

# The impact of nutrition education with and without a school garden on knowledge, vegetable intake and preferences and quality of school life among primary-school students

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## Abstract

**Objective:** To investigate the impact of school garden-enhanced nutrition education (NE) on children's fruit and vegetable consumption, vegetable preferences, fruit and vegetable knowledge and quality of school life.

**Design:** Quasi-experimental 10-week intervention with nutrition education and garden (NE&G), NE only and control groups. Fruit and vegetable knowledge, vegetable preferences (willingness to taste and taste ratings), fruit and vegetable consumption (24 h recall  $\times$  2) and quality of school life (QoSL) were measured at baseline and 4-month follow-up.

**Setting:** Two primary schools in the Hunter Region, New South Wales, Australia.

**Subjects:** A total of 127 students in Grades 5 and 6 (11–12 years old; 54% boys).

**Results:** Relative to controls, significant between-group differences were found for NE&G and NE students for overall willingness to taste vegetables ( $P < 0.001$ ) and overall taste ratings of vegetables ( $P < 0.001$ ). A treatment effect was found for the NE&G group for: ability to identify vegetables ( $P < 0.001$ ); willingness to taste capsicum ( $P = 0.04$ ), broccoli ( $P = 0.01$ ), tomato ( $P < 0.001$ ) and pea ( $P = 0.02$ ); and student preference to eat broccoli ( $P < 0.001$ ) and pea ( $P < 0.001$ ) as a snack. No group-by-time differences were found for vegetable intake ( $P = 0.22$ ), fruit intake ( $P = 0.23$ ) or QoSL ( $P = 0.98$ ).

**Conclusions:** School gardens can impact positively on primary-school students' willingness to taste vegetables and their vegetable taste ratings, but given the complexity of dietary behaviour change, more comprehensive strategies are required to increase vegetable intake.

**Keywords**  
School garden  
Vegetable  
Primary school  
Intervention

Extensive epidemiological evidence indicates that insufficient vegetable intake is associated with increased risk of numerous chronic, non-communicable diseases including heart disease, obesity and some cancers<sup>(1)</sup>. However, recent Australian national data have shown that children's vegetable intakes are inadequate with only 25% of younger age groups and 1–11% of older age groups meeting national recommendations<sup>(2)</sup>. Childhood has been identified as a critical period for the development of eating patterns that track to adulthood, particularly for vegetable consumption<sup>(3)</sup>. Considering the importance of good nutrition in childhood to achieving healthy growth and development<sup>(4)</sup>, giving children opportunities to learn more about vegetables, including their benefits, how to prepare them and how they taste, may help to facilitate increases in their vegetable intake. This is both a public health priority and a major challenge for health promotion<sup>(5)</sup>. There is an urgent

need to develop and investigate novel ways of increasing vegetable intake among children. School-based programmes represent an ideal setting to facilitate dietary behaviour change, as most children attend school regularly and consume at least one meal and one snack at school each day. Studies have found that school-based nutrition education (NE) programmes can lead to moderate increases in vegetable consumption for children<sup>(6)</sup>, but are generally more effective in increasing fruit rather than vegetable intake<sup>(7)</sup>. Reinaerts *et al.*<sup>(8)</sup> have reported differences in factors influencing fruit and vegetable consumption in children and found that while habit was important for both fruit and vegetables, availability was important for fruit but not vegetables and exposure was important for vegetables but not fruit.

As knowledge, accessibility<sup>(9)</sup> and preferences<sup>(10–12)</sup> are important predictors of dietary intake among school-children, interventions should target these potential

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mediators to maximise the likelihood of success<sup>(12,13)</sup>. School gardens have emerged as an innovative and potentially engaging strategy to improve vegetable intake among children as they increase students' exposure to vegetables, which may positively impact on attitudes, preferences and eating behaviours<sup>(5)</sup>. Garden-based experiences provide a context for understanding seasonality, add a sensory domain to learning, and foster a better understanding of how the natural world is sustained and where food comes from<sup>(5)</sup>. School gardens provide an opportunity to teach life skills such as gardening, cooking, working cooperatively on real tasks and they involve students in planting, harvesting and food preparation.

Despite the many potential benefits of school gardens for children, limited evidence exists as to their effectiveness as a NE strategy<sup>(14)</sup>. A recent review of the impact of garden-based nutrition interventions delivered in the USA highlighted the potential of school garden programmes as a setting to impact on vegetable consumption of children. However, indicating a dearth of quality research in this area, only five eligible school-based studies were identified in the review. The need for comprehensive evaluations of the effectiveness of school garden programmes, particularly in countries outside the USA, has been strongly recommended<sup>(5,14)</sup>. In the only published study from Australia, Somerset and Markwell<sup>(15)</sup> found that a school garden improved attitudes and skills, which were purported to facilitate increased fruit and vegetable consumption in primary-school students. In addition, the importance of exploring the benefits of NE alone *v.* NE enhanced with garden-based experiences is a research priority<sup>(14)</sup>.

Thus, the present study sought to measure the effects of a garden-based NE programme in upper primary-school children compared with a control group, on fruit and vegetable knowledge, willingness to taste, preference ratings of selected vegetables, fruit and vegetable intake, and perceived quality of school life. The primary study hypothesis was that the garden-enhanced NE intervention would have a greater impact on increasing children's vegetable preferences and intake compared with NE alone or to a control group.

