-rainy season model, we input the independent variables identified in the final post-rainy season into the post-harvest model—again comparing AIC values to evaluate the explanatory power of the model. Sample size varied across seasons; therefore, we corrected each AIC by the relevant n (AIC/n) (Sakamoto et al., 1986).

Standardized growth measures from October 2018 were calculated and compared with growth measures from April to May 2018. Changes in standardized growth measures for each child were calculated by subtracting *z*-scores in April–May (post-rainy season) from *z*-scores in October (post-harvest season).

Statistical analyses were performed using Statistical Package for the Social Sciences version 25.

3 | RESULTS

3.1 | Sample characteristics

Of the 120 households in Natarbora involved in Judge and colleagues' longitudinal study, 98 and 93 households were available and consented to be interviewed and measured during the post-rainy and the post-harvest season, respectively. Three hundred and seventy-seven children were measured in the post-rainy season and 329 in the post-harvest season. Children were grouped into age categories for analyses (Figure S1). Twenty-four-hour food recalls were obtained from 93 households in April–May and 87 in October.

3.2 | Household food consumption

Across data collection periods, all but two households consumed three meals per day; exceptions consumed only two meals due to funeral attendances. Households consumed more food items per day in October (7.6 ± 2.0 food items) than in April–May (6.6 ± 1.5 food items; $p < 0.001$, independent **t**-test). Most respondents reported eating no snacks. Between 3 and 12 different food items per day were consumed in April–May, and 4 and 13 in October.

Breakfast usually consisted of bananas or fried cassavas and sugary coffee. Most of the midday and evening meals consisted of rice accompanied by *modo* (Timorese term for a side dish, usually a leafy green or vegetable); commonly, the same food types were eaten for both meals. Rice was consumed as the main staple for midday and evening meals in all households, except two in the post-rainy season and one in the post-harvest season. Other staple starches (such as corn, cassava or taro) eaten for lunch and dinner were always complementary to rice. In the post-rainy season, households with low dietary diversity consumed mostly staple starches (cassava or rice for breakfast; rice for lunch) and leafy vitamin A-rich foods. Medium-diversity households consumed more vegetables and fruits than low-diversity households, and high-diversity households were characterized by more plant- and animal-source protein consumption (Figure 1). High DDS households consumed more legumes.

Mean household DDS increased by half a food group between April–May (DDS = 3.9, SD = 1.0) and October (DDS = 4.3, SD = 1.2; paired $t = 2.573$ $p = 0.012$; $n = 76$). Overall, higher frequencies of vegetables and meat, poultry and seafood were eaten in October, while households consumed more leafy greens in April–May (Table 2). The *maximum* observed household DDS was six food groups (out of nine) in both seasons.

The DDS distribution differed in the post-rainy period compared with the post-harvest period (Figure 1). While the percentage of households categorized as low DDS households (≤3 food groups) remained similar, a higher proportion of households were categorized as high DDS (≥5 food groups) in the post-harvest period than in the post-rainy period (Figure 1). More low- and medium-diversity households' diets included animal-source foods in the post-harvest season compared with the post-rainy season (Figure 1); in the post-rainy season, approximately 10% of low and 30% of medium DDS households consumed meat, poultry and seafood. These figures increased to 20% and 60%, respectively, in the post-harvest season. A lower percentage of high-diversity households consumed legumes and nuts in the post-harvest season (27%) than in the post-rainy season (50%). Very few (<10%) of low and medium DDS households reported including legumes and nuts in their diet throughout both seasons. Approximately 15% of low- and high-diversity households consumed dairy in the post-rainy season. In the post-harvest season, this figure dropped to 0% and 7%, respectively. For medium DDS households, dairy consumption increased from approximately 10% in the post-rainy season to 30% in the post-harvest season. Household consumption patterns were similar across seasons for staple starches, sugar and fruit (Figure 1).

Eggs were eaten rarely and were the least consumed food group through both seasons—4% of households (4/93) consumed eggs in the post-rainy period and 10% of households (9/87) consumed eggs in the post-harvest season. Eggs were the only animal-source protein not consumed by low DDS households. A few women reported that they mostly fed the eggs to children, not to adults.

In both seasons, fewer than half of children aged under 2 years were breastfed.

3.3 | Dietary diversity and child *z*-weight

In the post-rainy season, children (0–10 years) in medium and high DDS households were significantly heavier (*z*-weight) than children in households with low DDS ($p = 0.006$; Table 3A). Other independent predictors of higher *z*-weight in the post-rainy season were household number of pigs, improved water treatment and age less than 2 years (Table 3A). The youngest children had the highest *z*-weight (though they still were more than 1 SD below the international median). Neither household number of chickens nor the DDS by age group interaction were significant independent predictors (Table 3A), but both contributed to a better explanatory model (lower AIC) than when they were removed. Children in households that boiled and strained their water had significantly better *z*-weight than those who drank untreated water ($p = 0.049$).

