

Validity and reliability of a calcium checklist in early elementary-school children

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Submitted 29 June 2006; Accepted 13 February 2007; First published online 1 August 2007

Abstract

Objective: To create, validate and assess the reliability of a checklist to measure calcium intake in children.

Design: Calcium intakes from a checklist and parent-assisted 24-h dietary recall were compared. Checklist reliability was assessed separately.

Setting: After-school programmes in the United States.

Subjects: Forty-two children (18 males, 24 females, age = 8.0 ± 0.9 years) participated in the validation analysis and 49 children (28 males, 21 females, age = 7.5 ± 0.9 years) in the reliability analysis.

Results: No differences in mean calcium intakes were found by method or gender. The checklist correlated well with recall among girls ($r = 0.65$, $P = 0.01$) but not boys ($r = -0.33$, $P = 0.19$). Agreement over time was above 80% for most foods.

Conclusion: The calcium checklist is useful for assessing calcium intake among groups of 6–10-year-old children in settings that preclude parental assistance. More research is needed to improve accuracy among boys.

Keywords
Calcium checklist
Calcium intake

Field trials that aim to modify dietary behaviours require assessment methods that accurately measure key nutrients. Options for assessing dietary intake include the food frequency questionnaire (FFQ), 24-h dietary recall, food records and diet history^{1,2}. However, young children lack the cognitive development, literacy and writing skills necessary to conceptualise their intake and self-report dietary habits, and thus limits the use of these traditional assessment techniques^{3,4}.

The 24-h dietary recall provided by parents or by the child with parental assistance is generally accepted as a statistically reliable method for describing intake in 4–8-year-old children^{1,2,5–7}. One limitation of the parent-assisted recall is that parents cannot verify reported food intake during times when the child is away from home^{8,9}. Memory prompts, such as the use of previously collected food records¹⁰, may be helpful; parental assistance complements and clarifies the information initially provided by children during 24-h recalls⁷. The FFQ is a popular method to assess usual intake among adults and adolescents^{1,3,11,12}, but it involves a generalised recall of usual food intake over many days or weeks, and that is beyond young children's cognitive capacity. Checklists of frequently consumed foods which require subjects to check items eaten over the past 24 h have also been used to

assess intake of particular foods such as fruits and vegetables^{12–16} or nutrients such as calcium^{17–20}, fat^{21–23} or fibre^{24,25}, but no such tool exists for assessing calcium intake in young children.

This study was part of a 2-year randomised controlled trial called The BONES (Beat Osteoporosis: Nourish and Exercise Skeletons) Project, which took place in after-school programmes across Massachusetts and Rhode Island from 1999 to 2004. The goal of BONES was to maximise bone development, bone quality, muscular strength and calcium intake in 6–10-year-old children attending after-school programmes in diverse communities. At study onset, no tool was available for measuring calcium intake in early elementary-school children that did not involve parental assistance. Therefore, we developed a food checklist for use in BONES to estimate calcium intake over the previous 24 h. This report describes the reliability and validity of the calcium checklist.

Methods

Development of the calcium checklist

The checklist was derived from four sources: the Continuing Survey of Food Intakes by Individuals 1994–1996,

1998 (CSFII)^{26,27}, the National Health and Nutrition Examination Survey of 1988–1994 (NHANES) III²⁸, the National School Lunch Program (NSLP)²⁹ standard serving sizes and from direct observation of children eating snacks in after-school settings. First we identified common sources of calcium in children's diets using national survey data^{26,28} to capture the foods that contribute a majority of calcium in children's diets. In addition, we surveyed new calcium-rich foods or calcium-fortified foods and beverages that were on the market. This yielded an extensive list of foods, and was used to further identify calcium-rich foods consumed by children who were observed in three BONES pilot programmes. Finally we interviewed programme leaders and children regarding their snack and meal pattern to make sure no other calcium-rich foods were missed.

Consistent with national data, the foods consumed by most children were milk, cereal, pizza, and macaroni and cheese. Our observations and review of school meal and snack menus revealed that several foods, such as yoghurt and calcium-fortified foods such as juice, cereal bars, graham crackers and frozen waffles, had become popular since NHANES III, and these foods were also included in the list. To reflect ethnic dietary patterns, specific foods that contribute calcium in some cuisines such as tofu, red beans and rice, bok choy and kale were also added. A juice category included fruit juice, fruit drinks and ades. Soft drinks were included as a dummy category because they often replace calcium-rich beverages such as milk in a child's diet^{30–32} and because the larger BONES study tracked this information. 'Child-friendly' foods such as a hot dog, a hamburger, and a peanut butter and jelly sandwich were also added as 'dummy' foods to mask the purpose of the checklist.