## Experimental methods

### *Participants and recruitment*

The study was conducted in two primary schools (intervention and wait-list control) in the Hunter Region of New South Wales (NSW), Australia and included 127 students (54% boys). On the basis of 80% power to detect a significant difference ( $P=0.05$ , two-sided), a sample size of thirty-three students for each group was needed to detect a 30 g daily difference in vegetable intake among groups, which was based on a study of students of similar demographic (age and socio-economic

status)<sup>(16)</sup>. In the outcome evaluation of a school-based in-classroom fruit, vegetable and water promotion, the mean increase in combined fruit and vegetable consumption estimated by 24 h recall was 0.35 servings. We applied this to a standard vegetable serving with rounding up to 30 g. Using a quasi-experimental design, four classes of Grades 5/6 students (11–12 years old) within the intervention school (53% boys) were assigned to two groups in a non-random manner: nutrition education and garden (NE&G;  $n$  35) or NE only ( $n$  35). At another local primary school, all students in Grades 5/6 were allocated to a wait-list control group ( $n$  57, 55% boys). Eligibility criteria were for students to be enrolled in Grades 5 or 6. Pre- and 16-week post-intervention assessments were conducted at each school in July 2008 and October/November 2008, respectively, following the 10-week intervention.

Treatment assignment was decided by the principal and curriculum coordinator at the intervention school on the basis of timetabling and other school-based practicalities. Despite this being a potential source of bias, it was a necessary condition to make the intervention feasible and bias was minimised as group allocation was not based on self-selection by the teachers who would deliver either the NE or NE&G units. It is of note that the most experienced teacher was allocated to one of the NE classes only and the least experienced to one of the NE&G classes.

Principal consent to participate was obtained at both schools and written informed consent was obtained from all parents. While all schoolchildren participated in the school garden activities regardless of consent, only those who consented to the evaluation of the garden project were included in the assessments. Furthermore, the study information letters indicated that students could withdraw from the evaluation component of the study at any time. Ethics approval for the protocol was obtained from the Human Research Ethics Committee of both the University of Newcastle and the NSW Department of Education and Training.

## **Intervention**

### *Nutrition education*

The NE unit was a 10-week programme (3 × 1 h NE lessons in the classroom) delivered by classroom teachers to students in their normal class groups at school. The researchers identified previously used curricula identified in other studies<sup>(17–19)</sup> and modified them for the Australian context and worked with teachers to develop an integrated unit of work called 'How do you grow?' Teachers also accessed lesson ideas from their personal teaching resources. The 10-week curriculum included the following topics: what influences my health? requirements of the body, requirements of plants, parts of plants, seed germination, nutrients, healthy eating, food labels, consumerism, lifestyle diseases, physical activity, exercising safely and setting goals<sup>(17)</sup>. The learning experiences for this unit were integrated in all other subjects

of the primary curriculum and delivered by the classroom teachers, which importantly meant no additional teaching, and in the long term would be sustainable. A series of newsletters ( $n = 3$ ) were also provided to parents over the intervention period that focused on the health benefits of eating fruit and vegetables and strategies for increasing intake at home. The provision of newsletters aimed to reinforce concepts taught in class, improve family awareness and interest in the unit of work and promote familial discussion about healthy food choices. Parents were also encouraged to complete simple homework tasks with their children, such as writing down the ingredients to their favourite vegetable-based recipe, and to send this to school with their child for inclusion in a class recipe book.

#### *Gardening programme*

Both treatment groups (NE and NE&G) received the same classroom-based NE unit. In addition to receiving the nutrition education, the two NE&G classes also participated in the planting and tending of a school garden in a unit known as 'How does your garden grow?' The unit involved the class spending approximately 45 min in the garden four times a week. The garden programme was based on Social Cognitive Theory (SCT) as it is well established that school-based nutrition programmes that are based on a theoretical framework are more effective at changing health behaviours than atheoretical programmes<sup>(20)</sup>. SCT is comprised of three interrelated factors: the individual (e.g. student beliefs and knowledge about fruit and vegetables), the behaviour (e.g. skills needed to complete a task such as preparing a healthy meal); and the environment (e.g. surroundings, peer modelling and parental support) and provided the framework for the experiential learning<sup>(18,21)</sup>. The school garden programme targeted all three of these factors in an attempt to influence the students' behaviours. Through garden experiences, students were provided with opportunities to develop knowledge and skills related to healthy eating, and the garden enhanced their learning environment and surroundings. As previously identified, programmes based on SCT acknowledge that young children are still greatly influenced by their surroundings<sup>(22)</sup>. All lessons were delivered by the classroom teacher.

A representative from the organisation Slow Foods Hunter (NSW) was involved in recruiting the schools to become involved in the study and attended preliminary meetings with teachers to provide advice regarding the nature of garden-based activities, maintenance of the garden and provision of some garden-related educational resources. They were not directly involved once the garden programme started and did not interact with teachers or influence the children's participation or interaction with the garden. Students planted both seeds and plants (beetroot, lettuce, spring onions, spinach, potatoes, cauliflower, zucchini, rosemary) and were involved in the maintenance of the garden including weeding,

watering, harvesting and managing pests under the supervision of teachers. The garden-based activities were designed to complement the nutrition lessons. Students were also involved in other garden-based activities including developing a class cookbook and food experiences in the kitchen using vegetables harvested from the garden. No specific incentives were used to increase compliance or adherence.