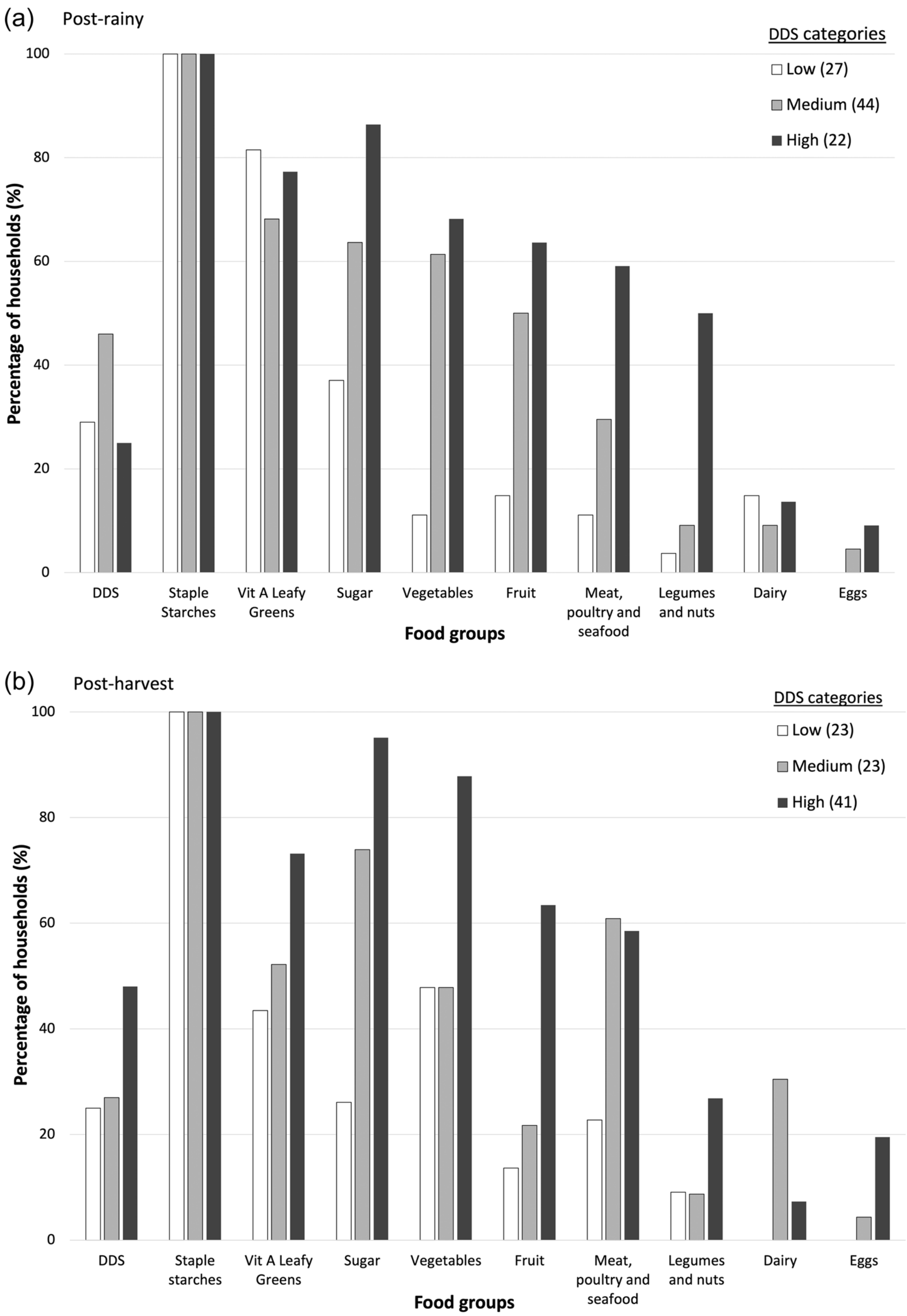

FIGURE 1 Dietary diversity score (DDS) and food group consumption in the post-rainy ($n = 93$) and post-harvest periods ($n = 87$). Percentages of low (DDS ≤ 3), medium (DDS = 4) and high (DDS ≥ 5) dietary diversity households in the two seasons are shown. Data were collected via 24-h recalls.

Unlike the post-rainy season, dietary diversity was not a significant predictor of *z*-weight in the post-harvest season ($p = 0.637$). The only significant predictor of *z*-weight was a taller mother (Table 3B). The AIC/*n* generated in the post-harvest season was higher than that by the post-rainy season model. Therefore, a household ecology model better explains the diversity in z-weight during the post-rainy period than it does in the post-harvest season.

3.4 | DDS and child *z*-BMI

In the post-rainy season, children (0–19 years) in households with greater DDS had significantly higher *z*-BMI scores than children in households with low or medium DDS (Table 4A). Other significant predictors of *z*-BMI in the post-rainy season were age group, sex and household number of pigs (Table 4A). Water treatment and the mother's height strengthened the final model but were not

TABLE 2 Dietary differences across seasons.

	Post-harvest − post-rainy mean difference (SD)	*t*	*p*
Overall DDS	**0.40 (1.34)**	**2.573**	**0.012**
Staple starches	0.01 (1.06)	0.109	0.913
Vitamin A-rich foods	**−0.35 (1.05)**	**−2.870**	**0.005**
Vegetables	**0.31 (1.13)**	**2.357**	**0.021**
Fruit	0.03 (0.68)	0.341	0.734
Meat, poultry and seafood	**0.31 (0.96)**	**2.772**	**0.007**
Legumes and nuts	0.13 (0.62)	1.855	0.068
Dairy	0.00 (0.40)	0.000	1.000
Eggs	0.53 (0.36)	1.270	0.208
Sugar	0.13 (0.6)	1.924	0.058

Note: Comparison of foods consumed in the post-rainy and post-harvest seasons, as per 24-h recalls. Difference = post-harvest − post-rainy. Significant differences ($p < 0.05$, using paired-samples **t**-tests) are shown in bold, $n = 76$.

Abbreviation: DDS, dietary diversity score.

independent, significant factors. The youngest two age groups (0–2 and 2–5 years) had average *z*-BMI within 1 SD below the international median. Mean *z*-BMI scores declined with each subsequent age group. Girls had higher *z*-BMI than did boys (Table 4A). The interaction of DDS and age group was not significant; however, its removal increased the AIC from 698.684 to 706.814, and the interaction was retained in the model.