Next, the calcium content of various foods was calculated using standard United States Department of Agriculture (USDA) serving sizes based on NSLP standards for children²⁹. We also calculated the calcium content of these same foods using NHANES III²⁸ data for 6–11-year-old children. However, there were a limited number of children in this age range consuming these calcium-rich foods (e.g. pudding, fortified juice). In addition, the calcium content per gram of several food items (e.g. milk, broccoli) was similar between NHANES III and NSLP. Therefore, we used the NSLP standard in lieu of data from NHANES III.

Finally, to further refine the checklist, we developed a scrapbook with pictures of common containers and servings of foods to help with recall of foods where serving sizes were observed to be highly variable. These included yoghurt (children selected the container size consumed from a range of widely available single-serving yoghurts) and ice cream (children indicated number of scoops or type of specialty bar). Soft drinks are not part of the NSLP and hence a 6-oz serving was assigned based on intakes reported by young children in national surveys^{26,30,33}.

Table 1 shows the foods in the final calcium checklist; it includes 19 commonly consumed foods and beverages, of which 10 are naturally calcium-rich, five are frequently fortified and four are 'dummy' foods. It was designed to be interviewer administered since parents were not available to assist with dietary reporting.

Subjects and procedures

The validation study tested the extent to which a child would recall the same foods using two different methods: a parent-assisted 24-h dietary recall and the calcium checklist. All children whose parents had consented to participate in the main BONES study were sent invitations to participate in the validation study by mail. Information describing the dietary recall procedure was sent ahead of time to parents asking them to note and record the general types of foods their children ate. The 44 children who volunteered from 29 BONES after-school programmes in 16 communities came to the USDA Human Nutrition Research Center at Tufts University in Boston, MA, during weekend or school vacation days to participate in the study. The 24-h recall and the calcium checklist were administered in a randomly determined order approximately 1.5 h apart. Parents assisted children during the 24-h recall, which was considered the reference standard, but were not present during the calcium checklist interview.

The reliability study determined whether the checklist provided consistent results over time. It was conducted among children at six different after-school programmes in six communities during regular programme hours (approximately 2:30–5:30p.m.). Recruitment flyers were posted at the after-school programme so that any child between the ages of 6–10 years attending the programme could participate in it and 56 children volunteered. The calcium checklist was administered twice to each child by two different trained interviewers at least 1 h apart, and coded as time 1 (T1) and time 2 (T2).

No child who was part of the validation study was part of the reliability study. All procedures were approved by the Tufts University Institutional Review Board and met standard ethical procedures regarding use of children in research. Parents gave their signed, informed consent and children over the age of 7 years gave their written assent.

Parent-assisted 24-h dietary recall

The 24-h dietary recall interview method was adapted from the standard multiple-pass procedures used in the Nutrition Data System for Research (NDS-R) software (Nutrition Coordinating Center, University of Minnesota, Minneapolis, MN).

During the first pass of the interview, the child was asked to recall all foods, meal by meal that had been consumed over the past 24 h starting with the most recent meal and going back over the remainder of the period.

Table 1 Foods on the calcium checklist

Food	Details if food consumed*	Serving size if consumed	Calcium (mg) per serving consumed
Juice	Brand/fortified?	6 oz	262.5 if fortified, multiplied by number of servings
Milk	Multiple servings? Plain, flavoured, soy or fortified? Home or School?	8 oz	300 for plain, flavoured soy 500 for fortified Multiplied by total number of servings
Yoghurt	Multiple servings? 2, 4, 6 or 8 oz	Child selects size	75 for 2 oz, 150 for 4 oz, 225 for 6 oz, 300 for 8 oz
Cheeset	Slice, string, hard, other	1.5 oz if <9 years 2 oz if ≥9 years	300 if <9 years, 400 if ≥9 years, 75 if cottage cheese
Soda	Caffeinated?	6 oz	NA
Soup	Cream or broth-based?	1 cup	170 if cream-based
Cereal	Brand/fortified?	1 oz or $\frac{3}{4}$ cup	100 or 1000 depending on brand if fortified
Snack bar	Brand/fortified?	1 bar	200 if fortified
Waffles or pancakes	Frozen or homemade?	3.1 g	80 if fortified or homemade
Ice cream or frozen yoghurt	1 or 2 scoops? Specialty bar?	Child selects	100 if one scoop or specialty bar 200 if two scoops
Pudding or custard	No additional details	$\frac{1}{2}$ cup	150
Tofu	No additional details	1.5 oz	270
Rice and beanst	No additional details	$\frac{3}{8}$ cup	24
Peanut butter and jelly	No additional details	1 sandwich	102
Hotdog with roll	No additional details	1 hotdog	65
Broccoli, kale, bok choy	No additional details	$\frac{1}{2}$ cup	47.5
Hamburger on bun‡	No additional details	1 burger	65
Pizza†	No additional details	1 slice (75 g)	388
Macaroni and cheeset	No additional details	1 cup	296