#### *Control group*

The control group did not complete any nutrition-related lessons or garden-based experiences during the study period and continued on with their normal class programme.

#### *Instruments*

Our primary outcome was vegetable intake with secondary outcomes including vegetable preferences, fruit and vegetable knowledge and quality of school life.

#### *Fruit and vegetable intake*

Dietary assessment in children is fraught with challenges and requires cognitive maturity and the skills of: attending, organisation, storing, retrieval and report of stored information<sup>(23)</sup>. The children in the present study had the cognitive maturity to undertake a 24 h recall and this method has been used commonly in this age group in other school-based studies; in addition, the method is sensitive to short-term changes in food intake unlike an FFQ<sup>(24)</sup>. The 24 h food recall aims to capture a complete record of intake over the previous 24 h or previous day with recency shown to improve the accuracy of recall<sup>(25)</sup> and repeating this method increasing the representativeness of information obtained for habitual food intake. Therefore, the dietary assessment method employed was  $2 \times 24$  h recalls which were conducted at both pre- and post-intervention.

The  $2 \times 24$  h recalls were collected using the three pass technique<sup>(26)</sup>. (i) A quick list of foods eaten or drunk over the previous 24 h was reported predominantly uninterrupted by the child and recorded by the interviewer. At the end of this recall, intake was reviewed using time and activity prompts and any additional items recalled were added. (ii) Using the first pass food list, students were asked to provide additional detail on all items including a full description of the food or beverage with brand name, foods likely to be eaten in combination, details of ingredients in home-cooked meals; quantitative information with the assistance of household measures and photographs of different portion sizes of foods; details of leftovers or second helpings. (iii) The interviewer reviewed all the foods eaten and drunk in chronological order and prompted for any additional eating or drinking occasions or foods/drink possibly consumed and clarified any ambiguities regarding the type of food eaten or portion size.

The consumption of fruit and that of vegetables are different behaviours and the reasons/motivators to eat fruit and vegetables differ<sup>(8)</sup>. Our intervention was focused on vegetables, but as a point of interest and comparison we also assessed and compared fruit intake as some strategies were implemented that targeted fruit. For example, the NE component in the classroom and the parental newsletters included information on the health benefits of eating fruit and strategies to improve fruit intake. The school also had a fruit tasting day in addition to a vegetable tasting day. Trained research assistants extracted all references to fruit and vegetable intake from each 24 h recall. The quantity of fruit and vegetables consumed was then estimated in grams using the FoodWorks software version 5 (2007; Xyris Software, Brisbane, Australia) dietary analysis programme. Detailed food rules were established to ensure a standardised approach to entering reported fruit and vegetable quantities into FoodWorks and for allocating alternative foods to those contained in the database. High-fat/sugar foods that contained minor amounts of fruit or vegetables, e.g. muffins, muesli bars or pizza, were disregarded. In composite dishes such as spinach and ricotta cannelloni or pumpkin soup, either the additional information that the student had provided or standard recipes were used to estimate fruit and vegetable intake in grams. The number of servings consumed was calculated by dividing the estimated intake of fruit and vegetables in grams by standard serving sizes in grams for fruit and vegetables (i.e. 75 g = one serving of vegetables and 150 g = 1 serving of fruit).

#### *Vegetable preferences*

Food preferences were determined using 'taste and rate' methods developed by Birch and Sullivan<sup>(27)</sup> and the assessment protocol based on that published by other researchers previously<sup>(22)</sup> with adaptation for Australian vegetables. Teachers were not involved in the assessment of preferences or intake and students were informed that their individual results would not be reported back to their teachers. Students completed the preference protocol one-on-one with a trained research assistant to avoid any influence from peers. The research assistant read each question to the student and recorded the response in a standardised manner.

Children were first asked to identify each of six raw vegetables (carrot, pea, tomato, broccoli, capsicum, lettuce) in their whole form and an assessment was made of their willingness to taste and their preference for each. The vegetables were cut up and served plain for taste testing. Students were then asked if they would like to try any of the vegetables and tasted only those they chose in order to provide a more accurate account of their true preferences<sup>(10)</sup>. The research assistant asked students the following questions: (i) *What is the name of this food?* (ii) *Will you taste this food? (If you tasted this food, what*

*did you think of it?)* (iii) *Would you eat this food as a snack?* Children who tasted a vegetable were asked what they thought of it and to indicate their preference using a facial hedonic scale developed by Birch<sup>(28)</sup> and instructed to place a finger on one of the five face pictures enlarged to fit on one page and explained to the child before tasting: ☺☺ I really liked it a lot!; ☺ I liked it a little; ☺ It was OK; ☹ I did not like it; ☹☹ I really did not like it! The vegetables were presented in the following order: carrot, pea, tomato, broccoli, capsicum and lettuce. Carrots were presented first as children would be more likely to identify and be willing to taste carrots over other vegetables<sup>(29)</sup>. Of these vegetables, only one (lettuce) was grown in the school garden. Each section of the questionnaire was scored separately. For the identification and willingness to taste section, students received 1 point for a correct or positive response with a total of 6 points possible. For the tasting preference, students could score a maximum of 5 points per vegetable, giving a total of 30 possible points. As part of our ethics approval, we were required to select the vegetables for taste testing before the garden programme started and without knowing exactly what vegetables the school would choose to grow. However, we hypothesised that experiences in the garden and NE both at home and school may impact on preferences for vegetables in general and not just those grown in the garden.