Age group, sex and DDS remained significant predictors in the post-harvest model (Table 4B). Children in high DDS households had higher *z*-BMI than children in medium DDS households. Pigs were not a significant predictor of *z*-BMI in the post-harvest season ($p = 0.317$). As in the *z*-weight model, the lower AIC/*n* value in the post-rainy period when compared with the post-harvest AIC/*n* indicated that household factors, including dietary diversity, explain more of the variation in children's growth in the post-rainy season than they do in the post-harvest period.

3.5 | Changes in child short-term growth

Over the seasons, children gained weight (8.4% mean weight gain, SD = 8.9, $t = 14.96$, $p < 0.001$, $n = 248$, one-sample **t**-test relative to 0% gain) and young children increased in *z*-weight ($x = 0.131$, SD = 0.49, $t = 3.042$, $p < 0.01$, $n = 130$ children ≤10 years, paired **t**-test). The increase in *z*-BMI was not significant ($p = 0.24$). Dietary diversity in the post-harvest period was a significant predictor of percent body weight change between April–May and October ($p < 0.01$); the percentage weight increase of children in high DDS households was almost twice that of children in medium ($t = -1.176$, $p < 0.01$) and low ($t = -1.593$, $p < 0.01$) DDS households. Sex, water treatment, agricultural activities and number of household chickens strengthened the final model but were not significant independent predictors of percent weight change (Table S3).

4 | DISCUSSION

This study investigated seasonal variation in household dietary diversity in a lowland rural Timor-Leste community, and related household DDS to children's *z*-weight for ages up to 10 years and *z*-BMI for up to 19 years.

4.1 | Seasonal household dietary habits

Household food consumption mirrored a typical Timorese diet (Fidalgo Castro, 2013). The core foods consumed by households were consistent throughout the post-rainy and post-harvest periods, in both seasons consisting of rice (or an equivalent staple starch) and *modo*. As expected, dietary diversity within households was greater in the post-harvest season than in the post-rainy season. Households consumed more vitamin A-rich leafy greens in the post-rainy season, but significantly more vegetables in the post-harvest season. Vitamin A-rich leafy greens, such as cassava and papaya leaves, are harvestable in the post-rainy season, while the *isin* (fruits or tubers) of vegetables are harvested later in the year, explaining this trend. Households with high dietary diversity (DDS ≥ 5) in the post-rainy season included more protein-rich food (meat, poultry and seafood and/or legumes and nuts) in their diet, while low and medium DDS households mostly consumed rice and *modo*. In the post-harvest period, more low and medium DDS households consumed meat, poultry and seafood relative to the post-rainy period. High DDS households continued to include animal-source foods in their diet; however, fewer households reported consuming legumes and nuts. Ceremonies that include communal feasting (weddings, religious festivals and funeral-related events) are concentrated during the latter part of the dry season, which may explain the increase in animal-source food consumption during this period. Egg consumption was low in the post-rainy season and increased slightly in the post-harvest season. Chickens comprise a form of small investment (Wong, 2018) and households commonly hatch eggs during the post-rainy season for propagation. Thus, more eggs are available for consumption in the post-harvest season. Milk consumption is unusual in contemporary Timor-Leste (Wong et al., 2018) and was reported rarely by households (mostly in the form of milk powder). Government expenditure cuts in 2018 halted the recent school lunch programme, and all children ate at home. As households tend to serve the same foods at the midday and evening meals, this is likely to have reduced dietary diversity for school children.

Within Timor-Leste, Natarbora's food intake is comparable to other coastal rural communities. A study that analysed seasonal

TABLE 3 Post-rainy (A) and post-harvest (B) linear mixed model of *z*-weight in Timorese children.

(A) Post-rainy model (April–May)					
Parameter	**Categories**	**Parameter estimates (SE)**	**EMM (SE)**	***t***	***p***
Intercept		−6.829 (2.66)		−2.564	0.012
DDS	**Low**	**−0.681 (0.24)**	**−2.132 (0.22)**	**−2.774**	**0.006**
	Medium	−0.189 (0.21)	−1.593 (0.16)	−0.893	0.278
	(High)		−1.337 (0.22)		
No. of pigs		**0.083 (0.03)**		**2.809**	**0.007**
Boil and strain water	**No**	**−0.457 (0.23)**	**−1.916 (0.22)**	**−2.003**	**0.049**
	(Yes)		−1.460 (0.13)		
Age group	**0–2**	**0.787 (0.48)**	**−1.409 (0.24)**	**1.651**	**0.048**
	2.01–5	0.167 (0.33)	−1.760 (0.17)	0.502	0.458
	(5.01–10)		−1.894 (0.16)		
Mother's height (cm)		0.034 (0.02)		1.973	0.052
Owns chickens	None	0.128 (0.30)	−1.742 (0.27)	0.431	0.690
	0–5	0.039 (0.21)	−1.826 (0.16)	0.186	0.865
	6–10	0.559 (0.32)	−1.320 (0.30)	1.768	0.095
	(10+)		−1.862 (0.18)		
DDS × age group interaction					0.945
(B) Postharvest model (October)					
Parameter	**Categories**	**Parameter estimates (SE)**	**EMM (SE)**	***t***	***p***
Intercept		−11.585 (3.84)		−3.016	0.004
DDS	Low	−0.188 (0.35)	−1.233 (0.33)	−0.540	0.591
	Medium	0.291 (0.33)	−1.584 (0.28)	−0.870	0.387
	(High)		−1.501 (0.22)		
No. of pigs		0.039 (0.05)		0.742	0.462
Boil and strain water	No	−0.391 (0.28)	−1.635 (0.30)	−1.407	0.165
	(Yes)		−1.243 (0.17)		
Age group	0–2	0.531 (0.37)	−1.098 (0.36)	1.427	0.157
	2.01–5	−0.077 (0.30)	−1.602 (0.21)	−0.260	0.796
	(5.01–10)		−1.618 (0.19)		
Mother's height (cm)		**0.065 (0.02)**		**2.637**	**0.011**
Owns chickens	None	0.464 (0.50)	−1.094 (0.49)	0.931	0.357
	0–5	0.129 (0.30)	−1.429 (0.25)	0.429	0.670
	6–10	−0.117 (0.27)	−1.675 (0.22)	−0.426	0.672
	(10+)		−1.558 (0.23)		
DDS × age group interaction					0.190