* Picture book used to help child identify brand (juice, cereal, snack bars, frozen waffles/pancakes, soda) or type of food (size of yoghurt container, type of cheese or ice cream); with help, children report number of times they consumed juice and milk, and the type of soup consumed. If brand could not be identified, no calcium is assumed for non-dairy products and a minimal value is assigned for dairy products.

† Calcium and serving size based on National School Lunch Program standard recipes for age.

‡ If cheeseburger, then cheese recorded as 'slice' under cheese item.

This methodology was used to make the recall task more age-appropriate and comprehensible since children have a limited concept of time^{4,35}. During the second pass, food models, bowls, plates, measuring cups and rulers were used to assist in the recall of portion sizes. Parents were instructed to assist children if needed, and typically contributed information regarding the hour of the meal, portion size and preparation. All foods and beverages were recorded by hand and entered into NDS-R software.

Calcium checklist administration

Trained research assistants used the same methodology for the first pass during the 24-h recall as described above to help the child identify items on the checklist that he/she ate during the reference time period, asking for clarifications when necessary, but without probing or suggesting responses. During the second pass, each item was repeated to the child so that he/she could identify any foods that were missed.

The scrapbook with pictures of various products was shown to the children to obtain specific information about items on the checklist that individual children said they ate. For example, a child who consumed milk was

asked to recall the number of times that he/she had milk at home and/or at school. Then, with the help of pictures, the child was asked to indicate whether or not it was chocolate, plain, soy or calcium-fortified. Similarly, if there was a calcium-fortified version of the food, such as juice, cereal or snack bars, the child was shown photographs of actual food containers so that he/she could indicate which brand had been consumed. The interviewer recorded the brand code onto the data sheet for later analysis. Since new products appear frequently on the market, children were instructed to tell the interviewer when they could not find the brand they ate and to describe it if possible, but not to guess.

Statistical analyses

Data were analysed with SPSS (version 12.0, SPSS Inc., 2003). Parent-assisted 24-h dietary recalls were analysed using NDS-R (version 4.02_30) and transferred into SPSS. Nutrients from foods not included in the NDS-R system were entered by hand. Calcium from dietary supplements was not included in the estimate of the total daily calcium intake because very few children used them. Foods and beverages were then coded by category to match those on the checklist (e.g. milk, yoghurt, cereal) so that

estimates of calcium intake from a particular food could be assessed by the two methods.

To estimate dietary calcium from the checklist, each item consumed was multiplied by the calcium content of a standard serving based on the USDA's NSLP guidelines (7CFR part 210.10) according to age of the child. For yoghurt the child selected the container size; for ice cream the child selected number of scoops or the specialty bar; and 6 oz was used for soft drinks. Serving sizes were assumed to be whole, not partial, and multiple servings of food items were accounted for in the calculations. Calcium from all items consumed was summed to estimate total calcium intake; calcium from dairy items was summed to estimate total calcium intake from dairy. Since both calcium estimates followed a normal distribution, mean intakes are reported.

Paired *t*-tests were used to compare the mean intake of dietary calcium between recall and checklist in the validation analysis, and between T1 and T2 in the reliability analysis, by all subjects and by gender. Tests were considered significant at the $P < 0.05$ level. Spearman rank order correlations were used to assess the relationships between overall calcium intake and calcium intake from dairy foods as evaluated by the two methods (recall and checklist) and over time (T1 and T2). In addition, Spearman correlations were also used to assess the effect of individual items in the checklist in order to examine their usefulness individually as well as to examine differences in item efficacy by gender. The Bland–Altman method³⁵ was used to examine the measurements of calcium intake obtained by the two methods (recall and checklist). The influences of gender, age and test order on the differences between estimates of total calcium intake from the recall minus calcium intake from the checklist were assessed with regression analysis, as were the effects of individual interviewers and interviewer pairs.

The agreement for consumption of each food item was assessed by method and over time using an agreement score, calculated as the percentage of respondents who answered each question in a similar manner on both recall and checklist and each of the two time points (T1 vs. T2). For example, if a child indicated that a food item was or was not consumed either with both instruments or times points (e.g. a 'yes'–'yes' or a 'no'–'no' response), then agreement was 100%. If the child changed his/her

response, then agreement was zero for that item. If a child responded the same way for all 19 items, the per cent agreement was 100%.

