Dietary Environment in Early Care and Education Settings and Young Children's Eating Behavior: A Systematic Review of Literature

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Objectives: An increasing number of young children spend time and eat at least one meal per day in childcare programs, highlighting the significance of early care and education (ECE) settings in promoting children's healthy dietary behaviors. The purpose of this review was to summarize quantitative studies on the relationship between the dietary environment in ECE settings and the eating behaviors of children aged 0-6 years. **Methods:** We consulted Web of Science, PsycInfo, ProQuest, and Emerald electronic databases, searching for empirical studies from 2000 to 2022. **Results:** Ultimately, we included 38 studies. Measures of the dietary environment varied considerably across studies. Following healthy diet regulations and nutrition-related activities were positively correlated with children's intake of healthy foods. Strategies such as serving fruits and vegetables in advance, serving small portion sizes, and providing children a variety of vegetables increased children's intake of healthy foods. Results on caregivers' feeding practices remained mixed. **Conclusions:** These findings reveal the necessity and importance of paying attention to different aspects of the dietary environment and to take a comprehensive approach to understanding the role that environment plays in cultivating children's dietary behaviors.

Keywords: dietary environment; eating behavior; feeding practice; early care and education (ECE); nutrition education

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Dietary behavior is one of the most important risk factors for children's nutritional status,[1] obesity,[2] and some psychological disorders.[3,4] Eating habits develop in early life through caregivers' feeding practices, and often, are maintained in later life.[5] Early care and education (ECE) settings provide a vital opportunity to influence young children's dietary behavior and health, as an increasing number of young children spend a considerable amount of time and eat at least one meal per day in ECE programs. For instance, approximately two-thirds of preschoolers in the United States (US) receive nonparental childcare services.[6] They spend 40 hours per week on average and eat one or 2 meals plus snacks in ECE institutions.[7] This is the same case in China. Consequently, the *Learning and Development Guidelines for Children Aged 3-6* clearly state that the staff of ECE institutions are responsible for creating a supportive environment for children, providing nutritious diets and cultivating good eating habits.[8]

The dietary environment in ECE settings plays a vital role in affecting children's diets and health. The term 'dietary environment' refers to the combination of specific food offered in childcare, how foods are served, and the feeding practices of caregivers.[9] Its quality could have an impact on children's diets and health in multiple ways. For example, providing a variety of vegetables and fruit can increase children's consumption of both food types in a childcare facility, and having childcare staff sitting with children at

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lunch is associated with children's lower energy intake and higher vegetable intake.[10-12] However, due to variations in study aims, it remains a challenge to understand what a supportive dietary environment is like in ECE settings and how it might affect children's dietary behaviors.

Therefore, the objective of this study was to examine the relationships between the dietary environment of ECE settings and young children's eating behaviors. We tested the hypothesis that a high-quality dietary environment was associated with children's healthy eating. Through systematically searching and reviewing published empirical studies, in this review, we summarized a wide range of measures of the dietary environment (eg, diet regulations, feeding practices, and nutrition education) and children's eating behaviors (eg, food intake, diet quality, and novel food acceptance). Such a review not only helps researchers better understand previous research on the dietary environment in ECE settings, but also provides early childhood educators insights as how to create a supportive dietary environment to promote children's diet quality and nutritional status.

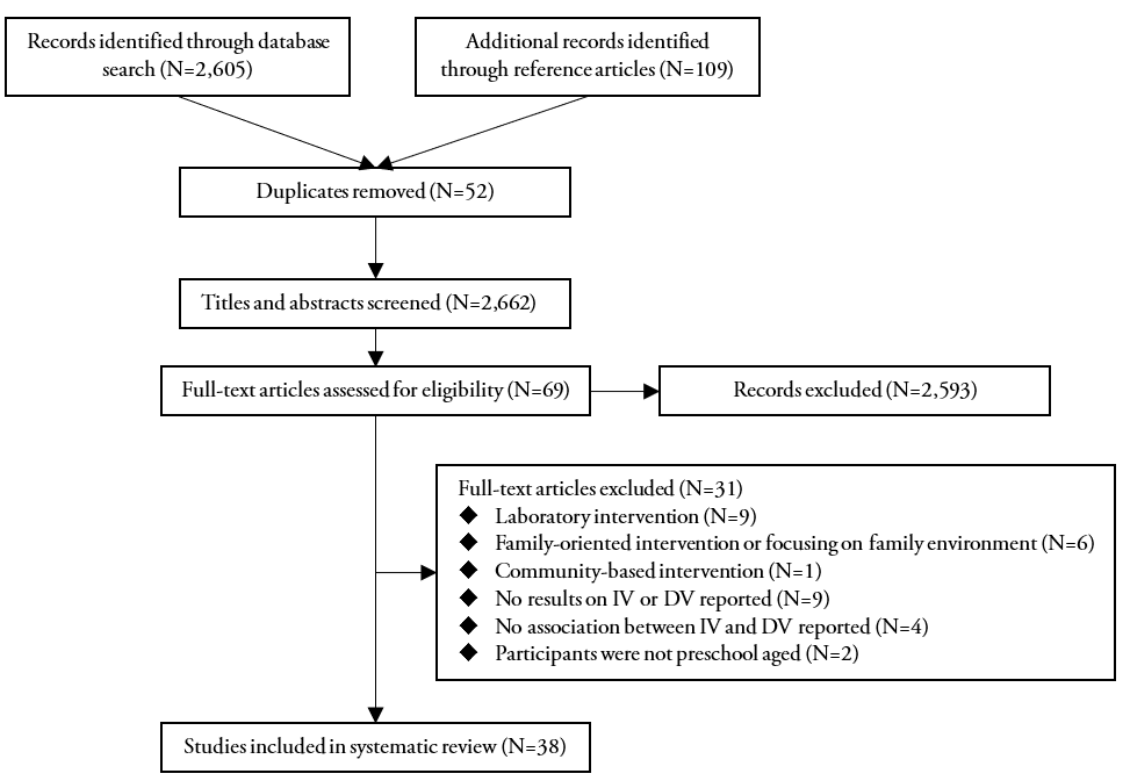
METHODS

The systematic search for literature from January 2000 to June 2022 was performed using 4 electronic databases (Web of Science, Psycinfo, ProQuest, Emerald) by examining the subject or title based on a careful selection of key words.