#### *Fruit and vegetable knowledge*

A fruit and vegetable knowledge questionnaire used in the US 'Gimme 5' intervention was adapted and used<sup>(30)</sup>. In this questionnaire, children are asked about the health benefits of fruit and vegetables and are asked how to increase fruit and vegetable intake from a range of options in several meal/snack scenarios. Our modified version consisted of eight multiple-choice questions, a copy of which is available on request. For example:

*Let us say your family is going on a picnic. You are trying to eat more fruit and vegetables so you could:*

1. *Make sure the potato chips get packed.*
2. *Offer to pack some oranges and bananas.*
3. *Offer to pack the strawberry jam.*
4. *Offer to pack the orange soft drink.*
5. *Make sure the apple pie gets packed.*

The fruit and vegetable knowledge questionnaire was administered in the classroom setting by the classroom teachers.

#### *Quality of school life*

The quality of school life (QoSL) instrument is designed to assist in the examination of social outcomes of schooling and has been assessed for construct validity and reliability<sup>(31)</sup>. The instrument enables users to collect information to provide an insight into student attitudes towards school, learning, teachers and other students.

The survey consists of forty statements about schools and students are asked to indicate their level of agreement on a four-point Likert scale. The forty items were aggregated to provide an overall view of the QoSL for each student (Cronbach's alpha = 0.80). The QoSL instrument was administered in the classroom setting by the classroom teachers.

*Data analysis*

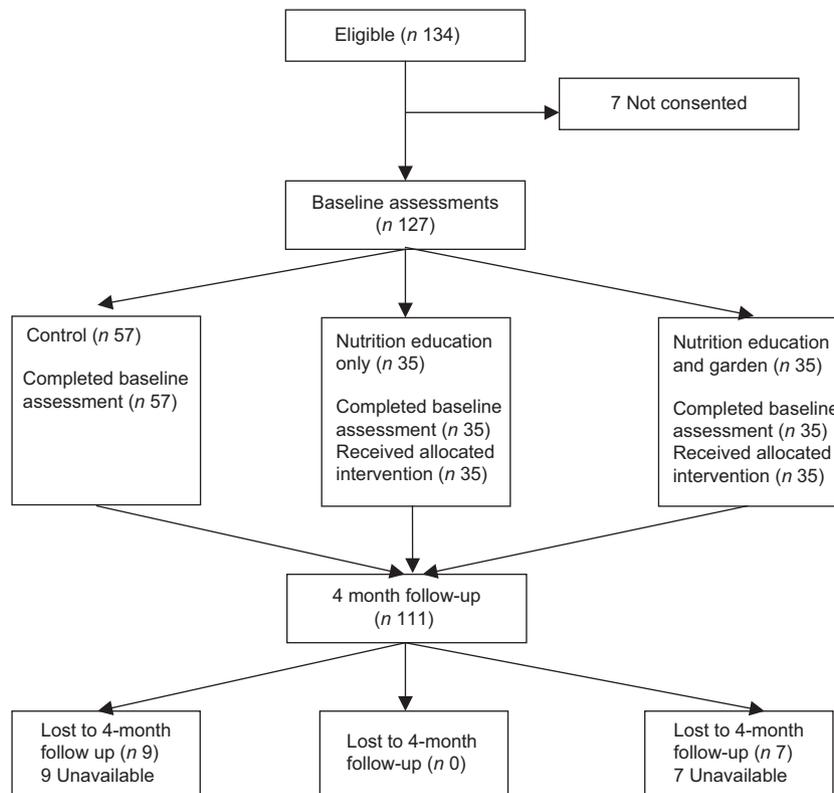
To assess the effects of the intervention for fruit and vegetable knowledge, ability to identify vegetables, overall willingness to taste and taste ratings of specific vegetables, fruit and vegetable intake and QoSL variables, analysis of covariance (ANCOVA) was conducted, in which the relationship between conditions (NE&G; NE; Control) and time (pre- and post-test) was examined. For each outcome, the post-test score was the dependent variable, treatment condition was the fixed factor and the pre-test score was the covariate. This analysis allows for existing differences between groups at baseline to be controlled for in the final analysis. For each ANCOVA, we tested the homogeneity of slopes assumption; i.e. if slopes were not homogeneous, the non-homogeneous slopes model was used to test the effects and effect estimates were calculated at suitably chosen pre-test scores to demonstrate the impact in a region away from the mean pre-score.