Note: Initial input variables: household identity, age group, sex, mother's height, water treatment, household number of pigs, household number of chickens, number of electrical appliances, and crop cultivation. Household identity is included as a random factor to control for the clustering of children in households. Variable associations with $p < 0.05$ are shown in bold. Reference category is shown within parenthesis. Post-rainy: AIC = 420.645, initial AIC = 427.150, AIC/n = 2.84; children ≤10 years, n = 148; post-harvest: AIC = 365.758, AIC/n = 2.93; children ≤10 years, n = 125.

Abbreviations: AIC, Akaike information criterion; DDS, dietary diversity score; EMM, estimated marginal means.

TABLE 4 Post-rainy (A) and post-harvest (B) linear mixed model of *z*-BMI in Timorese children.

(A) Post-rainy model (April–May)					
Parameter	**Categories**	**Parameter estimates (SE)**	**EMM (SE)**	***t***	***p***
Intercept		−2.062 (2.17)		−0.951	0.345
Age group	**0–2**	**1.158 (0.51)**	**−0.503 (0.25)**	**2.256**	**0.025**
	2.01–5	**0.845 (0.37)**	**−0.663 (0.16)**	**2.342**	**0.020**
	5.01–10	0.751 (0.36)	−1.404 (0.14)	0.493	0.622
	10.01–15	0.632 (0.35)	−1.167 (0.13)	1.794	0.074
	(15.01–19)		−1.505 (0.17)		
Sex	**Female**	**0.318 (0.12)**	**−0.890 (0.11)**	**2.554**	**0.011**
	(Male)		−1.207 (0.12)		
DDS	**Low**	**−0.539 (0.19)**	**−1.260 (0.16)**	**−2.789**	**0.019**
	Medium	**−0.366 (0.18)**	**−1.136 (0.13)**	**−2.061**	**0.045**
	(High)		−0.750 (0.16)		
No. of pigs		**0.063 (0.03)**		**2.336**	**0.022**
Mother's height (cm)		0.003 (0.01)		0.242	0.809
Boil and strain	No	−0.192 (0.18)	−1.145 (0.16)	−1.058	0.294
	(Yes)		−0.952 (0.09)		
DDS × age group interaction					0.502
(B) Postharvest model (October)					
Parameter	**Categories**	**Parameter estimates (SE)**	**EMM (SE)**	***t***	***p***
Intercept		−4.703 (3.29)		−1.430	0.157
Age group	0–2	0.180 (0.49)	−0.149 (0.36)	0.367	0.714
	2.01–5	0.390 (0.39)	−0.655 (0.20)	1.005	0.316
	5.01–10	−0.102 (0.35)	−1.230 (0.16)	−0.289	0.773
	10.01–15	−0.101 (0.32)	−1.520 (0.18)	−0.311	0.756
	(15.01–19)		−1.607 (0.30)		
Sex	**Female**	**0.337 (0.16)**	**−0.863 (0.16)**	**2.094**	**0.038**
	(Male)		−1.201 (0.16)		
DDS	Low	0.034 (0.60)	−0.672 (0.25)	0.057	0.954
	Medium	**−1.805 (0.71)**	**−1.481 (0.25)**	**−2.546**	**0.012**
	(High)		−0.943 (0.16)		
No. of pigs		0.041 (0.04)		1.010	0.317
Mother's height (cm)		0.023 (0.02)		1.082	0.283
Boil and strain	No	−0.163 (0.23)	−1.114 (0.22)	−0.709	0.481
	(Yes)		−0.950 (0.13)		
DDS × age group interaction					0.076

Note: Initial input variables: household identity, age group, sex, mother's height, water treatment, household number of pigs, household number of chickens, number of electrical appliances, and crop cultivation. Household identity is included as a random factor to control for the clustering of children in households. Variable associations with $p < 0.05$ are shown in bold. Reference category is shown within parenthesis. Post-rainy: AIC = 698.684, initial AIC = 705.735, AIC/n = 2.83; children ≤19 years, n = 247; post-harvest: AIC = 625.707, AIC/n = 3.05; children ≤19 years, n = 205.

Abbreviations: AIC, Akaike information criterion; DDS, dietary diversity score; EMM, estimated marginal means.

dietary diversity among mothers and children aged 6–59 months in coastal rural Timorese regions demonstrated similar seasonal dietary characteristics to our population; consumption of animal-source foods, such as meat and poultry, increased in the dry harvest season relative to the rainy season, while fish consumption was higher in the rainy season (Bonis-Profumo et al., 2021). Eggs were also commonly fed to children (Bonis-Profumo et al., 2021).

In Natarbora, the 2018 post-rainy season growth indicators differ from the 2016 post-rainy period (Spencer et al., 2018b) in which there was no relation between DDS and standardized growth. The El Niño drought over the 2015–2016 crop-growing season reduced the number of crops grown in Timor-Leste, and the overall crop output was poor (Seeds of Life, 2016). Households' DDS in post-rainy season 2016 were low and overall food availability was low (Spencer et al., 2018b). This reduced the diversity across all households (Spencer et al., 2018b). The mean household DDS in 2016 ($x = 3.03$, SD = 0.88; Spencer et al., 2018b) was lower by one food group than in 2018 ($t = 6.393$, $p < 0.01$). In 2018, the presence of increased variety and quantity of foods in the market suggests a more plentiful harvest. The market also appeared to include more vendors from outside the Natarbora area —perhaps due to the increase in intercommunity transport (mini-vans, buses, etc.). This suggests that annual, as well as seasonal, differences in food availability may impact child growth.