Search Strategy

The key words related to dietary environments (independent or predicting variable in the current study) included food environment*, nutrition practice*, feeding practice* and food intervention*. Dependent variables are children's eating behaviors, including food intake*, food preference*, food consumption*, eating behavior*, diet*and nutrition*. Logic words AND and OR were used to merge the aforementioned key words (Appendix 1). Reference lists of eligible studies or systematic reviews and meta-analyses also were reviewed to ensure that all potentially eligible studies were retrieved. The search process identified 2714 articles (Figure 1). After further screening, we included 38 articles in this review.

Figure 1
Overview of the Process of Literature Selection



Inclusion Criteria

Studies were included if: (1) participants were caregivers/staff or children from ECE institutions; (2) quantitative methods (surveys by questionnaires, measurements, quasi-experimental or structural observations) were used to collect, organize and analyze data; (3) independent variables were dietary environments, including food environment, nutrition practice, and feeding practices of caregivers, among others, and dependent variables were eating behaviors of young children, (eg, food intake, and diet quality); and (4) they were original studies that had been peer-reviewed and published in English.

Exclusion Criteria

Studies were excluded if: (1) participants were animals, family members, teachers or students of primary/elementary/middle schools or colleges/universities; (2) they only examined dietary environments or children's eating behaviors, and associations between these 2 variables were not reported; (3) they were intervention studies not taking place in ECE settings (eg, family intervention, community-based intervention, laboratory intervention); (4) they only used qualitative methods or did not use any research method (eg, authors' opinion stated); and (5) they were drafts, meeting abstracts, study protocols, commentaries, or reviews.

Screening and Data Synthesis

After duplicate articles were eliminated, 2 reviewers (LW and XW) independently scanned titles, abstracts, and later, the full texts of the identified articles against the inclusion criteria. Cohen's kappa was 0.95, indicating strong consistency. Discrepancies were resolved by consultation between the first 2 authors. Then, the 2 reviewers used a standardized data synthesis form to extract data from each included study. Data were extracted by one reviewer (LW) regarding key characteristics of each study (ie, author name, year of publication, study design, study area, sample size, age at baseline, follow-up years, number of repeated measures, and statistical methods), measures (ie, measures of the dietary environment, and eating behaviors), and main findings concerning the association between dietary environments and eating behaviors. This was checked by another senior reviewer (XW). Table 1 presents the study characteristics. Two other tables were created to report measures and main results, one for cross-sectional studies (Table 3) and another for longitudinal intervention studies (Table 4).

Study Quality Assessment

We applied the Effective Public Health Practice Project Quality Assessment Tool (EPHPP) to assess the quality of each included study.[13] The EPHPP assesses the risk of bias and the methodological quality of studies with different study designs, including cross-sectional, before-and-after studies, and randomized controlled trials (RCTs). Two authors independently evaluated each study based on the 6 items listed in the assessment tool, ie, selection bias, study design, confounders, blinding, data collection method, and dropouts. Each item was rated as strong, moderate, or weak. The study had a strong global rating if it had no weak item ratings, a moderate global rating if it had one weak item rating, or a weak global rating if it had 2 or more weak item ratings. The inconsistencies were resolved by other reviewers.

RESULTS

Study Characteristics

Table 1 summarizes the characteristics of the studies included in this review. Of the 38 included studies, 18 (47%) were conducted in Europe,[5,14-30] 17 (45%) were carried out in North America,[10,11,31-45] and the remaining 3 studies were conducted in Australia,[46] Turkey,[47] or Thailand.[48] Most studies took place in nurseries, childcare centers or kindergartens, with 2 exceptions in family childcare venues.[10,34]

Almost all studies (87%) were published after 2010. On average, the minimum age of children was 9 months,[17] and the maximum was 6.1 years old.[43,44] Sample size varied. The largest sample size was 166 centers[34] and 838 children,[31] whereas the smallest size was one center[10,23,27,33,35,37,39,41,43] and 14 children.[36] In addition, 12 of the 38 studies were cross-sectional studies, 26 of them adopted an experimental design, with 11 within-subject and 15 between-subject designs.

The intervention period ranged from 20 minutes to 9 months. Intervention strategies varied across studies, including nutrition education programs, food serving strategy, and caregivers' feeding practices, such as role modeling. Many studies took anthropometric characteristics of children, such as weight, height, BMI, and backgrounds of early childhood educators and parents, as confounding variables.

Table 1
Characteristics of 38 Included Studies

First author (year)	Study design[a]	Study area [scale][b]	Sample size	Sample age	Statistical methods
Ahern (2014)[14]	I-NC	West Yorkshire, UK [S]	29 children in 4 nurseries	15-56 m	multilevel models
Ahern (2019)[15]	I-NC	West and South Yorkshire, UK [S]	95 children in 5 nurseries	24-60 m	repeated measure ANCOVA
Andreyeva (2018)[16]	C	Connecticut, USA [S]	838 children in 97 centers	preschool-aged	mixed linear regression
Anundson (2018)[17]	C	Oklahoma, USA [S]	201 children in 25 centers	3-5 y	multilevel mixed-model analysis
Anzman-Frasca (2012)[18]	I-C	Central Pennsylvania, USA [S]	47 children in 1 childcare	3-6 y	Repeated measure analysis
Barnes (2021)[19]	C	New South Wales, Australia[S]	448 children in 22 childcare centers	2-5 y	multilevel mixed-effects linear regressions
Baskale (2011)[20]	I-C	Izmir, Turkey[C]	238 children (at baseline) in 12 nurseries	5 y	two-way repeated measures analysis of variance
Benjamin-Neelon (2018)[21]	C	North Carolina, USA[S]	496 children in 166 family childcares	18 m-4 y	linear regression
Bouhlal (2014)[22]	I-C	Dijon, France [C]	151 children in 6 nurseries	2-3 y	ANOVA and paired t-tests
Caton (2013)[23]	I-C	West and South Yorkshire, UK[S]	72 children in 6 nurseries	9-38 m	ANCOVA, ANOVA
Dazeley (2015)[24]	I-C	Berkshire, UK[S]	92 children in 6 nurseries	12-36 m	t test, Wilcoxon test
Gubbels (2010)[25]	C	Maastricht, the Netherlands [C]	135 children in 9 centers	2-3 y	Point biserial correlations
Gubbels (2015)[26]	C	the Netherlands [N]	398 children in 24 centers	1-4 y	multilevel linear regression analyses
Harnack (2012)[27]	I-NC	Minneapolis, USA [C]	53 children in 1 center	2-5 y	ANOVA
Hausner (2012)[28]	I-C	Copenhagen, Denmark [C]	104 children in 5 nurseries	22-38 m	ANCOVA
Hendy (2000)[29]	I-C	Eastern Pennsylvania, USA [S]	14~34 children in a series of studies	Preschool aged	ANOVA
Hendy (2002)[30]	I-C	eastern Pennsylvania, USA [S]	22 children in 1 center	3-6 y	repeated measure ANOVA
Himberg-Sundet (2018)[31]	C	Vestfold and Buskerud, Norway [Cn]	73 kindergartens	With children aged 3-5 y at baseline	Non-parametric Mann-Whitney U and Kruskal-Wallis tests
Hoppu (2017)[32]	I-C	Hanko, Finland [C]	68 children in 2 centers	3-6 y	Wilcoxon and Friedman
Horne (2011)[33]	I-NC	Bangor, UK [C]	20 children in 1 nursery	24–52 m	ANOVA and t-test
Hughes (2007)[34]	C	Houston, USA [C]	549 in 13 Head Start centers	3-5 y	Multi-level modeling
Joseph (2015)[35]	I-NC	Connecticut, USA [S]	49 children in 1 childcare centers	3-5 y	McNemar's chi-square test, Wilcoxon's rank-sum test
Kakietek (2014)[36]	C	New York, USA [C]	636 children in 106 centers	3-4 y	logistic regression
Kharofa (2016)[37]	C	Cincinnati, Ohio, USA [C]	349 children in 30 centers	36-72 m	general linear mixed model
Korwanich (2008)[38]	I-C	Phrae, Thailand [S]	219 children in16 centers	5-6 y	t-test
Lehto (2019)[39]	C	Municipalities in Finland [Cn]	586 children in 66 centers	3–6 y	linear regression model
Looney (2011)[40]	I-NC	Knoxville, USA [C]	17 children in 1 center	2-5 y	Repeated measures analyses of covariance; hierarchical linear regression
Nekitsing (2019)[41]	I-C	West Yorkshire, UK [S]	219 children in 11 preschools	2-5 y	Logistic regression General linear repeated measures analysis
Nor (2021)[42]	I-NC	Berkshire, UK [S]	172 children in 6 schools	3-5 y	Paired t-tests and one-way repeated measure ANOVAs
O'Connell (2012)[43]	I-C	A small northeastern city, USA [C]	96 children in 2 centers	3-6 y	mixed factorial analysis of variance
Olsen (2019)[44]	I-NC	Copenhagen, Denmark [C]	86 children in 1 nursery	2-6 y	one-way ANOVA
Roe (2013)[45]	I-NC	University park, Pennsylvania, USA [C]	61 children in 1 family center	3-5 y	Repeated measures binary logistic regression
Rolls (2000)[46]	I-NC	University park, Pennsylvania, USA [C]	32 children in 1 center	3-6.1 y	analysis of variance
Spill (2011)[47]	I-NC	University park, Pennsylvania, USA [C]	40 children in 2 centers	3.7-6.1 y	Mixed linear model with repeated measures
Ward (2017)[48]	C	Saskatchewan and New Brunswick, Canada [Sn]	723 children in 50 centers	Mean age=4.0 y, SD=0.7	multilevel linear regressions
de Wild (2013)[49]	I-C	Wageningen, the Netherlands [C]	40 children in 2 centers	2-4 y	General linear model
de Wild (2014)[50]	I-C	Wageningen, the Netherlands [C]	39 children in 2 centers	1.5-4 y	General Linear Model for repeated measures
Zeinstra (2018)[51]	I-C	Utrecht, the Netherlands [C]	250 children in 4 centers	0-4 y	Mixed model analyses and paired t-test

Note.
[a] Study design: C, cross-sectional study; I-C, intervention with control group; I-NC, pre-post intervention with no control group.
[b] Study scale: [N], national; [S], state or equivalent unit; [Sn], n states or equivalent units; [C], city or equivalent unit; [Cn], n cities.

Quality Assessment of Selected Studies

Table 2 attempts to illuminate the quality of the 38 studies. Most studies scored weakly regarding blinding of participants (87%), and moderately regarding study design (61%). Concerning the global quality, 11% of the studies were rated of strong quality, 47% were moderate, and 42% were weak.

Table 2
Study Quality

First author (year)	Selection bias	Study design	Confounders	Blinding	Data collection	Dropouts	Global
Ahern (2014)	0	0	-	-	+	+	-
Ahern (2019)	+	0	+	-	+	+	0
Andreyeva (2018)	+	0	+	-	+	+	0
Anundson (2018)	0	0	+	-	+	+	0
Anzman-Frasca (2012)	0	+	+	-	+	+	0
Barnes (2021)	+	0	+	-	+	+	0
Baskale (2011)	+	+	0	-	+	+	0
Benjamin-Neelon (2018)	0	0	+	+	+	+	+
Bouhlal (2014)	+	+	+	+	+	+	+
Caton (2013)	0	+	+	+	+	+	+
Dazeley (2015)	0	+	+	-	+	+	0
Gubbels (2010)	+	0	0	-	+	+	0
Gubbels (2015)	0	0	+	-	+	+	0
Harnack (2012)	-	0	+	0	+	+	0
Hausner (2012)	-	+	+	-	+	+	-
Hendy (2000)	-	-	+	-	+	+	-
Hendy (2002)	0	-	+	-	+	0	-
Himberg-Sundet (2018)	0	0	-	-	+	+	-
Hoppu (2017)	-	+	+	-	+	+	-
Horne (2011)	-	0	0	-	+	+	-
Hughes (2007)	0	0	-	-	+	+	-
Joseph (2015)	-	0	+	-	+	+	-
Kakietek (2014)	+	0	+	-	+	+	0
Kharofa (2016)	+	0	-	-	+	+	-
Korwanich (2008)	+	-	+	-	+	+	-
Lehto (2019)	0	0	+	-	+	-	-
Looney (2011)	-	0	+	-	+	+	-
Nekitsing (2019)	+	+	+	-	+	-	-
Nor (2021)	+	0	+	-	+	+	0
O'Connell (2012)	0	+	+	-	+	+	0
Olsen (2019)	-	0	+	-	+	+	-
Roe (2013)	0	0	+	-	+	+	0
Rolls (2000)	-	0	+	-	+	+	-
Spill (2011)	0	0	+	-	+	+	0
Ward (2017)	+	0	+	-	+	+	0
de Wild (2013)	+	+	0	+	+	+	+
de Wild (2014)	0	+	0	-	+	+	0
Zeinstra (2018)	0	+	+	-	+	+	0
Sum weak (%)	9(24%)	3(8%)	4(11%)	33(87%)		2(5%)	16(42%)
Sum moderate (%)	16(42%)	23(61%)	5(13%)	1(3%)		1(3%)	18(47%)
Sum strong (%)	13(34%)	12(32%)	29(76%)	4(11%)	38(100%)	35(92%)	4(11%)

Note.
"+," strong; "0," moderate; "-", weak

Indicators and Measures of Dietary Environments

Researchers in the 12 cross-sectional studies measured varied aspects of dietary environments in ECE settings. The *Environment and Policy Assessment and Observation* (EPAO) instrument was applied in 7 of these studies (Table 3). Some studies investigated one specific aspect of dietary environments, with caregivers' feeding practices attracting wide attention. For instance, Anundson et al.[32] and Kharofa et al.[11] used the feeding practice subscale from the EPAO to measure staff mealtime behaviors in ECE settings.[11,32] There were also studies assessing more than one aspect of dietary environments. For instance, Barnes et al[19] selected items from the EPAO to outline feeding practice, nutrition education, and nutrition policy in ECE settings. Benjamin-Neelon et al.[34] applied all 7 subscales (ie, foods provision, beverage provision, feeding environment, feeding practice, menus and variety, nutrition education, and nutrition policy) of the EPAO to assess the dietary environment of 166 family childcares.

Table 3
Measures of Dietary Environment, Child Eating Behaviors and Outcomes in the 12 Cross-sectional Studies

First author (year)	Measures of dietary environment	Measures of eating behaviors	Confounding variables	Main results
Andreyeva (2018)[16]	feeding practice (Rudd Center Child Care Meal Observation Tool)	food intake (plate waste weighing and visual observation)	child gender, center characteristics	Family-style service had a significant negative association with percent calories consumed from saturated fat (Estimate=-2.74*, SE=1.12); Teacher role modeling predicted lower consumption of calories from fat (Estimate=-5.10*, SE=1.99).
Anundson (2018)[17]	nutrition-related behavior (EPAO subscale)	food item tasted (observation)	age, sex, child-staff ratio	Response to fullness appropriately made a difference on children's tasing fruits (mean difference=1.05~1.31) and high-fat meat (mean difference=-0.34~-0.31); staff modeling predicted children's tasting of vegetables (mean difference=1.02).
Barnes (2021)[19]	feeding practice, nutrition education, nutrition policy (EPAO)	intake of fruits and vegetables (weighted lunchbox)	SES, center characteristics	No significant associations between dietary environment and child intake of fruit and vegetable.
Benjamin-Neelon (2018)[21]	nutrition environment (EPAO; 7 sub-scales)	healthy eating index (HEI; observation using DOCC)	child age, gender, race, BMI; center characteristics; provider characteristics	Higher scores on EPAO sub-scales for food provided (Estimate=8.98*** , 95%CI: 3.94, 14.01), nutrition education (Estimate=5.37* , 95%CI: 0.80, 9.94), and nutrition policy (Estimate=2.36** , 95%CI: 0.23, 4.49) were all associated with greater child HEI score.
Gubbels (2010)[25]	dietary environment (EPAO)	dietary intake (observation)	NR	Food serving style (r=0.43~0.74), staff behavior (r=0.30~0.58) were significantly associated with child dietary intake.
Gubbels (2015)[26]	staff practice (adapted EPAO)	dietary intake (observation)	Child age and gender	Staff explains food preparation associated with fruit intake (B=10.16 **); stimulation to eat associated with vegetable intake (B=6.11 **).
Himberg-Sundet (2018)[31]	dietary environment (questionnaire)	vegetables intake at group level (five-day diary)	NR	A larger amount (p=.046) of vegetables was eaten in kindergartens that had written guidelines for food and beverages provision.
Hughes (2007)[34]	staff feeding behavior (observation) and feeding style (self-report)	child food consumption (observation)	NR	Indulgent feeding positively associated with children's vegetable (B=43.10, t=2.42*, pr=.24), dairy (B=627.30, t=2.00*, pr=.20), and starch (B=44.68, t=2.35*, pr=.27) intake.
Kakietek (2014)[36]	compliance with beverage regulation (observation, interview and site inventory; dichotomous coding)	frequency of beverage intake (observation and dichotomous coding)	center and staff characteristics	Following beverage regulation decreased high-fat milk (AOR=0.03*, 95%CI: 0.01-0.09) and sugar-sweetened beverage intake (AOR=0.14* , 95%CI: 0.07–0.26).
Kharofa (2016)[37]	staff mealtime practices (EPAO)	child energy, vegetable and fruit intake (observation)	NR	Staff sitting with children was associated with lower energy (p=.04) and higher vegetable (p=.03) intake; Staff eating the same foods was associated with higher energy (p=.008) and higher vegetable (p=.04) intake;
Lehto (2019)[39]	staff feeding practice (NAP SACC, self-developed items, and EPAO)	child intake of vegetables, energy, fiber, and added sugar (observation)	child age, gender, food intake at home, municipality	Staff role modeling was associated with lower energy intake (B=-0.81*, 95%CI: -1.60, 0.02) ; encouragement to eat fruit and vegetable increased fiber intake (B=0.29*, 95%CI: 0.05, 0.53).
Ward (2017)[48]	educators' nutrition practice and nutrition education (NAP SACC)	diet intake in amount (plate waste weighing and visual observation)	child gender, age, BMI; center characteristics	Modeling predicted sugar intake (β=0.141; 95%CI: 0.03, 0.27); nutrition education predicted calorie (β=-0.456; 95%CI: -1.46, -0.02) and fiber (β=-0.066; 95%CI: -0.12, -0.01) intake; not using food as rewards predicted fat intake (β=-0.144; 95%CI: -0.52, -0.002).

Note.
Abbreviations: EPAO, Environment and Policy Assessment and Observation, an observation tool for assessing childcare dietary environment; SES, social economic status; DOCC, Diet observation at childcare; HEI, healthy eating index; BMI, body mass index; NR, not reported; NAP SACC, nutrition and physical activity self-assessment for childcare; AOR, adjusted odds ratio.
*p < .05, **p < .01, ***p < .001

In the remaining 26 intervention studies (Table 4), intervention strategies were implemented to improve the quality of dietary environments and effects on children's eating behaviors were examined. The most frequently used strategy in these studies was dietary learning,[14-17,20,26,28-30,33,42] including repeated exposure (RE), flavor-flavor learning (FFL, a strategy by which a novel flavor is paired with another, already liked flavor), and flavor-nutrient learning (FNL, a strategy by which associations are established between a novel flavor of food and its post-ingestion consequences).

Table 4
Intervention Strategies, Measures of Child Eating Behaviors and Outcomes in the 26 Intervention Studies

First author (year)	Intervention strategy	Intervention period	Measures of eating behaviors	Confounding variables	Main results
Ahern (2014)[14]	dietary learning (RE vs. FFL vs. control)	ca. 1 month	novel vegetable puree intake in amount	NR	no main effect of condition
Ahern (2019)[15]	dietary learning (RE vs. RE-variety)	4 weeks	vegetable intake in amount	child age, BMI	no main effect of condition
Anzman-Frasca (2012)[18]	RE (to vegetable alone) vs. associative conditioning (AC, exposure to vegetable with a liked dip)	4 weeks	vegetable intake in amount	child age, BMI, vegetable liking; parents' education, income	Overall increase in vegetable intake from pre- to post-test (p<.01); no main effect of condition.
Baskale (2011)[20]	nutrition education	6 weeks	Food consumption frequency (parental report)	NR	Increase in milk (p<.001), cheese (p<.05), fish (p<.05) and green leaf vegetable (p<.05) consumption from pre- to post-test in experimental condition; no differences were found in the control group.
Bouhlal (2014)[22]	dietary learning (RE vs. FFL-Salt vs. FFL-Nutmeg)	4 weeks	novel vegetable puree intake in amount	child age, gender, BMI	Vegetable intake increased from pre-to post-exposure in all groups (F=2.83*). The increase was higher in RE group than in the FFL-salt group (Δ intake=41**).
Caton (2013)[23]	dietary learning (RE vs. FFL vs. FNL)	NR	novel vegetable intake in amount	child age, BMI	Vegetable intake increased in all three conditions (p=.001); no main effect of condition was observed.
Dazeley (2015)[24]	non-taste sensory activities	4 weeks	novel vegetables and fruits taste (observation)	child age	vegetable taste increased in treatment condition (Δ mean=0.18, Z=2.24*); no effect on fruit taste
Harnack (2012)[27]	meal service strategy (fruits and vegetables in advance vs. portioned and plated vs. family-style (control condition)	6 weeks	fruit and vegetable intake (onsite observation)	child age, race, BMI; parental education	Serving fruit and vegetable in advance increased fruit intake (Mean difference=0.08**); provider portioned decreased fruit intake (Mean difference=-0.07***) and vegetable intake (Mean difference=-0.03**) vs. control.
Hausner (2012)[28]	dietary learning (RE vs. FFL vs. FNL)	4 weeks	novel vegetable intake in amount	child age, gender	Average intake of vegetable increased across the exposure in the RE condition ($F_{(2,31)=}$22.77**); intake increased across exposures in the FFL group ($F_{(2,32)}$=29.9***); no effect of FNL condition.
Hendy (2000)[29]	teacher modeling	NR	Familiar and novel food acceptance (observation)	Child gender	Silent teacher modeling had no effect on child food acceptance. Enthusiastic teacher modeling had an effect on child novel food acceptance (E=7.17*).
Hendy (2002)[30]	peer modeling (boy model vs. girl model vs. no model)	20 minutes	novel food acceptance (child interview and observation)	child age, BMI, gender, social competence of peer models	peer role modeling had significant effect on novel food acceptance ($F_{(2,24)}$=5.17*); girl model were more effective than boy model to increase food acceptance (t=2.68*).
Hoppu (2017)[32]	sensory-based food education activities	5 weeks	Child willingness to eat	Child food preference	In the intervention group, the willingness to eat the sample vegetables and fruits increased (p<.001).
Horne (2011)[33]	modeling and rewards	NR	Target fruit (vegetable) vs. non-target fruit (vegetable) intake	NR	a significant increase of target fruit intake after fruit intervention (t=6.76***, d=1.78); a significant increase of target vegetable intake after vegetable intervention (t=6.07***, d=1.64);

First author (year)	Intervention strategy	Intervention period	Measures of eating behaviors	Confounding variables	Main results
Joseph (2015)[35]	nutrition education	2 weeks	Child snack choice (observation)	Child age, gender, ethnicity, race, BMI, snack preference	Children did not significantly improve (p > .05) their snack choice between a healthy and unhealthy choice after the nutrition education program.
Korwanich (2008)[38]	development and implementation of a healthy eating policy	9 months	frequency of snack intake (onsite observation)	child gender; pocket money; family SES	following healthy eating policy decreased sugar-sweetened food (Δfrequency=-0.28*~-0.03*) and sugar drink (Δfrequency=-0.08*)
Looney (2011)[40]	food provision (portion size)	1 month	Snack intake	Child BMI, caretaker demographics	Greater energy consumed in the large as compared to small portion condition (F=5.21*).
Nekitsing (2019)[41]	taste exposure (TE), nutrition education	9 weeks	Child intake of an unfamiliar vegetable	Child age, baseline intake	Children in nutrition education condition had higher odds of eating the target vegetable (OR=6.43, 95%CI: 1.5, 27.8, $\chi^{2=}$5.73*). Intake increased significantly in the TE condition (F=11.21**).
Nor (2021)[42]	RE	10 days	Child intake of an unfamiliar vegetable	Child taste sensitivity	Overall intake significantly increased post-intervention (t=6.17***).
O'Connell (2012)[43]	RE	1 month	Child vegetable consumption during lunch	NR	A decrease of vegetable consumption from pre- to post-test in experiment condition (F=10.81**).
Olsen (2019)[44]	offering a choice (in contrast to no choice)	ca.3 weeks	Vegetable intake	Child age	The mean total vegetable intake was significantly higher (p=.04) in the free choice condition compared to the no choice condition.
Roe (2013)[45]	serving a variety of vegetables and fruits	4 weeks	Intake of vegetables and fruit	Child age, BMI	Compared with offering a single type, serving a variety increased consumption of vegetables (p<.0001).
Rolls (2000)[46]	portion size (large vs. small)	3 weeks	food intake	Child weight, height, sex, ratings for liking of the target food	Older children (5-year-old) consumed a greater amount of energy when served the large portion (p<.002). for younger children (3-year-old), portion size did not significantly affect food intake.
Spill (2011)[47]	75% ED (energy density; kcal/g), 85% ED vs. 100% ED (control) condition	3 weeks	vegetable and energy intake in amount	child gender, age, BMI, food acceptability ratings, and food-preference rankings	vegetable intake increased 68%** (85% ED), and 103%** (75% ED) vs. control condition; energy intake decrease 142kcal** (75% ED) vs. control condition.
de Wild (2013)[49]	RE and FNL (low vs. high energy)	7 weeks	vegetable intake	NR	Repeated exposure had a main effect on libitum intake (F=21***). No main effect of FNL.
de Wild (2014)[50]	RE and FFL	6 weeks	vegetable intake	NR	Repeated exposure had a main effect (F=74***) on vegetable intake. No main effect of FFL.
Zeinstra (2018)[51]	RE	5 months	vegetable intake	child age	Pumpkin (t=6.07***) and radish (t=6.97***) intake increased significantly between pre- and post-test in the intervention group.

Note.
Abbreviations: RE, Repeated exposure; TE, taste exposure; FFL, Flavor-flavor learning; FNL, Flavor-nutrient learning; ED, energy density; NR, not reported; BMI, body mass index.
*p<.05, **p<.01, ***p<.001

In the second group of intervention studies, food and beverage provision was manipulated, for instance, serving fruits and vegetables in advance,[35] offering a choice,[15,27] or serving a specific portion size.[41,43] In addition, the energy density of beverage was manipulated in one study by incorporating pureed vegetables.[44] Children's fruits, vegetables, and energy intake were considered outcome variables in these studies.

In the third group of studies, caregivers' feeding practices have attracted wide attention. Role modeling often was used to alter children's novel food acceptance or intake of fruits and vegetables.[23,36,37] In one study, peers were trained as models,[37] while in 2 other studies, teachers played the role of models who ate the same food as children during mealtime.

In the fourth group of studies, effects of nutrition education programs or activities were investigated. Sensory activities were conducted in 2 studies to increase children's willingness to taste novel vegetables

and fruits.[18,22] The other 2 studies examined the impact of integrated curricula on children's healthy food preference and consumption.[39,47]

Finally, there was one article that focused on the whole process of how a healthy eating policy was developed and implemented in childcare.[48] In this study, children's intake of snacks was measured through onsite observation.

Associations between Dietary Environments and Children's Eating Behaviors

Tables 3 and 4 summarize the results of the 38 studies. Generally, findings identified relations between nutrition policy and children's eating behaviors. Compliance with beverage regulations decreased sugar-sweetened beverages and high-fat milk consumption.[40] In addition, developing and implementing an institutional-level diet policy reduced children's intake of sweets.[48] Moreover, as a subscale of the EPAO, following nutrition policy was found to be positively related to the diet quality of younger children in family childcare in one study.[34] However, this subscale included only one item, causing a limitation in measurement reliability.

What and how foods and beverages are provided are vital indicators to be considered. We found that the amount, type, and quality of food provision in family childcare significantly predicted children's diet quality;[34] in particular, greater energy was consumed by children when serving a large versus a small portion size.[41,43] In addition, offering children opportunities to choose from a variety of vegetables increased vegetable intake.[10,27] Serving fruits and vegetables in advance of other meals could increase children's intake of fruits rather than vegetables. In contrast, serving meals portioned and plated significantly reduced children's consumption of fruits and vegetables and increased the intake of energy.[35] Furthermore, adding vegetable puree to entrees was proven to be an effective way to increase vegetable consumption and decrease energy intake.[44]

Regarding caregivers' feeding practice, we found that caregivers' role modeling was a predictor of children's dietary behaviors. Through sitting with children during meals and eating the same food, caregivers' role modeling decreased the calories and energy intake of children.[11,31,32] However, another study found that caregivers' modeling increased children's sugar intake.[45] According to the authors, this probably reflects the high-sugar-content foods served in childcare.[45] Besides acting as models on their own, caregivers also could choose peer models as a method to encourage children's food acceptance. When peers were trained to eat novel foods and praised the foods in words (acting as models), it promoted food acceptance of children who were onlooking.[37] Girl models were more effective than boy models in this study in promoting novel food acceptance of onlooking children.[37] Verbal encouragement and using foods as rewards were often observed feeding practices of caregivers. If caregivers encouraged children to eat new or unpopular fruits and vegetables, children would take more fiber.[24]

Dietary learning was the most frequently used strategy in the included studies.[14-17,20,26,28-30,33,42] Repeated exposure (RE) was more effective than flavor-flavor learning (FFL), which means a new flavor/food paired with an already familiar and liked flavor, increased infants' and toddlers' acceptance of novel vegetables.[16,29] Flavor-nutrient learning (FNL), which occurs when associations are established between a flavor of food and its post-ingestion consequences, had no effect on children's vegetable intake.[20,28] There were also studies showing no effect[14,15] or even negative effect[42] of dietary learning on vegetable consumption.

Finally, 6 studies revealed the value of nutrition education for children's healthy eating.[18,22,25,34,45,47] Non-taste sensory (looking, listening, feeling, smelling) activities[18,22] could change children's attitudes toward healthy food and increase their intake of vegetables. It is also worth noting that providing nutrition education for caregivers and parents was also important in cultivating healthy eating behaviors of young children.[34,47]

DISCUSSION

The hypothesis that dietary environments in ECE settings were associated with children's eating behaviors was supported by the majority of the included studies (31 out of 38), which were conducted in 10 countries. Following food regulations was shown to have consistent positive relationships with children's healthy eating.[21,34,40,48] Regarding food provision, serving fruits and vegetables in advance, serving small portion size, and providing children free choice among a variety of vegetables associated with children's vegetable intake.[5,10,27,31,34,35,41,43] Positive effects of nutrition education on children's healthy eating were identified in 6 out of 7 studies,[18,22,25,34,45,47]

with one exception which found no effect of a short-term (2 weeks) nutrition education program on children's healthy snack choice.[39] Results on staff practice were mixed. In most cases teachers' role modeling and verbal encouragement predicted low energy intake and healthy eating.[5,19,23,24,31,32] When teachers ate the same food with children, however, children's energy or sugar intake increased.[11,45]

We found several research gaps in this field and pointed out interesting avenues for future studies. First, a majority of the included studies (92%) were conducted in Europe and North America, indicating that this topic was under-investigated in other regions. Second, measures of the dietary environment varied considerably across studies, and a comprehensive approach to assessing the dietary environment is needed. Attention was mainly paid to educators' feeding practice during meals, such as role modeling, verbal encouragement, and using food as rewards. Systematic investigations of different aspects of dietary environments are rare. Borrowed from the concept of ecological systems theory of Bronfenbrenner[49] the dietary environment in ECE settings was rarely treated as a system with microsystem environments (eg, food provided, educators' feeding practice) and macrosystem environments such as nutrition policy. Therefore, it is necessary to take a comprehensive approach for understanding how children's eating habits or styles are cultivated in dietary environments in ECE settings and how different aspects of dietary environments interact with each other.

With respect to children's eating behaviors, food intake and novel food acceptance were referred to in most studies, partially because these 2 indicators had been clearly defined and could be directly measured by objective methods. Eating habits,[50,51] dietary hygiene,[52] and eating etiquette are also important aspects of eating behaviors but are under-investigated. Furthermore, observation is the most often used method to measure children's food consumption in amount, and child interviews and weighing methods also have been used in some studies. Previous studies also have adopted the Children's Eating Behavior Questionnaire (CEBQ) to measure the eating behaviors of children in the family.[53,54] Future studies could explore the appropriateness of using questionnaires in combination with observation methods in childcare centers.

By reviewing the related work, we found that the dietary environment of ECE settings has impacts on children's eating behavior. First, the quality of foods provided in childcare centers is important to the nutrition and health of young children. There are nationwide regulations in many countries concerning food provision in ECE settings. The US, the United Kingdom (UK), and the Netherlands highlighted the nutritional adequacy of foods and beverages commonly served to young children in childcare settings.[55-57] The Chinese *Dietary Guidelines for Preschool Children*[58] suggest that young children eat nutritionally balanced foods and drink boiled water. Compliance with food regulations has a positive effect on promoting healthy diets for children. In addition to what is served, how food is served is also crucial. Strategies such as serving fruits and vegetables in advance, serving small portion sizes, and providing children free choice among a variety of vegetables increased children's intake of healthy food.[5,10,27,31,34,35,41,43]

Second, caregivers' feeding practices, such as dietary learning, role modeling and verbal encouragement, are closely concerned. Dietary learning is clearly effective for introducing novel foods to children. However, there are researchers stating it is, on the other hand, a method with a slow rate of progress, requiring great patience from early educators.[17,59,60] Children over 2 years old are often afraid of novel foods and refuse to taste them, and it takes at least 5-10 times for a dietary learning strategy to work.[61] Therefore, combining dietary learning with other strategies, such as rewards (eg, smile or sticker), non-taste sensory activities, and picture book reading, is necessary.[62-64]

According to social cognitive theory, eating behavior (as well as other behaviors) is learned in early childhood by observing and imitating.[65] Caregivers in childcare centers play an important role in shaping young children's dietary habits. Studies included in this work also confirmed the value of caregivers' modeling. However, this effect is mixed because teachers often provide enthusiastic modeling, which means modeling is used in combination with verbal encouragement.[36] A surprising result of 2 studies is that caregivers' eating the same food in front of children increased children's sugar or energy intake.[45] The authors explained this effect by the interdependence of caregiver modeling with the food provided in childcare settings. If high-sugar-content foods are provided in childcare settings, caregivers' modeling

would lead to children's intake of more unhealthy foods. This further confirms our statement that the dietary environment should be investigated by adopting a comprehensive approach and that interactions between different aspects should be considered. In addition to caregiver modeling, peers also have a powerful impact on the behavior of young children, as they frequently vocalize about foods, and both offer them to, and request them from other children.

Finally, nutrition education plays an important role in children's nutritional status and healthy development. Both formal (eg, integrated curriculum) and informal educational activities in daily life can promote children's understanding of the relationship between food and health, thereby fostering their interest in food and willingness to eat healthy food. In addition, nutrition education for educators is pivotal to enhance their awareness of the value of early nutrition education and to make them skillful in providing supportive feeding practice. Although the national food and dietary guidelines in many countries (eg, the Australian Guide to Healthy Eating [AGHE], the Statutory framework for the early years foundation stage in the UK) clearly state food requirements and quality standards for healthy eating, meeting these standards requires intervention programs.[66,67] For instance, Yoong et al.[68] designed a 6-month multi-strategy implementation intervention to improve menu compliance with the AGHE in 25 childcare centers in New South Wales, Australia. Various nutrition education activities (eg, educational resources distribution, educational meeting, audit and feedback provision) targeted toward different stakeholder groups were adopted in this program to teach them about how to implement the nutrition guidelines. Furthermore, children's eating behaviors are jointly influenced by parents and teachers. Therefore, nutrition education for parents through workshops, daily communications, and other messaging should be given close attention. A Swedish study witnessed that healthier eating behaviors of children could be obtained by parents participating in the diet program of ECE institutions.[69]

Through systematically searching and reviewing published empirical studies, we summarized early childcare dietary practices reported by various sources across the world and reported conclusions from these studies in detail. Cross-sectional studies as well as intervention studies were reviewed, which make it possible to examine different aspects of dietary environments in ECE settings. We followed prespecified criteria and procedures to minimize selection and reviewer-related bias. However, this review has several limitations. Studies in this review were restricted to English-language, thereby preventing relevant studies not published in English from being reviewed. Also, our included studies were predominated by developed countries in Europe and North America and could not provide a comprehensive understanding of the associations between dietary environment and eating behaviors worldwide. Additionally, the quality of most included studies was scored as moderate or weak. The sample size of most controlled trials was limited and participants were not necessarily representative. Results of this study are inconclusive due to the aforementioned limitations. Future studies could take some potential confounders as moderators, such as diet regulations in different regions or areas, to analyze how effects of dietary environment varied across subpopulations. Furthermore, aspects of children's eating behaviors, other than food intake, are important research considerations.

Conclusions

A growing body of studies from 11 countries shows that following and implementing dietary guidelines was positively related to children's healthy food consumption. Serving strategies such as serving fruits and vegetables in advance, serving small portion sizes, and providing children free choice among several vegetables increased children's intake of healthy food. A variety of nutrition-related activities positively correlated with children's healthy eating attitudes and behaviors. The results of educators' feeding practices remained mixed.