Results

Validation

Of the 44 children, two were excluded from analysis (for incomplete recall or unsolicited parental assistance during checklist administration), leaving 42 (18 M, 24 F) subjects. Ages ranged from 7.1 to 8.9 years (mean age was 8.0 years); 28 were Caucasian, eight were African-American, six were of 'other' race/ethnicities (Hispanic, multi-racial and Native American) and one did not disclose ethnicity.

Mean calcium intake was 1053 mg (SD 502) on the parent-assisted 24-h dietary recall and 935 mg (SD 530) on the checklist (Table 2). Neither the differences in calcium intake for the group as a whole or by gender were significant. Calcium intake estimated from checklist was significantly correlated with that estimated from the recall among girls ($r = 0.65$, $P = 0.01$), but not among boys. In regression models, gender, age, testing order and interviewer pair did not affect the differences between methods in mean calcium intake (data not shown). Mean calcium intakes from dairy products were not significantly different by checklist and recall. Intakes of dairy calcium from recall and checklist were correlated for the group as a whole ($r = 0.51$, $P = 0.01$). Correlations were high among girls ($r = 0.75$, $P = 0.01$), but not for boys.

The major sources of calcium on the 24-h recall were milk (28% of total), pizza and cheese (both 13% of total) and juice (9% of total). The per cent agreement between recall and checklist for consumption of these and other dairy foods ranged from 72% (juice for boys) to 100% (milk for boys, and juice and macaroni and cheese for girls).

Figure 1 depicts the limits of agreement in Bland–Altman plots between the mean calcium intake from recall and checklist and the difference between calcium intake as assessed by recall and checklist; all points fell within ± 2 SDs of the mean difference, although variability increased when calcium consumption rose above 1000 mg, indicating that differences between the checklist and the recall were larger at higher intake levels.

Table 2 Dietary calcium intake (mean mg \pm SD) from all foods and from dairy foods by method (parent-assisted 24-h recall vs. calcium checklist), by gender and overall for the group, and Spearman rank correlations for total calcium and calcium from dairy foods

	Total calcium from recall	Total calcium from checklist	Spearman ρ (total calcium)	Dairy calcium from recall	Dairy calcium from checklist	Spearman ρ (dairy calcium)
Boys ($n = 18$)	1217 \pm 471	983 \pm 513	-0.33	849 \pm 419	821 \pm 433	0.0
Girls ($n = 24$)	931 \pm 480	898 \pm 550	0.65*	584 \pm 421	724 \pm 487	0.75*
Total ($n = 42$)	1053 \pm 502	935 \pm 530	0.28	698 \pm 435	766 \pm 462	0.51*

SD – standard deviation.

* Significant at $P = 0.01$.