For categorical outcome variables ('willingness to taste' and 'eat as a snack' for individual vegetables), we used

generalised estimating equations (GEE) to model group, time (pre- and post-test) and group-by-time effects with an exchangeable correlation structure. Effect estimates were for (post – pre) scores for each group and also ratios of (post – pre) scores between groups. The SPSS statistical software package version 17.0 (SPSS Inc., Chicago, IL, USA) was used for the ANCOVA analysis and SAS for Windows statistical software package version 9.1 (TS1M2; SAS Institute Inc., Cary, NC, USA) was used for the GEE analysis.

**Results**

Figure 1 illustrates the flow of students through the study for the primary outcome with 87% of students retained at 4-month follow-up. There were no differences in baseline scores between those retained in the study and those lost to follow-up ( $P > 0.05$ ). Results for the baseline testing for all variables are displayed in Table 1 and highlight that there were no differences between groups. Table 2 reports results for between-group mean differences of change scores (post minus pre) for fruit and vegetable knowledge, vegetable preferences, fruit and vegetable intake and quality of school life. We found that, at post-test, students in the NE&G and NE groups were significantly more willing to taste vegetables and rated the tastes more highly than did students from the control group ( $P < 0.001$ ). In terms of



**Fig. 1** Participant flow through the study for the primary outcome (vegetable intake)

**Table 1** Baseline scores for fruit and vegetable knowledge, vegetable preference, fruit and vegetable consumption and quality of school life in upper primary-school children by group (control, nutrition education (NE) and nutrition education and school garden (NE&G))

	Control (n 57)		NE (n 35)		NE&G (n 35)		All (n 127)	
	56.1		48.6		57.1		54.3	
Sex, male (%)	Mean	SD	Mean	SD	Mean	SD	Mean	SD
F & V knowledge* (/8)†	6.1	1.8	5.1	1.3	5.4	1.4	5.6	1.6
Ability to identify vegetables‡ (/1)	0.9	0.1	0.9	0.1	0.9	0.1	0.9	0.1
Overall willingness to taste‡ (/6)	3.9	2.0	4.5	1.9	4.5	1.5	4.3	1.9
Overall taste ratings (/30)	15.5	8.8	18.2	8.8	18.5	7.4	17.1	8.5
Lettuce taste rating (/5)	3.3	1.9	3.7	1.9	4.1	1.5	3.6	1.8
Carrot taste rating (/5)	3.5	1.8	3.7	1.6	3.7	1.6	3.6	1.7
Capsicum taste rating (/5)	2.0	2.2	3.0	2.1	2.4	2.1	2.4	2.2
Broccoli taste rating (/5)	2.1	2.1	2.8	2.0	2.6	1.8	2.4	2.0
Tomato taste rating (/5)	2.5	2.3	2.4	2.3	2.9	2.3	2.6	2.3
Pea taste rating (/5)	2.0	1.9	2.8	1.8	2.9	1.8	2.5	1.9
Vegetable intake (servings)	2.0	1.4	1.9	1.3	2.0	1.7	1.8	1.5
Fruit intake (servings)§	1.0	0.9	1.5	1.0	1.2	1.0	1.2	1.0
Quality of School Life   (/5)	3.0	0.4	3.2	0.3	3.2	0.2	3.1	0.3
	<i>n</i>	%	<i>n</i>	%	<i>n</i>	%	<i>n</i>	%
Willingness to taste								
Lettuce	44	77.2	29	82.9	33	94.3	106	83.5
Carrot	47	82.5	31	88.6	31	88.6	109	85.8
Capsicum	29	50.9	27	77.1	21	60.0	77	60.6
Broccoli	33	57.9	26	74.3	25	71.4	84	66.1
Tomato	34	59.6	19	55.9	21	60.0	74	58.7
Pea	36	63.2	26	74.3	24	68.6	86	67.7
Eat as a snack								
Lettuce	22	38.6	19	54.3	21	60.0	62	48.8
Carrot	36	63.2	22	64.7	23	67.6	81	64.8
Capsicum	13	22.8	9	26.5	7	21.2	29	24.0
Broccoli	11	19.3	6	18.2	2	5.9	19	15.3
Tomato	24	42.1	16	48.5	15	46.9	55	45.1
Pea	14	24.6	8	23.5	7	21.2	29	23.4

F &amp; V, fruit and vegetables.

\**n* 105.†*t*(*n*) denotes a score out of *n*.‡*n* 126.

§Fruit serves, no juice.

||*n* 108.

taste rating scores for specific vegetables, there were significant between-group differences for lettuce ( $P=0.02$ ), broccoli ( $P=0.01$ ), tomato ( $P=0.03$ ) and pea ( $P<0.001$ ). NE&G and NE students rated the taste of lettuce and pea more highly than did control students, while NE&G students rated pea more highly than NE only and rated tomato more highly than controls. It is noted that for broccoli, a significant treatment effect of the garden was only seen for those students who began the programme with lower taste ratings (Table 2). For fruit and vegetable knowledge, there was a significant difference ( $P=0.02$ ) between the NE&G and control groups, but only when comparing those students who started with lower fruit and vegetable knowledge (Table 2). Similarly, the NE&G group improved significantly ( $P<0.001$ ) in their ability to identify vegetables when compared with the NE and control groups, but only for those students with lower scores at baseline (Table 2). No between-group differences were found for vegetable intake ( $P=0.22$ ), fruit intake ( $P=0.23$ ) or QoSL ( $P=0.98$ ).

Table 3 illustrates findings for individual vegetables for both 'willingness to taste' and student preference to 'eat

as a snack'. For willingness to taste, there were significant between-group differences for four vegetables (capsicum ( $P=0.04$ ), broccoli ( $P=0.01$ ), tomato ( $P<0.001$ ) and pea ( $P=0.02$ )) with NE&G students significantly more willing to taste these than NE and control students. Students in the NE&G group were also more likely to report that they would eat broccoli ( $P<0.001$ ) and pea ( $P<0.001$ ) as a snack than NE and control students.

## Discussion

The aim of the present study was to investigate the effects of garden-enhanced NE on primary-school students' fruit and vegetable consumption, vegetable preferences, fruit and vegetable knowledge and QoSL. Our study is unique in that it examined whether garden-based NE delivered by classroom teachers would enhance vegetable knowledge, preferences and consumption more than NE alone or a control group, addressing the limitations identified in a recent review<sup>(14)</sup>. We found no significant differences between groups for fruit and vegetable consumption

**Table 2** Between-group differences for fruit and vegetable knowledge, vegetable preferences, fruit and vegetable consumption and quality of school life in upper primary-school children (*n* 109) by group (control, nutrition education (NE) and nutrition education and school garden (NE&G))

Variable	Mean difference between groups (95% CI)†						P value‡
	NE&G – control		NE&G – NE		NE – control		
	Mean	95% CI	Mean	95% CI	Mean	95% CI	
F & V knowledge§	1.90	0.29, 3.49	0.53	-1.08, 2.14	1.36	-0.11, 2.84	0.02*,##
Ability to identify vegetables	0.21	0.13, 0.30	0.16	0.06, 0.25	0.06	-0.02, 0.14	<0.001**,##
Overall willingness to taste¶	1.27	0.61, 1.93	0.54	-0.17, 1.25	0.73	0.12, 1.35	<0.001**
Overall taste ratings¶	5.79	3.30, 8.29	2.24	-0.45, 4.93	3.55	1.23, 5.87	<0.001**
Lettuce taste rating¶	1.04	0.28, 1.81	0.26	-0.57, 1.09	0.79	0.07, 1.50	0.02*
Carrot taste rating	0.63	-0.05, 1.30	-0.04	-0.78, 0.71	0.66	0.02, 1.30	0.07
Capsicum taste rating	0.76	0.03, 1.49	0.60	-0.19, 1.39	0.16	-0.53, 0.85	0.12
Broccoli taste rating	1.93	1.21, 2.70	1.31	0.52, 2.10	0.62	-0.06, 1.30	0.01*,##
Tomato taste rating	0.95	0.25, 1.66	0.49	-0.29, 1.27	0.47	-0.21, 1.14	0.03*
Pea taste rating¶	1.41	0.72, 2.10	0.41	-0.32, 1.14	1.00	0.36, 1.64	<0.001**
Vegetable intake (servings)	-0.08	-0.70, 0.53	-0.51	-1.16, 0.14	0.43	-0.15, 1.01	0.22
Fruit intake (servings)	0.05	-0.58, 0.68	0.51	-0.17, 1.19	-0.46	-1.0, 0.14	0.23
Quality of school life††	0.01	-0.12, 0.14	0.01	-0.12, 0.15	-0.01	-0.12, 0.11	0.98

F &amp; V, fruit and vegetables.

\**P* < 0.01; \*\**P* < 0.001.

†Represents difference between group change scores.

‡*P* value is for group effect.§*n* 87.||*n* 105.¶*n* 106.††*n* 96.##Homogeneity of regression assumption broken: F & V knowledge, group × pre-score, *P* = 0.013, difference between means determined at pre-score = 3 units; ability to identify vegetables, group × pre score, *P* = 0.001, difference between means determined at pre-score 0.7 = units; broccoli taste rating, group × pre score, *P* = 0.013, difference between means determined at pre-score = 2 units.

assessed by repeated 24 h recall or in their QoSL. However, we found that students who experienced the garden-enhanced education were generally more willing to taste vegetables and rated their taste for some vegetables significantly higher than did students in the NE and control groups. Students from the NE&G group also reported being more willing to eat some vegetables as a snack. We also found that, of the students who had lower fruit and vegetable knowledge and ability to identify vegetables at the start of the programme, those in the NE&G group improved significantly more than did students from the NE and control groups.

We found no treatment effect for fruit and vegetable consumption. Exposure to vegetables, in general, has previously been found to be associated with increased consumption<sup>(32)</sup>, but few studies have explored the impact of school gardens on vegetable intake and results have been inconsistent, which is partly explained by the poor quality of some of the assessment methods. Parmer *et al.*<sup>(33)</sup> found an increase in vegetable consumption among Grade 2 students with a school garden intervention, but the sample was mostly made up of boys. McAleese *et al.*<sup>(34)</sup> also reported an increase in vegetable consumption among Grade 6 students after a school garden programme, but used 24 h food recall workbooks completed by students, which would have been prone to bias and measurement error. Lineberger and Zajicek<sup>(19)</sup> also did not impact on vegetable intake, despite impacting on children's vegetable preferences.