4.2 | Annual household dietary habits

For adequate growth and development, dietary guidelines encourage children and adolescents to incorporate a mix of vegetables, fruits, lean meats, legumes, wholegrain cereals, dairy and eggs into their diets and to reduce sugar and saturated fat intake (United Nations Children's Fund UNICEF, 2019). While vegetables and fruits (particularly those rich in vitamin A and C) are commonly eaten in most Timorese households (Fidalgo Castro, 2013), these foods are often consumed as small side portions. Even in high DDS households (typically characterized by the consumption of protein-rich food), Timorese children may still miss out on additional nutritional components, such as fibre from whole grains, omega-3 fatty acids from fish, nuts and seeds, and further nutrients from dairy sources. This may explain why child growth in Natarbora is poor by international standards even in households with greater than the average dietary diversity.

While calorie-dense and high-fat processed foods are becoming more available at small kiosks in rural Timor-Leste (Wong et al., 2018), not many Natarbora households reported consuming processed and/or packaged foods. Although households reported not eating snacks during the day, personal observations during fieldwork indicated that children eclectically consume chocolates, sugar-sweetened beverages and other processed snack foods outside the home. Spencer et al. (2018b) reported that households often found snack-related questions confusing, perhaps explaining the inconsistency observed. The increased availability of calorie-dense and high-fat processed foods in rural Timor suggests that the population may be exposed to a nutrition transition similar to that of neighbouring countries (Mahmudiono et al., 2017; Saibul et al., 2009). Currently, rural Timorese communities continue to report consuming traditional diets for breakfast, lunch and dinner.

4.3 | Factors associated with child growth

Assessing anthropometrics over two seasons allowed us to capture the changes in short-term growth over an 'average' Timorese year (not affected by drought or floods). Dietary diversity had a stronger relationship to both *z*-weight and *z*-BMI in the post-rainy season than in the post-harvest season. This suggests that growth is more sensitive to community variations in the food-scarce rainy season. While more difficult to implement, interventions timed to the rainy season and early post-rainy season are likely to be more effective than during the harvest season. During the post-harvest season, most households increased their DDS and children demonstrated increased standardized growth scores—though still below international standards. While household DDS did not predict variations in children's *z*-weight in the post-harvest season, higher diversity predicted higher *z*-BMI in children aged 0–19 years.

Children in households with greater plant- and animal-source protein consumption (high DDS households in post-rainy, and medium and high DDS households in post-harvest) showed better child growth than children in households with low DDS (and low protein-rich food consumption). Animal-source foods are rich in growth-promoting micronutrients such as iron, calcium, riboflavin and zinc (WHO & Food and Agriculture Organization of the United Nations, 1991) that are essential for children's physical and cognitive development (UNICEF, 2020). Numerous studies demonstrate correlations between protein consumption and better overall child growth independent of dietary diversity (Darapheak et al., 2013; Hatløy et al., 1998; Ruel, 2003b), providing further evidence that protein improves child growth. Thus, increased protein consumption in the post-harvest season may allow children to recoup weight losses from the rainy season. In post-harvest Natarbora, access to protein (particularly animal-source protein) is less related to household economy than in the rainy season, as this is a period of concentrated ceremonies that commonly include meat consumption. Attendance at ceremonies is based on kinship and social relationships rather than household resource levels, and children from low and medium dietary diversity households may be receiving their animal-source protein consumption at these events. While available, as demonstrated by their consumption by high DDS households, legumes could be a promising source of protein intake for rural Timorese communities and children.

Other significant household factors included ownership of pigs and improved water treatment. Pigs may indicate a family's ability to invest in medium return agriculture (Wong et al., 2018); families with sufficient resources to feed pigs may be relatively resource-rich

(Spencer et al., 2017b). By October, most households will have sold their pigs or have consumed them during ceremonies (Wong et al., 2018). This reduces the variation in pig holding among households and may explain why the household number of pigs was only a significant independent predictor of child growth in April–May. Post-rainy season, children in households who boiled and strained their drinking water demonstrated better *z*-weight than children in households who drank untreated water. Water sources and systems in Timor-Leste are commonly contaminated with bacteria (World Bank, 2018), increasing the risk of water-borne disease transmission among children (Ngure et al., 2014). Water treatment is particularly important in the rainy season because runoff due to heavy rains and floods can contaminate water sources such as open wells. Thus, children who drink boiled and strained water are less susceptible to disease and will have greater energy available for growth and development (Black et al., 2013; Walton & Allen, 2011).

4.4 | Strengths, limitations and implications

One of the strengths of this study is that the role of dietary diversity is placed in the context of other household and individual characteristics associated with growth variation. That is, the role of DDS presented herein is controlled for other characteristics associated with economic status and health-promoting amenities, such as household capital, income and agricultural resources. Dietary diversity is assumed to be a function of the household, and the collection of household DDS is thus a proxy measure of the children's access to available foods and their surrounding environment (Swindale & Bilinsky, 2006). In this population, age and sex have been consistent predictors of variation in child growth over and above those included in WHO references (Sanders et al., 2014; Spencer et al., 2017b, 2018b). Including the full age range of children within the household (from birth to 19 years) within the anthropometric analyses allows us to compare children over 5 years and adolescents to international growth standards (de Onis et al., 2007), data that are often overlooked in dietary literature, which focus mostly on maternal, infant and young child nutrition (Nguyen et al., 2020). Nevertheless, capturing foods consumed at the household level may not reflect the individual dietary consumption of each child nor capture the differences in foods eaten across age groups.

While our study is part of a 10-year longitudinal growth project, our sample size and geography cannot be generalized to other populations, particularly to upland, mountainous communities; coastal Timorese communities are demonstrated to have higher dietary diversity than villages in mid-altitude and mountainous areas (Bonis-Profumo et al., 2021; Spencer & Judge, 2021; Spencer et al., 2018b). Higher reported dietary diversity in coastal villages could be related to greater fish consumption than inland communities (Farmery et al., 2020) or to higher agricultural productivity. We do not disaggregate animal-source foods by meat, poultry and seafood between the seasons and therefore cannot comment on the role of aquaculture in improving dietary diversity in Natarbora. It would be beneficial to assess the role of aquatic foods in improving diets and child growth in future studies.

5 | CONCLUSION

Dietary diversity in rural Timor-Leste is low, and improving the overall nutritional situation is key to improving Timorese children's growth (Grieve et al., 2016). This study explored the influence of seasonal dietary diversity on child short-term growth in the rural subdistrict of Natarbora. Following the post-rainy season, children in high dietary diversity households exhibited overall better short-term growth measures than children in households exhibiting low and medium dietary diversity. Following post harvest, household DDS did not predict variations in children's *z*-weight, but higher diversity predicted higher *z*-BMI. Nevertheless, most children, across both seasons, show low weight and BMI relative to WHO standards. Household DDS in Natarbora is low; average household dietary diversity increased by approximately half a food group between the post-rainy and post-harvest season. However, increasing household DDS (via greater plant- and animal-source protein consumption) may improve child growth in Natarbora. Cultural constraints on eating livestock may prevent households from consuming animal-source foods before the plentiful harvest season; legumes, however, are commonly grown in Timor-Leste (Inder et al., 2014). Food policies, strategies and programmes should thus work to promote the consumption of legumes and other protein-rich foods in low- and medium-diversity households (e.g., via food and agricultural subsidies). We further recommend support of the Timorese school feeding programme, which may diversify children's diets relative to household diets. Tailoring local food interventions, especially in the post-rainy season, may facilitate better nutritional outcomes for children in rural Timor-Leste.

AUTHOR CONTRIBUTIONS

Gabriela Guizzo Dri and Debra S. Judge designed the study. Gabriela Guizzo Dri, Raimundo da Costa and Debra S. Judge conducted the fieldwork. Gabriela Guizzo Dri and Debra S. Judge analysed the data. Gabriela Guizzo Dri, Debra S. Judge, Katherine A. Sanders and Phoebe R. Spencer wrote the paper. All authors approved the final manuscript.

ACKNOWLEDGEMENTS

This study was undertaken with the permission of the Ministry of Health Timor-Leste and the subdistrict administrators and elected chiefs of Natarbora. The authors thank Mr. Domingos de Oliveira for volunteering to teach us Tetun, the local Timorese language. We also thank Joanina de Jesus for her invaluable aid in data collection. We thank Rita da Costa and their family for their warm hospitality and Cesar dos Reis for transporting us safely to and from our field site. Finally, we thank the families of Natarbora, for their ongoing participation in this project, without which this study would not be possible. This study was funded by the School of Human Sciences of the University of Western Australia, the Margaret-Loman Hall Scholarship fund, the Australian Department of Foreign Affairs and Trade's New Colombo Plan (Mobility/Travel Grant) and the Claremont-Nedlands Lions Club.

CONFLICTS OF INTEREST

The authors declare no conflicts of interest.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request.

ETHICS STATEMENT

This study was conducted according to the guidelines laid down in the Declaration of Helsinki, and all procedures involving research study participants were approved by the Ministry of Health of the Democratic Republic of Timor-Leste (MS-INS/GDE/DP-EA/IV/2017/528) and by the Human Research Ethics Committee of the University of Western Australia (RA/4/12401). Witnessed, verbal informed consent was obtained from interviewed participants. Permission was also received and witnessed from the Natarbora-Barique subdistrict administrator and the village chiefs of Umaboko, Abatoan and Sicone di Ailoli.

ORCID

Gabriela Guizzo Dri http://orcid.org/0000-0003-4234-3530
Debra S. Judge http://orcid.org/0000-0003-0671-0743

REFERENCES

Andersen, A., Pant, J., & Thilsted, S. (2013). *Food and nutrition security in Timor-Leste*. http://pubs.iclarm.net/resource_centre/AAS-2013-29.pdf

Arimond, M., & Ruel, M. (2004). Dietary diversity is associated with child nutritional status: Evidence from 11 demographic and health surveys. *The Journal of Nutrition*, *134*(10), 2579–2585.

Black, R. E., Victora, C. G., Walker, S. P., Bhutta, Z. A., Christian, P., de Onis, M., & Uauy, R. (2013). Maternal and child undernutrition and overweight in low-income and middle-income countries. *Lancet*, *382*(9890), 427–451. https://doi.org/10.1016/s0140-6736(13)60937-x

Bonis-Profumo, G., Stacey, N., & Brimblecombe, J. (2021). Maternal diets matter for children's dietary quality: Seasonal dietary diversity and animal-source foods consumption in rural Timor-Leste. *Maternal & Child Nutrition*, *17*(1), e13071. https://doi.org/10.1111/mcn.13071

da Costa, M. J., Lopes, M., Ximenes, A., Ferreira, A. R., Spyckerelle, L., Williams, R., Nesbitt, H., & Erskine, W. (2013). Household food insecurity in Timor-Leste. *Food Security*, *5*(1), 83–94. https://doi.org/10.1007/s12571-012-0228-6

Darapheak, C., Takano, T., Kizuki, M., Nakamura, K., & Seino, K. (2013). Consumption of animal source foods and dietary diversity reduce stunting in children in Cambodia. *International Archives of Medicine*, *6*, 29. https://doi.org/10.1186/1755-7682-6-29

deOnis, M., Onyango, A. W., Borghi, E., Siyam, A., Nishida, C., & Siekmann, J. (2007). Development of a WHO growth reference for school-aged children and adolescents. *Bulletin of the World Health Organization*, *85*(9), 660–667. https://doi.org/10.2471/blt.07.043497

Farmery, A. K., Kajlich, L., Voyer, M., Bogard, J. R., & Duarte, A. (2020). Integrating fisheries, food and nutrition–Insights from people and policies in Timor-Leste. *Food Policy*, *91*, 101826. https://doi.org/10.1016/j.foodpol.2020.101826

Fidalgo Castro, A. (2013). *An approach to the food habits of three communities in Timor-Leste*. https://www.researchgate.net/publication/283463456_An_Approach_to_the_Food_Habits_of_Three_Communities_in_Timor-Leste

General Directorate of Statistic (GDS), Ministry of Planning and Finance (MoPF), & Ministry of Health (MoH). (2018). *Timor-Leste demographic and health survey 2016*. https://www.dhsprogram.com/pubs/pdf/FR329/FR329.pdf

General Directorate of Statistics (GDS), Food and Agriculture Organisation (FAO), & United Nations Population Fund (UNPFA). (2018). *Timor-Leste population and housing census 2015: Analytical report on agriculture*. https://www.statistics.gov.tl/wp-content/uploads/2019/10/2015-Census-Agriculture-and-Fisheries-report.pdf

Grieve, H., dos Reis Albino, O., & Da Costa, F. (2016). The nutrition situation in Timor-Leste. In H. Nesbitt, W. Erskine, C. J. da Cruz, & A. Moorhead (Eds.), *Food security in Timor-Leste through crop production* (pp. 19–27). Australian Centre for International Research (ACIAR).

Hatløy, A., Torheim, L., & Oshaug, A. (1998). Food variety—A good indicator of nutritional adequacy of the diet? A case study from an urban area in Mali, West Africa. *European Journal of Clinical Nutrition*, *52*(12), 891–898. https://doi.org/10.1038/sj.ejcn.1600662

Inder, B., Brown, A., & Datt, G. (2014). *Poverty and the agricultural household in Timor-Leste: Some patterns and puzzles*. https://seedsoflifetimor.org/wp-content/uploads/2014/12/Monash-Timor-research-paper-June-2014.pdf

Integrated Food Security Phase Classification (IPC). (2019). *The first IPC analysis report on the chronic food insecurity situation in Timor-Leste: Evidence and standards for better food security and nutrition decisions*. https://reliefweb.int/sites/reliefweb.int/files/resources/2_IPC_Timor%20Leste_CFI_20182023_English.pdf

International Food Policy Research Institute (IFPRI). (2016). *Global nutrition report 2016: From promise to impact: Ending malnutrition by 2030*. https://doi.org/10.2499/9780896295841

Judge, D. S., Sanders, K. A., Reghupathy, N., Amaral, P. C., & Schmitt, L. H. (2012). Family influences on long-term and short-term child growth in Ossu area, Timor Leste. In M. Leach, N. Mendes, A. B. da Silva, B. Boughton, & A. da Costa Ximenes (Eds.), *Communicating new research on Timor-Leste* (pp. 233–241). Swinburne Press.

Mahmudiono, T., Sri Sumarmi, M., & Rosenkranz, R. (2017). Household dietary diversity and child stunting in East Java, Indonesia. *Asia Pacific Journal of Clinical Nutrition*, *26*, 317–325.

Ministry of Health (MoH). (2015). *Timor-Leste Food and Nutrition Survey 2013*. https://dl.tufts.edu/pdfviewer/ng451v34w/cz30q4797

Ngure, F. M., Reid, B. M., Humphrey, J. H., Mbuya, M. N., Pelto, G., & Stoltzfus, R. J. (2014). Water, sanitation, and hygiene (WASH), environmental enteropathy, nutrition, and early child development: Making the links. *Annals of the New York Academy of Sciences*, *1308*(1), 118–128. https://doi.org/10.1111/nyas.12330

Nguyen, T. T., Darnell, A., Weissman, A., Cashin, J., Withers, M., Mathisen, R., Lapping, K., Mastro, T. D., & Frongillo, E. A. (2020). National nutrition strategies that focus on maternal, infant, and young child nutrition in Southeast Asia do not consistently align with regional and international recommendations. *Maternal & Child Nutrition*, *16*(S2), e12937. https://doi.org/10.1111/mcn.12937

Prentice, A. M., Moore, S. E., & Fulford, A. J. (2013). Growth faltering in low-income countries. *World Review of Nutrition and Dietetics*, *106*, 90–99. https://doi.org/10.1159/000342563

Provo, A., Atwood, S., Sullivan, E. B., & Mbuya, N. (2017). *Malnutrition in Timor-Leste: A review of the burden, drivers, and potential response*. https://pubdocs.worldbank.org/en/487831491465798343/Malnutrition-in-Timor-Leste.pdf

Reghupathy, N., Judge, D. S., Sanders, K. A., Amaral, P. C., & Schmitt, L. H. (2012). Child size and household characteristics in rural Timor-Leste.

American Journal of Human Biology, *24*(1), 35–41. https://doi.org/10.1002/ajhb.21232

Ruel, M. (2003a). Is dietary diversity an indicator of food security or dietary quality? A review of measurement issues and research needs. *Food and Nutrition Bulletin*, *24*(3), 231–232. https://doi.org/10.1177/156482650302400210

Ruel, M. (2003b). Operationalizing dietary diversity: A review of measurement issues and research priorities. *The Journal of Nutrition*, *133*(11), 3911–3926.

Saibul, N., Shariff, Z., Lin, K., Kandiah, M., Ghani, N., & Rahman, H. (2009). Food variety score is associated with dual burden of malnutrition in Orang Asli (Malaysian indigenous peoples) households: Implications for health promotion. *Asia Pacific Journal of Clinical Nutrition*, *18*(3), 412–422. https://doi.org/10.6133/apjcn.2009.18.3.14

Sakamoto, Y., Ishiguro, M., & Kitagawa, G. (1986). *Akaike information criterion statistics*. D. Reidel.

Sanders, K., Judge, D., Pauli, N., Amaral, P., & Schmitt, L. (2014). The Influence of sex, age and season on child growth in Ossu sub-district, Timor-Leste, 2009–2012. In H. Loney, A. da Silva, N. Mendes, A. da Costa Ximenes, & C. Fernandes (Eds.), *Understanding Timor Leste* (Vol. 2, pp. 190–198). Swinburne Press.

Seeds of Life. (2016). *El Niño Timor-Leste Update: Low rainfall impacts on animal health*. https://reliefweb.int/sites/reliefweb.int/files/resources/El%20Nino%20Crop%20Situation%20Report%2020160115.pdf

Spencer, P. R., & Judge, D. S. (2021). Relationships of resource strategies, family composition, and child growth in two rural Timor-Leste communities. *Social Sciences*, *10*(7), 273. https://doi.org/10.3390/socsci10070273

Spencer, P. R., Sanders, K. A., Canisio Amaral, P., & Judge, D. S. (2017a). Household resources and seasonal patterns of child growth in rural Timor-Leste. *American Journal of Human Biology*, *29*(1), e22916.

Spencer, P. R., Sanders, K. A., Canisio Amaral, P., & Judge, D. S. (2017b). Household resources and seasonal patterns of child growth in rural Timor-Leste. *American Journal of Human Biology*, *29*(1), 1–17. https://doi.org/10.1002/ajhb.22916

Spencer, P. R., Sanders, K. A., & Judge, D. S. (2018a). Growth curves and the international standard: How children's growth reflects challenging conditions in rural Timor-Leste. *American Journal of Physical Anthropology*, *165*(2), 286–298. https://doi.org/10.1002/ajpa.23350

Spencer, P. R., Sanders, K. A., & Judge, D. S. (2018b). Rural livelihood variation and its effects on child growth in Timor-Leste. *Human Ecology*, *46*, 1–13. https://doi.org/10.1007/s10745-018-0027-6

Swindale, A., & Bilinsky, P. (2006). *Household Dietary Diversity Score (HDDS) for measurement of household food access: Indicator guide*. https://www.fantaproject.org/sites/default/files/resources/HDDS_v2_Sep06_0.pdf

United Nations Children's Fund (UNICEF). (2019). *Children, food, and nutrition: Growing well in a changing world*. https://www.unicef.org/media/60811/file/SOWC-2019-Exec-summary.pdf

United Nations Children's Fund (UNICEF). (2020). *Review of national food-based dietary guidelines and associated guidance for infants, children, adolescents, and pregnant and lactating women*. https://www.unicef.org/media/102761/file/2021-Food-based-Dietary-Guidelines-final.pdf

Verger, E. O., Ballard, T. J., Dop, M. C., & Martin-Prevel, Y. (2019). Systematic review of use and interpretation of dietary diversity indicators in nutrition-sensitive agriculture literature. *Global Food Security*, *20*, 156–169. https://doi.org/10.1016/j.gfs.2019.02.004

Walton, E., & Allen, S. (2011). Malnutrition in developing countries. *Paediatrics and Child Health*, *21*(9), 418–424. https://doi.org/10.1016/j.paed.2011.04.004

Wong, J. T. (2018). *Raid: Healthier chickens means healthier children in Timor-Leste*. Australian Centre for International Agricultural Research.

Wong, J. T., Bagnol, B., Grieve, H., da Costa Jong, J. B., Li, M., & Alders, R. G. (2018). Factors influencing animal-source food consumption in Timor-Leste. *Food Security*, *10*(3), 741–762. https://doi.org/10.1007/s12571-018-0804-5

World Bank. (2018). *Timor-Leste water sector assessment and roadmap*. https://documents1.worldbank.org/curated/en/433121521173685667/pdf/124329-WP-P163648-PUBLIC-Timor-Leste.pdf

World Health Organization (WHO). (2003). *STEPS: A framework for surveillance*. https://www.who.int/ncd_surveillance/en/steps_framework_dec03.pdf

World Health Organization (WHO). (2008). *Training course on child growth assessment*. https://www.who.int/childgrowth/training/module_b_measuring_growth.pdf

World Health Organization (WHO), & de Onis, M. (2006). WHO child growth standards based on length/height, weight and age. *Acta Paediatrica*, *95*, 76–85. https://doi.org/10.1111/j.1651-2227.2006.tb02378.x

World Health Organization (WHO), & Food and Agriculture Organization of the United Nations (FAO). (1991). *Energy & protein requirements*. https://www.fao.org/3/aa040e/aa040e00.htm

SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

How to cite this article: Guizzo Dri, G., Spencer, P. R., da Costa, R., Sanders, K. A., & Judge, D. S. (2022). The seasonal relationships between household dietary diversity and child growth in a rural Timor-Leste community. *Maternal & Child Nutrition*, 18, e13363. https://doi.org/10.1111/mcn.13363