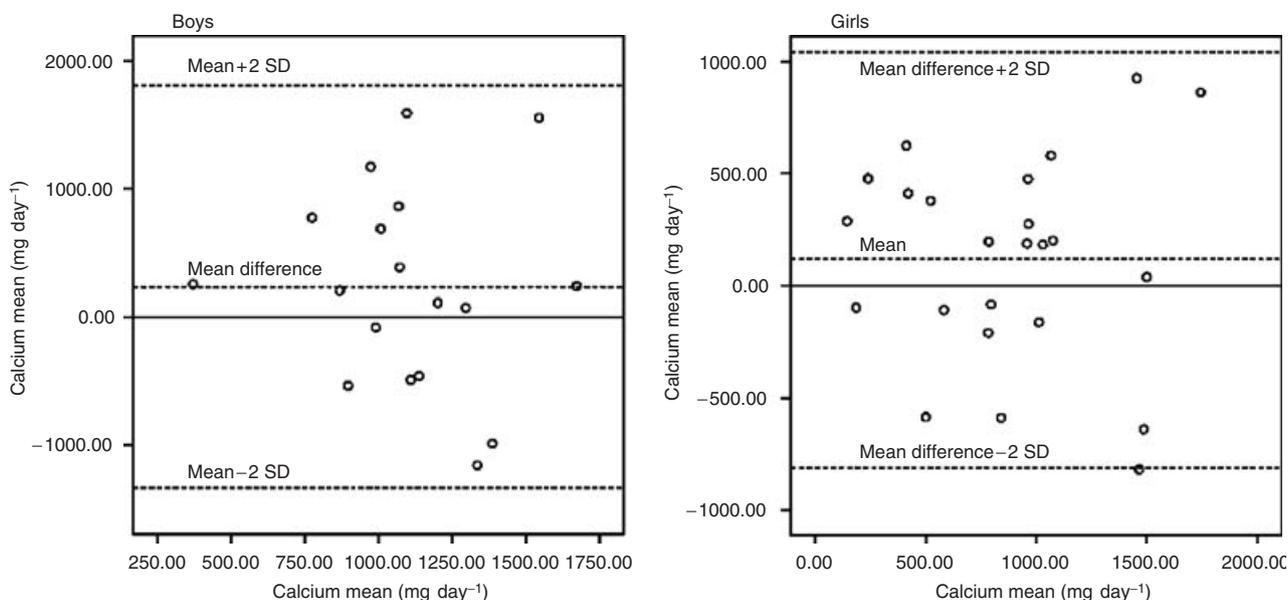


Fig. 1 Limits of agreement of calcium intakes between recall and checklist for boys and girls

Table 3 Total calcium intake (mean mg ± SD) from all foods on checklist and from dairy at T1 and T2 and Spearman rank correlations

	Calcium T1	Calcium T2	Spearman ρ (total calcium)	Dairy calcium T1	Dairy calcium T2	Spearman ρ (dairy calcium)
Boys ($n = 28$)	978 ± 573	959 ± 435	0.49**	793 ± 484	787 ± 322	0.46*
Girls ($n = 21$)	1256 ± 578	1117 ± 590	0.67***	1045 ± 516	976 ± 570	0.67***
Total ($n = 49$)	1095 ± 586	1027 ± 507	0.58**	901 ± 507	868 ± 450	0.57***

SD – standard deviation; T1 – Time 1; T2 – Time 2.
Significant at * $P < 0.05$; ** $P < 0.01$; *** $P = 0.001$.

Reliability

Of the 55 subjects, seven subjects were excluded (due to absenteeism and/or departure from the after-school programme before completion of both surveys), leaving 49 subjects (28 M, 21 F) with complete data for analysis. Ages ranged from 6.6 to 8.4 years (mean age was 7.5 years). Twenty-seven were Caucasian, six African-American, 11 reported other ethnicities and five did not disclose ethnicity.

There were no differences in total calcium intake or calcium from dairy foods reported between T1 and T2 for either girls or boys (Table 3). All correlations were significant at the $P < 0.05$ level and ranged from 0.46 (calcium from dairy among boys) to 0.67 (calcium from dairy among girls). Regression analysis showed that age, gender and interviewer pairs did not influence estimates of differences in calcium intakes between T1 and T2. The major sources of calcium at T1 were milk (51% of total calcium), cheese (10% of total calcium), ice cream (8% of total calcium) and pizza (4% of total calcium).

The per cent agreement for individual food consumption between T1 and T2 was above 80% for most foods except snack bars (75%) and cheese (79%) for boys, and cereal (71%) for girls. Correlations between intakes of

calcium from specific food items at T1 and T2 are shown in Table 4. Correlations for calcium from dairy foods ranged from 0.48 (milk for boys) to 0.93 (ice cream in girls).

Table 4 Spearman correlations for reported calcium intake from checklist foodst† for boys and girls from T1 and T2

Food	Boys ($n = 28$): Spearman ρ	Girls ($n = 21$): Spearman ρ
Milk	0.48**	0.70**
Yoghurt	0.71**	0.84**
Cheese	0.61**	0.61**
Ice cream	0.67**	0.93**
Pizza	0.44*	0.58**
Macaroni and cheese	0.68**	0.58**
Juice	0.178	0.432
Cereal	0.704**	0.618**
Granola bars	-0.090	0.580**
Waffles	0.706**	0.228
Rice and beans	0.609**	0.676**
Peanut butter and jelly	0.650**	1.0**
Hamburger	0.513**	0.583**
Hot dog	0.609**	0.791**

Significant at * $P = 0.05$; ** $P < 0.01$.

† The following items are not reported included in the analysis due to small numbers of children consuming these items: pudding, tofu, broccoli, soup and almonds.

Discussion

The checklist we developed to assess calcium intake in early elementary school-aged children without parental assistance provides an alternative to existing methods that require parental input^{11,17}, and to FFQs, which are not available for children in this age group^{3,19,20,36}. In studies with older children, correlations between information obtained from FFQs and records for calcium intake increase in a linear fashion with age, ranging from 0.35 among 9–11-year olds to 0.59 for 14–18-year-olds^{3,19,36}. Our study involved a younger sample of children and, as might be expected, the correlations between calcium intake on dietary recall vs. checklist were modest and somewhat lower for the group as a whole ($r=0.28$), but higher for girls ($r=0.65$). