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REVIEW

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From preschool to policy: A scoping review of recommended interventions for a systems approach to improve dietary intake in early childhood

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Summary

Early childhood is a key opportunity to establish healthy eating behaviors and prevent future non-communicable diseases associated with poor diets. How to effectively intervene in the system of the many determinants influencing children's dietary intake remains unclear. This scoping review aimed to map the determinants of nutrition and eating that have been addressed in early childhood nutrition interventions and identify which of these improve dietary intake. We searched six electronic databases to identify eligible studies published from January 2000 to January 2024. We included studies of any interventions reporting dietary intake among children aged between two and five years. A total of 193 eligible studies were identified and mapped to the Determinants of Nutrition and Eating (DONE) Framework. Parent ($n = 97$) and child ($n = 76$) food knowledge and skills were most frequently addressed. Most studies addressing parent (67%) and child (66%) food knowledge and skills reported improvements in dietary intake. Government regulations such as healthy food subsidies, and food advertising and labeling interventions showed promised, with 82% of studies reporting improvements in dietary intake. However, these interventions were predominantly implemented in the United States and Chile. This review provides a comprehensive and systematic map of a range of interventions that positively influence nutritional outcomes in preschool-aged children but recommends further policy-level action globally.

KEYWORDS
children, food systems, nutrition, toddler

1 | INTRODUCTION

Sub-optimal diets and high body-mass index (BMI) are among the leading modifiable risk factors for attributable deaths and years of healthy life lost due to premature mortality or disability.[1] Despite efforts worldwide, no country has reversed increases in obesity levels and sub-optimal diets continue to threaten public health progress.[2] The number of children and adolescents living with obesity has increased globally over the past 40 years and is predicted to continue to rise, reaching 254 million by 2030.[3–5] As rates of childhood obesity continue to rise, the projected worldwide economic burden is estimated to cost the healthcare system $13.62 billion and

$49.02 billion in direct and indirect annual costs respectively by 2050.[6]

Improving the quality of children's diets plays a pivotal role in preventing the rising obesity within healthy populations. This not only helps reduce the economic burden, but high-quality diets are also associated with positive outcomes for children, including improved IQ, reduced risk of metabolic syndrome, lower blood pressure, and HbA1c levels, and an overall improvement in mental health-related quality of life.[7] Particularly, the first 2000 days of a child's life from conception to 5 years has been proposed to be a critical window of opportunity where children are experiencing rapid growth and developing lifelong skills and habits..[8] However, most children in high-income countries consume insufficient fruit and vegetables and overconsume sugar-sweetened beverages (SSB).[9] In the United States, an analysis of the National Health and Nutrition Examination Survey 2015–2016 estimated that 40% of children aged 2–5 years have poor quality diets, which was defined as less than 40% adherence to the American Heart Association 2020 continuous diet score.[10] Similarly, in Australia, children are not meeting national dietary guidelines with less than 5% of children meeting recommendations for vegetables, and 39% of their daily energy intake comes from energy-dense nutrient-poor foods high in added sugar, fat, and salt.[11,12]

It has been proposed that the shift in dietary patterns and increase in obesity rates has been largely driven by the contemporary transformation of the food system.[13] The industrialization of food production, technological advances in food processing, and globalization of food distribution have resulted in a food system that prioritizes highly processed, marketed, and affordable foods.[14]

Children's diets are influenced by a multitude of interacting determinants with the food system, making it challenging to implement effective interventions.[15] During the first 2000 days, children are dependent on parents and caregivers to provide adequate nutrition and make choices about food and eating and thus they play key roles in shaping children's diets and exposure to determinants of obesity.[16] Additionally, families are influenced by broader socioecological determinants which encompasses social, cultural, and environmental determinants,[8] such as home, school, community, and digital food environments, as well as the policies that impact and regulate them[17,18].

Effective long-term interventions are needed to support children to achieve high-quality diets, however, what works in real-world settings remains unclear.[19,20] If population-based strategies are to improve and sustain children's diets, a systems-based approach is necessary.[21] Most published reviews have synthesized the evidence specific to a setting or nutrition outcome, however, few reviews have synthesized studies across all socioecological levels to provide a complete overview of the influence of determinants on children's diets. Previous reviews that have taken a systems approach have quantified the number of studies addressing determinants to identify areas most frequently addressed but did not report study outcomes.[22,23] Other reviews have mapped studies according to the socio-ecological model to identify the influence of determinants across individual, interpersonal, environmental, and policy levels[24] or have mapped systematic reviews using the Innocenti Framework to identify which intervention types were effective.[25] To inform priority areas for intervention it is important to identify which determinants have been understudied as well as the expected impact of addressing the determinant on children's dietary intake.

This review aims to add to this body of knowledge by scoping the evidence and providing an in-depth map of which determinants improve dietary intake responding to intervention. The review will also determine successful intervention strategies. The review will pinpoint gaps and identify where more evidence is needed in the context of the food system to design effective solutions to improve children's dietary intake. A scoping review was used to explore and map the breadth of evidence to provide a comprehensive overview of the food system that encompasses the wider determinants of nutrition and eating.[26]

2 | METHODS

This scoping review was conducted following the guidelines and methodology recommended by the JBI Manual for Evidence Synthesis and PRISMA extension for Scoping Reviews (Table S1).[26,27]

2.1 | Protocol and registration

The a-priori protocol for the review was registered on Open Science Framework (registration digital object identifier: https://doi.org/10.17605/OSF.IO/KP49E) on 25 July 2022. Due to the extensive number of studies identified from the search, the protocol was updated on 14 April 2023 to outline changes in reporting outcomes. The methods were previously reported in a separate study mapping the domains of intervention but are reiterated here for completeness and comprehension.[22]

2.2 | Eligibility criteria

Studies that began or targeted children aged between two to five years (up to but not including 6 years) were eligible. Children less than two years were not included due to their different nutritional needs and feeding and eating behaviors. As children's diets are influenced by individual, interpersonal, environmental, and policy factors, interventions targeting key stakeholders at each level including parents, carers, and early childhood education and care (ECEC) service staff were also eligible. Studies targeting children with clinical conditions were not eligible as they may require different dietary requirements and feeding practices. We considered any healthy eating interventions designed to improve children's dietary intake. Measures of dietary intake considered for inclusion are outlined in the core outcome set for early childhood obesity prevention intervention studies developed by Brown et al.[28] Multi-component interventions were included if dietary intake outcomes were reported separately. This ensured that the

review would be comprehensive and capture all published interventions. Eligible studies were conducted in high-income countries to capture the context of modern food systems, characterized by an abundance of highly-processed food that promotes excessive energy intake.[29] Eligible primary research study designs included experimental, quasi-experimental and analytical observational studies such as repeated cross-sectional surveys that reported exposure to intervention and outcome. Studies were eligible if they were published after January 2000 in the English language.