Increasing vegetable intake is difficult due to the complex nature of children's eating behaviour, which is

also substantially influenced by adults, and can be particularly difficult to change in short-term interventions. Given this complexity and that our programme operated for only one school term, the lack of effect on consumption is not surprising. A more intensive, comprehensive programme that utilised strategies to more directly engage parents to simultaneously increase the availability of vegetables in the home may be necessary in order to increase vegetable consumption in the long term<sup>(35,36)</sup>. This is likely to be important given that parental vegetable consumption is a strong determinant of children's vegetable consumption<sup>(36)</sup>. In addition, determinants of fruit and vegetable intake are embedded within external social and physical contexts<sup>(9)</sup>. Reinarts<sup>(8)</sup> has highlighted not only the need for parents to be included in interventions but also that impacting on consumption at home is particularly problematic and challenging<sup>(13)</sup>.

Limited empirical evidence exists regarding the impact of school gardens<sup>(5,14)</sup> on children's fruit and vegetable preferences, willingness to taste them and overall intake. Our results have shown that the school garden was an effective strategy to increase children's willingness to taste vegetables and improve their taste ratings for some vegetables. As the vegetables grown in the garden were different from those used in the assessment of preferences, it is encouraging that the garden-based activities increased the students' willingness to taste vegetables in general, which may have attenuated the effect size of the garden intervention. With multiple exposures to a variety of vegetables through hands-on garden experiences,

**Table 3** Within- and between-group differences for individual pre- and post-test vegetable preferences of primary-school children participating in a school garden programme by group (control, nutrition education (NE) and nutrition education and school garden (NE&G)). Data are presented as proportions (p) and OR (n 105)

Variable	Control						NE						NE&G						P value for effect of group × time
	Pre		Post		(Post/Pre)		Pre		Post		(Post/Pre)		OR (NE&G)/OR (Control)		OR (NE&G)/OR (NE)		OR (NE)/OR (Control)		
	p	OR	p	OR	95% CI	p	OR	p	OR	95% CI	p	OR	95% CI	OR	95% CI	OR	95% CI		
<b>Willingness to taste</b>																			
Lettuce	0.77	0.61	0.5	0.3, 0.8	0.83	0.85	1.2	0.4, 3.1	0.94	0.97	1.8	0.1, 32.2	3.8	0.2, 74.6	1.5	0.1, 32.6	2.5	0.8, 8.1	0.24
Carrot	0.82	0.70	0.5	0.3, 1.0	0.89	0.88	1.0	0.4, 2.2	0.89	0.92	1.6	0.6, 3.8	3.2	1.0, 9.7	1.6	0.5, 5.4	2.0	0.7, 5.8	0.14
Capsicum	0.51	0.35	0.5	0.3, 0.8	0.77	0.64	0.5	0.2, 1.3	0.60	0.74	1.9	0.8, 4.7	3.8	1.4, 10.1	3.7	1.0, 13.3	1.0	0.4, 2.8	0.04*
Broccoli	0.58	0.36	0.4	0.2, 0.7	0.74	0.61	0.5	0.3, 0.9	0.71	0.93	5.3	1.0, 28.2	12.7	2.2, 75.3	9.8	1.7, 57.2	1.3	0.6, 2.8	0.01*
Tomato	0.60	0.40	0.5	0.3, 0.8	0.56	0.48	0.7	0.4, 1.5	0.60	0.76	2.1	1.1, 4.1	4.7	2.0, 11.0	3.0	1.1, 7.8	1.6	0.7, 3.9	<0.001**
Pea	0.63	0.41	0.4	0.2, 0.7	0.74	0.76	1.1	0.5, 2.3	0.69	0.77	1.5	0.6, 3.7	3.7	1.3, 10.7	1.3	0.4, 4.3	2.8	1.1, 6.8	0.02*
<b>Eat as a snack</b>																			
Lettuce	0.39	0.30	0.7	0.4, 1.3	0.54	0.69	1.9	0.8, 4.4	0.60	0.68	1.4	0.5, 3.9	2.0	0.6, 6.8	0.7	0.2, 2.8	2.7	1.0, 7.8	0.15
Carrot	0.63	0.61	0.9	0.5, 1.7	0.64	0.60	0.8	0.4, 1.8	0.67	0.60	0.7	0.4, 1.3	0.8	0.4, 1.9	0.9	0.3, 2.4	0.9	0.3, 2.5	0.89
Broccoli	0.23	0.29	1.4	0.8, 2.4	0.26	0.29	1.1	0.5, 2.6	0.22	0.43	2.6	1.0, 6.8	1.9	0.6, 5.7	2.3	0.7, 8.2	0.8	0.3, 2.2	0.39
Tomato	0.19	0.06	0.3	0.1, 0.8	0.18	0.18	1.0	0.4, 2.9	0.06	0.40	10.8	2.6, 44.2	37.8	6.8, 29.0	10.6	1.8, 61.0	3.6	0.86, 14.9	<0.001**
Pea	0.42	0.34	0.7	0.4, 1.2	0.48	0.32	0.5	0.3, 1.0	0.46	0.48	1.1	0.6, 2.2	1.5	0.7, 3.5	2.1	0.8, 5.4	0.7	0.3, 1.6	0.31
	0.25	0.11	0.4	0.2, 0.9	0.24	0.32	1.4	0.7, 3.1	0.21	0.61	5.7	2.3, 13.9	15.2	4.2, 54.7	4.0	1.2, 12.8	3.8	1.2, 12.7	<0.001**

\*P<0.05; \*\*P<0.001.

†Ratio of OR: OR (post/pre score) for group of interest/OR (post/pre score) for reference group.

children were more willing to try and rate more highly vegetables not grown in the garden. This is consistent with a recent systematic review that highlighted the importance of increased exposure to fruit and vegetables<sup>(37)</sup>. It is possible that the treatment effect for both willingness to taste and preferences may have been greater if the same vegetables used in the testing were also grown in the school garden. Our findings suggest that garden-enhanced NE can positively influence vegetable preferences at a crucial life stage when lifelong eating habits are being formed<sup>(38)</sup>. It is also noteworthy that, relative to the controls, the students in the NE only group were also more likely to rate the taste of some vegetables more highly. Improving preferences requires both increased knowledge and exposure, which the education and garden activities provided for the NE&G students. The unit of classroom work and parental engagement strategies of the newsletters and home tasks may have provided this for the NE group.

The multiple exposures to vegetables through the hands-on learning experiences may also help to explain our findings. This is consistent with the findings of Reinaerts *et al.*<sup>(8)</sup> who found that exposure was more important than availability for increasing vegetable preferences or consumption. The impact of school gardens on preferences and willingness to taste from previous studies have been mixed, but they generally have not impacted on preferences<sup>(14)</sup>. A lack of peer-reviewed studies with control groups and examination of intake and preference data together has been a limitation of previous studies. Morris *et al.*<sup>(17)</sup> found that a school garden impacted positively on preferences but not willingness to taste, whereas in another study from the same group<sup>(22)</sup>, garden-enhanced NE had no impact on preferences, but did increase willingness to taste for first graders. The researchers speculated that the limited number of taste-testing opportunities in the garden unit may have adversely affected their findings for preferences<sup>(22)</sup>. The school garden programme evaluated by Lineberger and Zajicek<sup>(39)</sup> did not impact on intake or preferences for fruit, but had a positive impact on vegetable intake. The increased vegetable preferences shown in our study are promising, particularly as children's taste preferences for vegetables have been found to be one of the strongest predictors of future vegetable consumption<sup>(10,11,36)</sup>. Birch *et al.*<sup>(38)</sup> have previously stated that in order to improve children's food preferences, one needs to increase exposure that will then affect their willingness to taste.

We found no overall impact on fruit and vegetable knowledge, which is consistent with the findings in the literature<sup>(14)</sup>, although a potential ceiling effect may have confounded our analysis. However, we did find that the benefits depended on the starting knowledge of the children. For students with lower knowledge scores at pre-test, there was a greater treatment effect for those students from the NE&G group. These findings have implications for the targeting of programmes to those students who may benefit

the most, such as the provision of lunch-time or after-school garden and NE programmes for students who are identified as having lower levels of knowledge in this area.

We also found no impact on students' perceived QoSL. No previous studies have looked at this construct specifically. Activities in the school garden appear not to have influenced development in QoSL. Many of these variables are extremely complex and influenced by family and social life and learning in other subjects. Others have looked at the effect of a school garden on various life skills and attitudinal constructs. Waliczek *et al.*<sup>(40)</sup> did not find an impact on interpersonal relationships and attitudes towards school after a school garden programme and suggested that the timing of instrument administration (i.e. at the end of the school year) may have been a factor in the lack of effect. We also administered our instrument at the end of the school year and students may have had more negative views towards school at this stage.

This is one of the first studies to evaluate the impact of NE with and without a school garden and which has also used a concurrent control group. We used a range of quality measures in our evaluation including vegetable knowledge, preferences (ability to identify, willingness to taste and taste ratings), intake (measured by repeat 24 h recalls) and QoSL. Our study had some limitations that need to be acknowledged. This trial was not a randomised controlled trial and was conducted under the constraints of school-based research. As this study was conducted in one area of the Hunter region, the results may not be generalisable to other populations. The study was restricted to only two schools, which also limits generalisability, and students were the units of analysis, which does not account for the clustering effects of the data. Dietary intake was measured by a 24 h dietary recall as this method is suitable to detect changes in diet over the short term such as in this study. This method would not be appropriate to a study investigating the long-term health effects of vegetable intake on disease risk. Lastly, the limited programme length and follow-up may have influenced the outcomes. However, the study did comprehensively evaluate the impact of NE with and without a school garden and addresses an acknowledged gap in previous programme evaluations of this nature<sup>(5,14)</sup>. There has been little research on the effects of school gardens or on the factors that promote the sustainability of these programmes<sup>(5)</sup>. Future research should explore the sustainability of school gardens over an extended time period.

## Conclusions

The introduction of a school garden can enhance students' willingness to taste vegetables and taste ratings of vegetables and be a valuable component of experiential learning for nutrition education. While we did impact on vegetable intake, changing vegetable consumption in children is

complex and our findings lend support to school-based vegetable gardens as a promising tool to improve knowledge and preferences embedded within a health promoting school and community framework.

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