Human Subjects Approval Statement

This study did not involve collection of original research data from human subjects.

Conflict of Interest Disclosure Statement

All authors have no competing interests to declare.

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Appendix 1

Database	Search Terms	Numbers
Web of science	TS=("food environment*" OR "nutrition practice*" OR " feeding practice*" OR" food intervention*") AND TS=("food intake*" OR "food consumption*" OR "food preference*" OR "food selection*" OR "diet*"OR"eatingbehavior*"OR"nutrition*") AND AB=("preschool" OR "nursery "OR "childcare" OR "kindergarten" OR "child care" OR " day care" OR "daycare")	438
Psycinfo	main subject("food environment*") OR main subject("feeding practice*") OR main subject("nutrition practice*") OR main subject("food intervention*") AND main subject("food intake*") OR main subject("eating behavior*") OR main subject("nutrition*") OR main subject("food consumption*") OR main subject("food preference*") OR main subject("food selection*")	257
ProQuest	main subject("food environment*") OR main subject("nutrition practice*") OR main subject("food intervention*") OR main subject("feeding practice*") AND main subject("food intake*") OR main subject("food consumption*") OR main subject("food preference*") OR main subject("food selection*") OR main subject("eating behavior*") OR main subject("dietary habit*")	1324
Emerald	title("food environment*") OR title("feeding practice*") OR title("nutrition practice*") OR title("food intervention*") AND title("food intake*") OR title("food consumption*") OR title("food preference*") OR title("food selection*") OR title("eating behavior*") OR title("diet*")	586

Description of 31 Excluded Studies after Full-text Reviewed

First author (year)	Title	Reason for exclusion
Addessi (2005)	Specific social influences on the acceptance of novel foods in 2-5-year-old children	Laboratory intervention
Bell (2015)	Impact of a nutrition award scheme on the food and nutrient intakes of 2- to 4-year-olds attending long day care	No association between IV and DV reported
Blaine (2015)	Child Care Provider Adherence to Infant and Toddler Feeding Recommendations: Findings from the Baby Nutrition and Physical Activity Self-Assessment for Child Care (Baby NAP SACC) Study	No results on DV reported
Bock (2011)	Positive impact of a pre-school-based nutritional intervention on children's fruit and vegetable intake: results of a cluster-randomized trial	No association between IV and DV reported
Brouwer (2013)	Watch me grow: a garden-based pilot intervention to increase vegetable and fruit intake in preschoolers	No association between IV and DV reported
Coulthard (2017)	Play with your food! Sensory play is associated with tasting of fruits and vegetables in preschool children	Laboratory intervention
DeJesus (2019)	How Information About What Is "Healthy" Versus "Unhealthy" Impacts Children's Consumption of Otherwise Identical Foods	Laboratory intervention
Dial (2019)	A Mindfulness Intervention for Food Neophobia Among Preschoolers	Laboratory intervention
Edwards (2022)	Exposure to models' positive facial expressions whilst eating a raw vegetable increases children's acceptance and consumption of the modelled vegetable	Family-oriented intervention
Faith (2012)	A twin study of self-regulatory eating in early childhood: estimates of genetic and environmental influence, and measurement considerations	Family-oriented intervention
Fisher (2003)	Children's bite size and intake of an entrée are greater with large portions than with age-appropriate or self-selected portions	Laboratory intervention
Fisher (2007)	Effects of portion size and energy density on young children's intake at a meal	Laboratory intervention
Gagné (2013)	Impact of a childcare centre nutrition program on nutrient intakes in Nunavik Inuit children	No association between IV and DV reported
Galloway (2006)	'Finish your soup': counterproductive effects of pressuring children to eat on intake and affect	Laboratory intervention
Gebru (2021)	The relationship between caregivers' feeding practices and children's eating behaviors among preschool children in Ethiopia	No results on IV reported
Greenhalgh (2009)	Positive- and negative peer modelling effects on young children's consumption of novel blue foods	No results on IV reported
Kral (2010)	Effects of doubling the portion size of fruit and vegetable side dishes on children's intake at a meal	Laboratory intervention
Lakshmi (2005)	Dietary Adequacy of Indian Rural Preschool Children: Influencing Factors	No results on IV reported
Lanigan (2012)	The Relationship between Practices and Child Care Providers' Beliefs Related to Child Feeding and Obesity Prevention	No results on DV reported
McConaby (2002)	Food portions are positively related to energy intake and body weight in early childhood	Focusing on family environment
Nederkoorn (2018)	Taste the feeling or feel the tasting: tactile exposure to food texture promotes food acceptance	Laboratory intervention
Ramsay (2010)	''Are you done?'' Child Care Providers' Verbal Communication at Mealtimes That Reinforce or Hinder Children's Internal Cues of Hunger and Satiation	No results on DV reported
Reale (2018)	The Feasibility and Acceptability of Two Methods of Snack Portion Control in United Kingdom (UK) Preschool Children: Reduction and Replacement	Family-oriented intervention
Reimann (2015)	Leveraging the Happy Meal Effect: Substituting Food With Modest Nonfood Incentives Decreases Portion Size Choice	Participants were not preschool aged
Sanigorski (2005)	Lunchbox contents of Australian school children: room for improvement	Participants were not preschool aged
Seward (2017)	Improving the implementation of nutrition guidelines in childcare centers improves child dietary intake: findings of a randomized trial of an implementation intervention	No results on DV reported
Sisson (2019)	The Impact of 2017 CACFP Meal Pattern Requirement Change on Menu Quality in Tribal Early Care Environments: The FRESH Study	Community-based intervention
Vaughn (2020)	Evaluating a childcare-based social marketing approach for improving children's diet and physical activity: results from the Healthy Me, Healthy We cluster-randomized controlled trial	No results on IV reported
Vogel (2019)	Examination of how food environment and psychological factors interact in their relationship with dietary behaviors: test of a cross-sectional model	Focusing on family environment
Whiteside-Mansell (2019)	Evaluation of Together We Inspire Smart Eating: pre-school fruit and vegetable consumption	Focusing on family environment
Yoong (2019)	The impact of a childcare food service intervention on child dietary intake in care: an exploratory cluster randomized controlled trial	No results on IV reported

Note.
Abbreviations: IV, independent variable; DV, dependent variable