2.3 | Information sources

The search was conducted across six electronic databases including Embase via Ovid (1947 to present), ERIC via Ovid (1966 to present), Global Health via Ovid (1910 to present), MEDLINE via Ovid (1946 to present), Scopus (1996 to present), and The Cochrane Library (Cochrane Database of Systematic Reviews, Cochrane Central Register of Controlled Trials [CENTRAL], Cochrane Methodology Register). Additionally, a search of the reference lists of relevant systematic reviews, meta-analyses, and umbrella reviews was conducted for eligible studies missed by our search. The original search was performed in May 2022 and updated in January 2024 using methods described by Bramer & Bain.[30]

2.4 | Search

The search strategy was designed with an experienced academic librarian. The full electronic search strategy for Medline via Ovid database is provided in Table S2.

2.5 | Selection of sources of evidence

Records identified from the search were de-duplicated using methods described by Bramer et al managed in Endnote X20.[31] Selection was performed using the pre-specified eligibility criteria in the protocol. To calibrate and refine definitions of eligibility criteria, one author (J.C.) pilot tested the eligibility criteria using a random sample of 25 records. One author (J.C.) screened titles and abstracts of all studies for eligibility using Covidence software. Full-text records were retrieved for potentially relevant studies and reviewed by two authors (J.C. and P.C.) independently in Covidence. Conflicts were resolved by consensus or decision of a third author (M.A.F.) not involved in the selection process when consensus could not be reached.

2.6 | Data charting process

The JBI template data charting instrument for scoping reviews and umbrella reviews was adapted for this review.[26] One author (J.C.) extracted all data using the pre-specified data charting form and a second author (P.C.) independently extracted 20% of the data for verification in Covidence.

2.7 | Data items

The data extracted included study characteristics (first author, publication year, country, study design, study aim), inclusion/exclusion criteria, participants (sample size, age, ethnicity, socioeconomic status), intervention characteristics (description, comparator, duration, intensity), and outcomes and measures (data collection methods, outcome measures) and findings relating to children's dietary intake.

2.8 | Synthesis of results

The determinants addressed by interventions were systematically categorized using the Determinants of Nutrition and Eating (DONE) framework, which was developed by the Determinants of Diet and Physical Activity European research network of 87 members and 129 external experts.[32] The framework maps 411 factors driving nutrition and eating behavior into 56 determinant leaf categories, 11 stem categories, and four socioecological levels (individual, interpersonal, environment, and policy). Determinants related to the childcare food environment were not categorized by the DONE framework, so the existing 'School canteen food environment' determinant was modified to 'Childcare food environment' to capture this.

Studies were categorized by main socio-ecological levels, followed by stem and leaf categories, using extracted data related to intervention characteristics and outcome measures. One author (J.C.) synthesized all studies to the DONE Framework and a second author (P.C.) cross-checked 20% of included studies.

The intervention characteristics, determinants addressed by interventions, and outcomes were summarized in narrative form. Findings were organized and presented following the DONE framework stem categories: biological, demographic, psychological, and situational determinants at the individual level; social and cultural determinants at the interpersonal level; product, micro, meso/macro determinants at the environment level; and industry and government determinants at the policy level. The number of studies that reported improved outcome measures of diet quality, fruit, vegetable, combined fruit and vegetable, energy-dense nutrient-poor foods, or SSB intake, as outlined in the core outcome set,[28] were tabulated against DONE stem categories (Table 2) and leaf categories (Table 3).

3 | RESULTS

3.1 | Selection of sources of evidence

In total, 193 studies reported in 242 articles were included in the review following removal of duplicate records, title and abstract, and

full-text screening (Figure 1). Reasons for exclusion at the full-text level are reported in Figure 1.

3.2 | Characteristics of sources of evidence

A summary of the characteristics of the interventions are described in Table 1. Majority of studies were conducted in the United States ($n = 112$). Most studies used an experimental study design ($n = 122$). Majority were conducted in the ECEC setting ($n = 99$) including preschools, nurseries, childcare, and family childcare homes. Nearly 53% of interventions ($n = 102$) addressed more than one socio-ecological level of the DONE framework, and of those, 70 studies reported at least one improved dietary outcome. There were 91 studies that targeted a single, and of those, 69 studies reported at least one improved dietary outcome. The most frequently addressed were individual ($n = 102$) and interpersonal ($n = 116$) level determinants. The duration of studies ranged from single-day interventions to four years, with the duration of most studies being less than 6 months ($n = 113$). Intensity of intervention varied greatly between studies where the frequency of sessions varied from daily to monthly and the length of sessions varied from brief ten-minute interventions to two hours. The sample size of studies ranged between 10 participants[105] to over 500,000 participants per repeated cross-sectional interval.[47]

3.3 | Results of individual sources of evidence

Child dietary intake outcomes are summarized by DONE framework categories in Tables 2 and 3.

3.4 | Synthesis of results

3.4.1 | Individual

Biological

There were 18 studies targeting biological determinants and all aimed to influence children's sensory perception and learned taste preferences (Table 2). Of these, 11 studies reported improvements in vegetable intake (Table 3). One study reported repeated exposure decreased vegetable consumption.[101] Of the 11 studies that reported improved outcomes, all interventions involved repeated taste exposure to vegetables offered at meal or snack times by parents in the home setting or ECEC staff in the ECEC setting.[73,84,134,146,165,166,176,177,193,195,226] The number of exposures ranged from daily to twice weekly. Additional strategies such as rewards, dips, encouraging conversations during mealtimes, parent modeling, and multi-sensory exposure may improve vegetable consumption.[84,134,146,176,226]

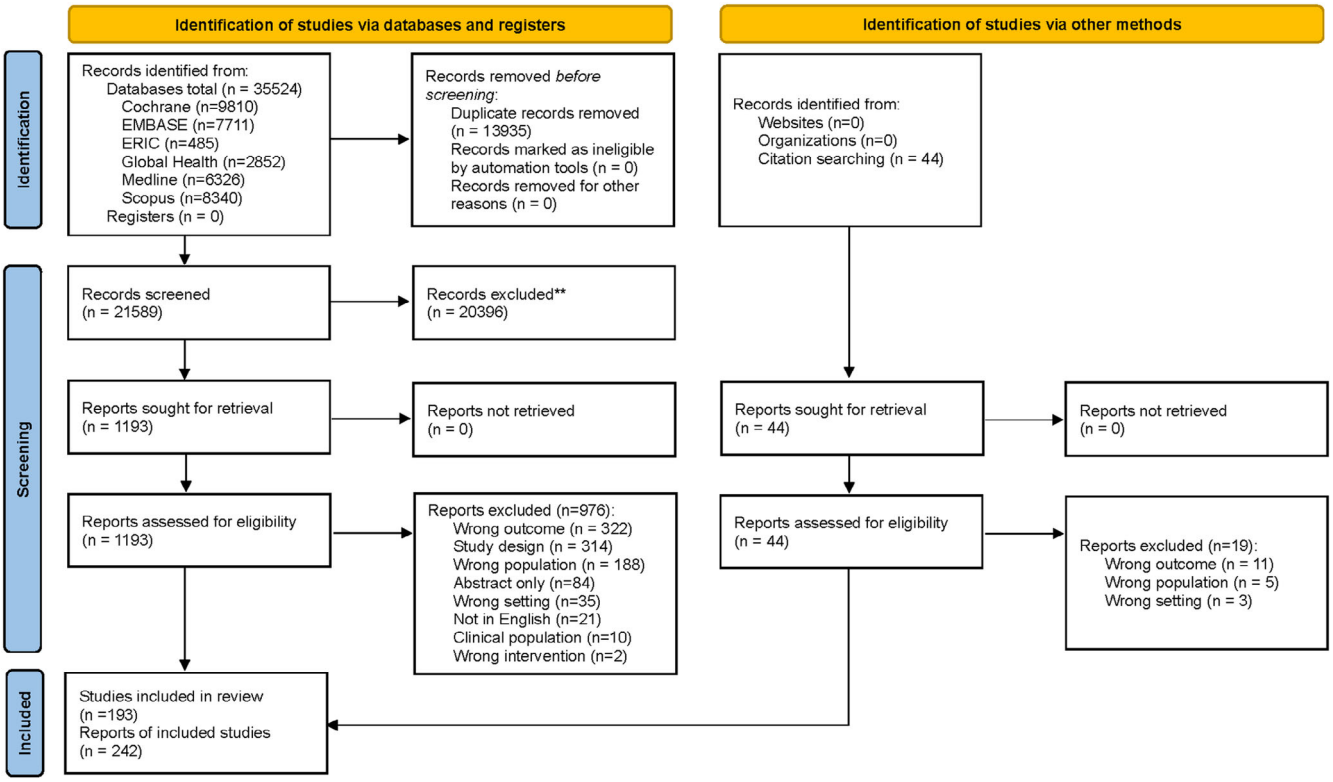

FIGURE 1 Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA) 2020 flow diagram for new systematic reviews which included searches of databases, registers, and other sources, as recommended by the PRISMA 2020 statement: an updated guideline for reporting systematic reviews.

TABLE 1 Characteristics of included studies ($n = 193$).

Study characteristics	Sub-category	Number of results (%)	References
Country	United States	112 (58%)	33–143
	Australia	18 (9%)	144–161
	United Kingdom	18 (9%)	162–179
	Canada	4 (2%)	180–183
	Chile	4 (2%)	184–187
	Germany	4 (2%)	188–191
	Netherlands	4 (2%)	192–195
	Portugal	4 (2%)	196–199
	Other European	16 (8%)	200–215
	Other Asian	5 (3%)	216–220
	Other	4 (2%)	221–224
Study design	Experimental	122 (63%)	34–37,39,42,45,50,51,56–65,67–72,75,82,84–86,88,92,96–101,103,104,106,107,110,112,113,115,116,119–122,124,125,132,133,135–144,146,148,149,151–154,156–165,167–174,176,177,181–184,189,190,192,193,195,196,200–205,207,209–215,217,218,222,223,225
	Quasi-experimental	59 (31%)	38,40,41,43,44,46,48,49,52–55,73,74,76–78,80,83,87,89,91,94,95,102,105,108,109,111,114,117,123,127–130,134,145,147,150,155,166,178,179,185,187,188,191,194,197–199,206,208,216,220,224,226
	Analytical observational	13 (7%)	33,47,66,81,93,118,131,142,175,180,186,219,221
Setting	Early childhood education and care	99 (51%)	33,34,38,41,44,46,50–53,56,57,59–61,63,64,70,71,73,74,81,83–87,94,96,97,99,101,103,104,106,107,109,112,113,122–125,127–129,132,134–137,139–143,145,151–153,157,159,160,162–164,167,171,172,176,180,181,183,184,187–193,195–198,201,205,206,209,212,213,215–217,219,220,222,224,226
	Home	44 (23%)	35,36,42,45,47,54,55,66,67,69,72,79,80,82,88,89,93,100,102,111,115,118,120,130,131,133,138,146,148–150,154,156,161,165,166,169,173,174,177,182,200,203,210
	Community	21 (11%)	37,40,43,49,68,76–78,95,98,105,114,117,144,147,175,214,218,221,223,227
	Multiple settings	20 (10%)	62,65,75,90–92,110,116,119,121,168,170,185,186,194,199,204,207,208,211
	Healthcare clinic	7 (4%)	39,48,108,158,178,179,202
	Other	2 (1%)	58,155
DONE Framework socioecological level[a]	Individual	102 (53%)	34,37,38,40,41,44,46,50,51,59–61,65,68–71,73,75,76,78,83,84,87,88,90–92,94–97,99–101,103,105,107,109,116,117,119,121,123–125,128,132–135,140–144,146,153,155,158,162–166,170–172,174,176,177,180,187,189–193,195,196,199,201,203–206,208,209,211–222,224,226
	Interpersonal	116 (60%)	35–37,39,40,43–45,48,49,53,54,58–63,65,67–69,71,72,75–79,82,83,87,88,90–92,95–100,103,105,108–111,113,115–117,119–121,123,124,127,128,130,138,140,142,144,146–150,155,156,158,160,161,165–170,174,177–179,182,183,187–191,194,197,198,200–204,206–215,218–223,227
	Environment	73 (38%)	33,36,42,45,47,51,52,54–57,62,64–67,74,75,80,81,85,86,89,90,93,96,97,102–104,106,107,112,114,116,118,122,124,127,129,131,133,136–139,142,145,147,151,152,154,157,159–161,164,168,173,180,181,184,186,188,191,194,201,203,207,211,213,215,221
	Policy	21 (11%)	33,47,52,55,66,74,80,81,89,93,102,114,118,129,131,145,175,185,186,221,227
Duration	0 to <3 months	89 (46%)	34,36,38,39,41–44,58,65,69–72,75–79,82,84–87,91,95,99–101,103,104,106,111–113,117,124,125,130,132–137,139,141,143,144,146,149,152,153,155,156,158,161,163–167,169,171–174,176–179,183,190,192,193,196–198,205,206,208,209,216–218,220,223,224,226
	3 to <6 months	24 (12%)	46,51,54,59–61,68,73,90,96,115,128,140,145,154,168,170,175,187,195,211,213,221,222
	6 to < 12 months	34 (18%)	35,40,48,53,55–57,64,67,83,88,98,105,107,108,110,116,120–123,138,142,150,157,160,181,182,189,200,204,207,210,215
	12 to <24 months	14 (7%)	63,80,92,94,148,151,159,188,191,194,199,203,212,214
	24 to <36 months	4 (2%)	45,109,119,127
	≥ 36 months	6 (3%)	37,62,147,201,202,227
	Other[b]	22 (11%)	33,47,49,50,52,66,74,81,89,93,97,102,114,118,129,131,162,180,184–186,219
Sample size	<50	39 (20%)	34,36,38,40,41,43,49,56,69,70,74,78,86,87,93,95,105,106,111–113,115,127,132,133,137,154,162,164,167,170,173,182,184,193,197,216,224,226

(Continues)

TABLE 1 (Continued)

Study characteristics	Sub-category	Number of results (%)	References
	50–150	49 (25%)	39,50,54,55,58,68,72,77,79,84,85,88,90,91,96,98,101,102,104,108,110,114,117,119,120,135,136,139–141,144,148,149,151,157,163,166,169,174,176–178,183,198,199,208,209,212,223
	151–500	60 (31%)	42,44,45,48,51,53,57,59,60,64,65,71,73,75,76,80,83,99,100,107,116,122,125,128–130,134,138,142,143,145,146,150,152,153,155,156,158,161,165,168,171,172,175,180,187–189,192,194–196,203–205,210,214,218,220,222
	>500	45 (23%)	33,35,37,46,47,52,61–63,66,67,81,82,89,92,94,97,103,109,118,121,123,124,131,147,159,160,179,181,185,186,190,191,200–202,206,207,211,213,215,217,219,221,227

[a]Studies may address more than one SEM level.
[b]Other includes studies that did not report duration or examined policy implementation.

Demographic

No studies addressed demographic determinants (Table 2).

Psychological

A total of 87 studies addressed psychological determinants and of these, 60 studies reported improvements in one or more measures of dietary intake with the intervention (Table 2). Most studies ($n = 76$) addressed children's food knowledge, skills, and abilities through group nutrition education sessions, and of those, a majority of interventions reported improvements in vegetable and combined fruit and vegetable intake and a decrease in consumption of energy-dense nutrient-poor foods (Table 3). Other dietary intake measures reported included energy intake and fat intake. The three studies that reported intervention effects on energy showed decreased energy intake.[37,187,222] Two studies reported decreased total fat intake[187] and saturated fat intake.[59] Most interventions addressing children's food beliefs, such as involving children in gardening and food preparation activities, showed improved fruit and vegetable intake, and reduced intake of energy-dense nutrient-poor foods and SSBs (Table 3). Nine of 11 interventions addressing children's eating regulation resulted in improvements in all outcomes, with most reporting improvements in vegetable intake and combined fruit and vegetable intake and decreased energy-dense nutrient-poor food intake (Table 3). Eating regulation interventions included mindful eating activities, offering a variety of vegetables, and portion-size plates. Positive outcomes were reported for ECEC-based interventions that incorporated nutrition education lessons delivered by ECEC staff into the curriculum.[46,51,59,65,73,83,90,92,97,103,116,123,125,128,135,153,180,187,192,204–206,209,211,216,217,219,222] In addition to nutrition education, some interventions included an interactive component such as food preparation, cooking, and gardening activities.[40,51,65,73,76,78,92,95,100,105,116,117,123,124,189,206,209,214,220,221,224]

Other strategies used to support and reinforce children's food knowledge, beliefs, and habits included the use of storybooks and/or puppets[69,76,99,103,123,128,135,158,171,192,224] and rewards such as stickers or praise.[84,99,103,133,166,174,224] Many studies also included a parent component in the intervention, however involvement ranged from newsletters and information to targeted family-based workshops.[37,40,59,65,68,69,73,76,78,83,90,92,95,103,105,116,117,123,124,128,144,158,187,189,203,204,209,218,220,222] Eight studies also included environment and policy changes to support children's eating behaviors.[65,97,116,124,180,203,211,221]

Situational

There were 23 studies that included strategies to address related health behaviors including physical activity and screen time (Table 2). Of those, 17 studies showed improvement in one or more measures of dietary intake (Table 2). Most interventions decreased consumption of energy-dense nutrient-poor foods (Table 3). Other dietary intake measures reported included energy intake and fat intake. Two studies reported on energy intake and both decreased energy intake.[37,222] Three studies reported total fat intake but found no significant changes. Two studies reported saturated fat intake, and one study found intervention reduced intake.[59] Of the 17 studies reporting improved dietary intake outcomes, most were family-based, multicomponent interventions that involved both healthy eating and physical activity and conducted in the community setting.[37,40,68,78,95,117,144,147,158,214,228] Other interventions involved incorporating both healthy eating and physical activity components in a classroom-based program delivered by ECEC staff.[59,92,124,128,211,222]

3.4.2 | Interpersonal

Social

A total of 117 studies addressed determinants related to social factors. Of these, 81 studies reported improvements in one or more dietary intake outcomes (Table 2). There were 13 studies targeting family food culture such as cooking and growing, with most interventions reported improvements in children's vegetable intake (Table 3). Most studies addressing social influence such as peer modeling, reported improved fruit and vegetable intake, and reduced intake of energy-dense nutrient-poor foods (Table 3). Interventions incorporating components of social or group support for families demonstrated increased vegetable intake and reduced consumption of energy-dense nutrient-poor foods and SSBs in most studies (Table 3). Parental

TABLE 2 Summary of nutrition interventions studies targeting children aged 2–5 years and reported dietary intake outcomes mapped to the determinant of nutrition and eating framework stem categories.

		Biological	Demographic	Psychological	Situational	Social	Cultural	Product	Micro	Meso/macro	Industry	Government
All outcomes [a]	*n* total [b]	18	0	87	23	117	4	9	37	32	1	20
	Improved (%) [c]	67%	0%	69%	74%	69%	50%	100%	68%	66%	100%	85%
Diet quality	*n* total	0	0	9	5	13	0	0	5	7	0	5
	Improved (%)	0%	0%	33%	40%	38%	0%	0%	60%	57%	0%	60%
Fruit	*n* total	0	0	33	11	47	0	1	16	22	0	11
	Improved (%)	0%	0%	39%	18%	23%	0%	0%	44%	27%	0%	36%
Vegetables	*n* total	18	0	53	12	60	0	3	21	24	0	11
	Improved (%)	61%	0%	55%	42%	45%	0%	100%	48%	38%	0%	18%
Combined FV	*n* total	0	0	17	2	29	3	0	11	8	0	4
	Improved (%)	0%	0%	47%	50%	34%	33%	0%	36%	50%	0%	25%
EDNP	*n* total	0	0	26	7	40	1	0	8	16	0	7
	Improved (%)	0%	0%	58%	86%	55%	0%	0%	13%	50%	0%	57%
SSB	*n* total	0	0	27	9	48	2	0	11	6	1	4
	Improved (%)	0%	0%	30%	33%	33%	50%	0%	18%	33%	0%	25%

Abbreviations: FV, fruit and vegetables; EDNP, energy-dense nutrient-poor; SSB, sugar-sweetened beverages.

[a]All outcomes include other reported outcomes such as energy intake not categorized in the table. Diet quality, fruit, vegetables, combined FV, EDNP, and SSB outcomes reported as outlined by COS-EPOCH.[28]

[b]*n* total indicates the number of studies mapped to the Determinants of Nutrition and Eating Framework stem categories.

[c]Improved outcome (%) heat map describes the percentage of studies with at least one improved outcome measure. Gray cells indicate no studies that addressed that determinant category and outcome. Red cells indicate 0–20% studies reporting improved outcomes, orange indicates 21–40% studies reporting improved outcomes, yellow indicates 41–60% studies reporting improved outcomes, light green indicates 61–80% studies reporting improved outcomes, and dark green indicates 81–100% studies reporting improved outcomes.

TABLE 3 Summary of nutrition interventions studies targeting children aged 2–5 years and reported dietary intake outcomes mapped to the determinants of nutrition and eating framework leaf categories.

	All outcomes[a]		Diet quality		Fruit		Vegetables		Combined FV		EDNP		SSB	
Leaf category	*n* total[b]	*n* (%) improved[c]	*n* total	*n* (%) improved	*n* total	*n* (%) improved	*n* total	*n* (%) improved	*n* total	*n* (%) improved	*n* total	*n* (%) improved	*n* total	*n* (%) improved
Individual														
Biological														
Sensory Perception	18	11 (61%)	0	0 (0%)	0	0 (0%)	18	11 (61%)	0	0 (0%)	0	0 (0%)	0	0 (0%)
Psychological														
Mood And Emotions	1	0 (0%)	0	0 (0%)	0	0 (0%)	0	0 (0%)	1	0 (0%)	1	0 (0%)	0	0 (0%)
Food Knowledge, Skills, and Abilities	76	50 (66%)	2	0 (0%)	20	10 (50%)	32	24 (75%)	10	7 (70%)	17	14 (82%)	17	8 (47%)
Food Habits	3	3 (100%)	0	0 (0%)	0	0 (0%)	3	3 (100%)	0	0 (0%)	0	0 (0%)	0	0 (0%)
Food Beliefs	36	27 (75%)	3	1 (33%)	12	7 (58%)	20	15 (75%)	6	3 (50%)	7	4 (57%)	4	4 (100%)
Eating Regulation	11	9 (82%)	1	0 (0%)	3	1 (33%)	7	4 (57%)	3	2 (67%)	2	2 (100%)	1	0 (0%)
Weight Control Cognitions and Behaviors	1	0 (0%)	0	0 (0%)	1	0 (0%)	1	0 (0%)	0	0 (0%)	0	0 (0%)	0	0 (0%)
Situational														
Related health Behaviors	23	17 (74%)	5	2 (40%)	12	3 (25%)	13	6 (46%)	2	1 (50%)	7	6 (86%)	10	4 (40%)
Interpersonal														
Social														
Family Structure	2	1 (50%)	0	0 (0%)	2	1 (50%)	0	0 (0%)	0	0 (0%)	0	0 (0%)	1	1 (100%)
Family Food Culture	13	10 (77%)	3	1 (33%)	5	2 (40%)	7	4 (57%)	3	1 (33%)	2	0 (0%)	8	2 (25%)
Social Influence	9	6 (67%)	0	0 (0%)	6	4 (67%)	8	5 (63%)	1	1 (100%)	3	2 (67%)	4	0 (0%)
Social Support	14	12 (86%)	1	0 (0%)	6	1 (17%)	9	5 (56%)	3	1 (33%)	3	3 (100%)	8	6 (75%)
Parental Resources and Risk Factors	97	65 (67%)	11	4 (36%)	38	9 (24%)	46	18 (39%)	28	10 (36%)	34	19 (56%)	41	14 (34%)
Parental Attitudes and Beliefs	25	16 (64%)	3	2 (67%)	6	1 (17%)	8	2 (25%)	7	2 (29%)	7	4 (57%)	15	5 (33%)
Parental Behaviors	24	14 (58%)	3	0 (0%)	9	3 (33%)	10	5 (50%)	7	2 (29%)	7	3 (43%)	14	5 (36%)
Parental Feeding Styles	25	19 (76%)	4	3 (75%)	8	2 (25%)	12	5 (42%)	7	5 (71%)	8	5 (63%)	5	0 (0%)
Cultural														
Cultural Cognitions	4	2 (50%)	0	0 (0%)	0	0 (0%)	0	0 (0%)	3	1 (33%)	1	0 (0%)	2	1 (50%)
Environment														
Product														
Intrinsic Product Attributes	8	8 (100%)	0	0 (0%)	1	0 (0%)	3	3 (100%)	0	0 (0%)	0	0 (0%)	0	0 (0%)
Micro														
Portion Size	7	7 (100%)	0	0 (0%)	4	3 (75%)	6	5 (83%)	1	1 (100%)	0	0 (0%)	0	0 (0%)
	20	12 (60%)	4	3 (75%)	8	3 (38%)	10	3 (30%)	0	0 (0%)	4	1 (25%)	7	1 (14%)

TABLE 3 (Continued)

Leaf category	All outcomes[a]		Diet quality		Fruit		Vegetables		Combined FV		EDNP		SSB	
	n total[b]	*n* (%) improved[c]	*n* total	*n* (%) improved	*n* total	*n* (%) improved	*n* total	*n* (%) improved	*n* total	*n* (%) improved	*n* total	*n* (%) improved	*n* total	*n* (%) improved
Home Food Availability and Accessibility														
Eating Environment	10	7 (70%)	2	1 (50%)	3	1 (33%)	4	2 (50%)	4	1 (25%)	3	0 (0%)	5	1 (20%)
Meso/Macro														
Environment Food Availability and Accessibility	32	23 (64%)	7	4 (57%)	22	6 (27%)	24	9 (38%)	8	4 (50%)	21	9 (43%)	6	3 (50%)
Societal Initiatives	1	1 (100%)	0	0 (0%)	1	0 (0%)	1	1 (100%)	0	0 (0%)	1	1 (100%)	1	1 (100%)
Policy														
Industry														
Industry Influence	1	1 (100%)	0	0 (0%)	0	0 (0%)	0	0 (0%)	0	0 (0%)	0	0 (0%)	1	0 (0%)
Government														
Government Regulations	17	14 (82%)	5	3 (60%)	10	4 (40%)	10	3 (30%)	3	1 (33%)	10	3 (30%)	3	0 (0%)
Campaigns	3	3 (100%)	0	0 (0%)	1	1 (100%)	1	0 (0%)	1	0 (0%)	2	2 (100%)	1	1 (100%)

Abbreviations: FV, fruit and vegetables; EDNP, energy-dense nutrient-poor; SSB, sugar-sweetened beverages.

[a]All outcomes includes other reported outcomes such as energy intake not categorized in the table. Diet quality, fruit, vegetables, combined FV, EDNP, and SSB outcomes reported as outlined by COS-EPOCH.[28]

[b]Total (*n*) indicates the number of studies mapped to the Determinants of Nutrition and Eating Framework leaf categories.

[c]Improved *n* (%) indicates the number and percentages of studies that reported improvements in dietary outcomes.

resources and risk factors, which focuses on parent nutrition knowledge, was the most frequently addressed determinants ($n = 97$). Of these studies, most interventions reported reduced energy-dense nutrient-poor food intake but no significant differences for diet quality, fruit, vegetable, and SSB consumption were found (Table 3). Most studies addressing parental attitudes and beliefs reported improvements in children's diet quality and decreased consumption of energy-dense nutrient-poor foods (Table 3). Of the studies that addressed parental behaviors, most reported non-significant outcomes on children's dietary intake (Table 3). Most studies addressing parental feeding styles reported improvements in diet quality, combined fruit and vegetable intake, and reduced energy-dense nutrient-poor food intake (Table 3). Of the 80 studies resulting in improved dietary outcomes, majority of interventions were conducted in the home setting, via home visits, telephone, or online[35,36,54,62,69,72,79,82,100,111,120,146,148–150,161,165,166,169,174,177,182,200,203,210] or in the ECEC setting with a parent component.[53,59,63,65,83,90,92,94,97,99,103,113,116,123,124,128,160,167,187,189,194,197,198,204,206,208,209,211,219,220,222] Most studies were multicomponent and used a range of behavior change techniques including group educational workshops or sessions for parents to provide information and build skills.[35,37,39,40,53,58,62,65,68,76–78,90,92,95,97,98,105,116,117,128,144,158,160,178,179,187,189,194,197,198,202,203,206,214,218] Other intervention strategies included individual counseling using motivational interviewing, home visits and feedback reports from health professionals to assist with goal setting, self-monitoring, and habit formation.[48,53,54,62,65,68,72,98,100,108,120,149,150,161,169,182,198,202,204,214] Interventions also included home based tasks or activities, take home written materials, and text message prompts and reminders to cue parental behaviors.[36,37,53,54,59,63,65,69,83,90,92,98,99,103,111,117,120,123,124,128,144,147,160,161,177,197,198,204,208,209,211,218,220,222,227] Some studies created opportunities for parents and children to receive social support peers and other families, through online discussion boards.[79,82,149,203] Digital tools including apps, websites, and Facebook were used to deliver nutrition education and support behavior change.

Cultural

There were four studies that addressed families' cultural values, beliefs, and perceptions about weight. Two of these studies reported improvement in one or more dietary intake outcomes (Table 2). Of the two studies that improved outcome measures, both were multi-level, multi-component studies.[40,128] One study, a culturally appropriate center-based program delivered by trained teachers, reported improvements in combined fruit and vegetable consumption.[128] One study was a community-based program delivered by trained bilingual community members and reported improvements in SSB, water, and milk intake.[40]

3.4.3 | Environment

Product

All studies addressing product attributes showed improvements in at least one outcome measure of children's dietary intake (Table 2). There were eight studies that addressed intrinsic product attributes such as adjusting the nutritional composition of foods offered (Table 3). One study addressed extrinsic product attributes through policy to change food labeling. Strategies to replace or substitute meals and snacks with vegetables improved dietary intake.[85,112,173] Seven studies examined substituting high energy density with low energy density foods or beverages such as soy-enhanced lunches and reduced-fat milk. Of these, four studies reported decreased energy intake.[85,86,112,137] One study reported increased energy intake which was higher than recommendations.[56] One study found that replacing meals with slowly digested carbohydrates lowered energy intake.[184] Policy changes to the front-of-package labeling of energy-dense nutrient-poor foods was associated with increased non-nutritive sweetener intake in one study.[186] No studies addressing product attributes reported on diet quality, energy-dense nutrient-poor food intake, or SSB intake. Across the studies that reported one or more improved outcome measures, the majority of interventions were single-level addressing product attributes in the ECEC food environment.[56,85,86,112,137,184]

Micro

A total of 37 studies addressed determinants in the micro food environment including portion size, availability and accessibility of healthy foods, and providing a supportive eating environment at home. Of these, 25 studies reported improvement in at least one outcome measure of children's dietary intake (Table 2). Of the studies that addressed portion size by adjusting the amount of food served to children at meal or snack times, most interventions improved fruit and vegetable intake (Table 3). Three of four studies showed that interventions addressing home food availability and accessibility, such as the provision of food packages, improved diet quality (Table 3). Studies addressing the home eating environment, such as changing mealtime structures and creating positive meal environments, reported improvements in diet quality and vegetable intake, however, this was inconsistent. Of the 25 studies with one or more improved outcomes, the majority were multi-level interventions.[36,54,55,62,65,66,80,90,93,102,118,131,133,161,164,203,211] Key strategies of successful interventions included increasing the portion size of fruit and vegetables at meals and snacks,[104,106,136,137,139,164,173] and teacher delivered program with home and classroom environment component.[65,90,211] Change in policy at the federal level to provide food subsidies for healthy foods was associated with improved dietary outcomes.[55,66,80,93,102,118,131]

Meso/macro

There were 32 studies that addressed the meso/macro environment, and of these, 21 studies reported significant improvements in at least one measure of children's dietary intake (Table 2). Studies focusing on the meso/macro environment predominantly targeted food availability and accessibility in ECECs. Four of seven studies reported improvements in children's diet quality (Table 3). Interventions that reported improved outcomes used strategies to target the food environment in ECEC settings such as the implementation of staff

training,[97,103,145,147,157,180,194] health professional feedback and support to revision and implementation of menus and nutrition policy,[64,97,116,122,124,145,147,157,159,180] and provision of healthy snacks and water stations.[103,160,211]

3.4.4 | Policy

Industry

One study addressed industry influence (Table 2). The intervention provided a template of activities such as lobbying and advocacy for SSB taxation to be implemented by local project teams.[221] The intervention was associated with increased water intake but no changes in SSB were found (Table 3).

Government

Seventeen of 20 studies that included components involving government-level regulations or campaigns to promote healthy eating reported improvement in at least one measure of dietary intake with the intervention (Table 2). Most government-level interventions reported improvement in diet quality (Table 3). Most government campaigns showed improvement in fruit intake and reduced consumption of energy-dense nutrient-poor foods (Table 3). Of the 17 studies with one or more improved outcomes, most interventions were implemented as a long-term policy change. Implementation of healthy food subsidies for low-income families as part of the Special Supplemental Nutrition program for Women, Infants, and Children (WIC) in the United States was associated with improved dietary intake.[55,66,80,93,102,118,131] Healthy food subsidies were also used in the ECEC setting in the United States in conjunction with meal pattern requirements and found improved dietary intake.[33,52,74,81] Other successful strategies implemented in the ECEC setting included a state-wide change in dietary guidelines and a program to implement staff training and menu and policy feedback.[129,145] Two studies conducted in Chile found that mandated front of package warning labels, restricting marketing directed at children and banning sale or promotion of energy dense nutrient poor foods in schools and nurseries improved dietary intake.[185,186] However, energy dense nutrient poor food consumption changes were not mediated by changes in advertising exposure which may suggest other aspects of the policy driving changes.[185] The policy changes were associated with non-nutritive sweetener intake in children.[186] One study reported a social marketing intervention was associated with improved snacking habits.[175]

4 | DISCUSSION

4.1 | Summary of evidence

This scoping review consolidates the evidence from studies addressing dietary intake in preschool children published in the last 24 years to provide an in-depth overview of interventions in the context of the food system. We identified 193 primary studies, mapped the evidence to the DONE framework, and quantified the number of studies associated with reporting improved outcomes for each determinant. Of the included studies, most interventions addressed social determinants, such as parental nutrition knowledge, skills, habits, and feeding styles, and children's nutrition knowledge and skills at the individual level. These interventions may support improvements in dietary intake in individual children, however, we found gaps in the evidence for other parts of the system which, if considered, may result in more widespread and equitable changes in young children's dietary patterns.

At the individual level, most interventions targeted psychological determinants which included strategies to improve children's nutrition knowledge and skills. Most studies showed targeting children's knowledge using strategies such as nutrition education positively influenced fruit and vegetable intake. However, a systematic review of interventions for increasing fruit and vegetable consumption found that the evidence supporting nutrition education interventions is of low quality and only showed small improvements.[229] We found that interventions that addressed other health behaviors such as physical activity and screen time resulted in improved dietary intake, particularly for energy-dense nutrient-poor foods. This is not surprising as higher screen time is associated with increased energy-dense nutrient-poor food intake.[230] Additionally, multi-component interventions that target multiple obesogenic behaviors result in better dietary outcomes.[231]

Parental nutrition knowledge, skills, and abilities were the most targeted determinant, however, the evidence for improving children's diets was mixed which is consistent with the findings of previous systematic reviews. Hodder et al found overall no effect of parent nutrition education interventions on child fruit and vegetable intake.[229] However, another review reported that childcare-based interventions with parental involvement showed promising effects on nutritional-related behavior with interventions that actively involved parents increasing the success of behavior change in children.[232] There was also little evidence available for addressing cultural beliefs and behaviors. This suggests that further research is needed to determine the most effective approaches for addressing parent-related determinants and how to best tailor interventions for culturally and linguistically diverse populations. Combining interventions to also target other psychosocial and parenting variables may improve the success of interventions such as parenting and feeding styles,[233] parental behaviors and modeling,[16] and social influence from siblings[234] and peers even at this young age.[235] A systematic review is recommended to identify the most effective strategies to improve the success of parent interventions to improve child dietary intake.

Within children's food environments, home food availability and accessibility have been identified as a critical but understudied determinant.[22] Findings from this scoping review suggest that there were some positive effects, predominantly from studies focusing on healthy food subsidy programs in low-income families or increasing portion size to increase fruit and vegetable intake. However, there remains an opportunity to identify effective strategies for decreasing intakes of energy-dense nutrient-poor foods and SSB in the home setting. In a systematic review, Johnson et al found limited evidence to support

the association between availability in the home and reduced intake of studies on child intake of energy-dense nutrient-poor food and beverages.[236]

The results appear promising for interventions addressing product attributes. Particularly, there is evidence to support the substitution of meals and snacks served to children with fruit and vegetables to improve consumption and lower energy intake in the home and ECEC settings. However, energy intake outcomes should be interpreted with caution due to misreporting which may result from subjective parent-reported dietary assessment methods.[237] Given the success, effectiveness of scaling up these interventions is recommended particularly in the ECEC setting, where menu policy guidelines can reach many children.

Nutrition interventions in the ECEC setting are well described, however, we found that the evidence for improving children's dietary outcomes was mixed. Similarly, a Cochrane review found that interventions in the ECEC setting may improve fruit and vegetable consumption but had little to no effect on energy-dense nutrient-poor food and SSB, however, the certainty of these findings was limited due to the quality of the evidence.[19] Despite most of the included studies being conducted in the ECEC setting, there was a lack of policy or sustainability components to embed interventions in the setting. To improve the effectiveness of interventions in the ECEC setting, sustainability needs to be included in the design and adoption phase, and wider policy-level action to ensure consistent implementation across the ECEC system and further implementation support is recommended.[238,239]

The results appear promising for government policy and regulations on children's overall diet quality and energy-dense nutrient-poor food consumption, but the evidence was limited for fruit and vegetable intake. The majority of studies examined the Special Supplemental Nutrition Program for Women, Infants and Children (WIC), and Child and Adult Care Food Programs (CACFP) conducted in the United States which provides healthy food subsidies for low-income households in the home and ECEC setting respectively. Similar to the findings from this scoping review, systematic reviews of the evidence for WIC and CACFP programs indicate that while healthy food subsidies improve purchasing, availability, and accessibility of fruits and vegetables, there is inconsistent evidence that this leads to improved dietary intake in children.[240,241] The federal nutrition assistance programs have great potential to reach and support children, however, it has been suggested that further consideration of the broader context of food insecurity, fragmented childcare system in the United States, and adequacy of implementation structure for these programs is needed ensure effective implementation at the population level.[242] Leveraging both child nutrition and social protection policy interventions such as the implementation of healthy food programs in childcare in conjunction with subsidies to make childcare more affordable is needed to address the underlying determinants of household food insecurity experienced by low-income families.[243] This review found limited studies outside of the United States designed specifically for children from low socioeconomic status communities that leverage both nutrition and social protection policies, suggesting a need for more interventions that target predisposing factors to health and nutrition inequities.

Exposure to food marketing has been shown to have a negative impact on pre-school children's food intake, food choice, and food preferences.[244,245] Currently, many countries have adopted industry self-regulation, however mandatory policy approaches to restrict food marketing are more likely to reduce exposure.[246] Despite endorsement for stronger legislative action from government to protect children from harmful food marketing,[247] implementation across high-income countries is poor. This scoping review found that the only evidence specifically targeting and recognizing the needs of children comes from Chile, as part of a broader evaluation of policies and actions being implemented in Latin America.[248] Chile's Food labelling and Advertising Law provides an example of the need for policy coherence and how a comprehensive package of policy options is needed to address multiple determinants and support effective implementation. The initial results are promising and provide evidence of scalability and may act as a "tipping point" for other countries to justify implementation of food marketing policy and legislation around nutrition labeling.[249]

The current review examines the evidence for positive dietary change in preschool-aged children against the DONE framework to discover which determinants are understudied and where further evidence is needed. For clarity, the results are presented according to distinct framework categories. However, most studies were complex interventions, targeting multiple determinants across different levels. Potential interactions were not fully captured in this scoping review as most included studies did not report synergistic effects. The evidence suggests that whole-of-system interventions addressing multiple determinants are needed to improve children's diets.[250] Recommendations for interventions should take a systems approach to target multiple levels and interactions between determinants.[251] Furthermore, most included studies reported fruit and vegetable outcomes. Additional high-quality studies to measure the effect on consumption of energy-dense and nutrient-poor foods and overall diet quality are recommended to provide a better picture of the effectiveness of early childhood nutrition interventions.

4.2 | Limitations

As this was a scoping review, we did not perform a quality assessment and as such included studies may be subject to various biases and the quality of evidence may vary. However, as the purpose of the review was to map the evidence and not to estimate intervention effect size, a scoping review was used which allowed for the inclusion of these studies to provide a complete and comprehensive overview.[252] Subsequent systematic reviews and meta-analysis with risk of bias and sub-group analysis assessments can be undertaken as recommended based on the results of this scoping review to determine effectiveness of interventions targeting specific determinants.

Given the large body of literature on early childhood nutrition, it is important to consolidate and map the evidence to identify gaps and

provide guidance for further research. A significant strength of this scoping review is the level of detail included by using the DONE framework to systematically map early childhood nutrition interventions. We were able to map the evidence to the framework of 411 determinants and then categorize these into leaf and stem-categories to synthesize and provide an overview of the evidence. Gaps in the evidence-base and areas where more primary studies are warranted to enable systematic reviews and causality to be determined were identified. The framework provides a novel and systematic way to categorize a broad range of determinants relevant to children, however, iterative updates are needed to accurately reflect current determinants and their interactions as they change, and new priorities arise.

5 | CONCLUSION

This review provides a systematic map of early childhood nutrition interventions. Interventions targeting children's individual psychological and biological determinants are well studied and can be effective at improving children's dietary intake. Social determinants, particularly parental nutrition knowledge, skills, attitudes, and beliefs were commonly addressed, however, there is limited evidence that targeting this leads to improved dietary outcomes in children. There is evidence to suggest interventions addressing environment and policy-level determinants may improve the success of interventions. While most studies were conducted in ECEC settings, there was a lack of policy to support cohesive implementation and sustainment of interventions. Manipulating the nutritional composition of meals and snacks provided to children at home and in the ECEC setting is a promising but under-explored gap that should be leveraged. Interventions addressing policy-level determinants including healthy food subsidy programs and food marketing and labeling laws are recommended as implementation is currently limited to the Unites States and Chile.

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CONFLICT OF INTEREST

The authors declare no conflicts of interest.

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SUPPORTING INFORMATION

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

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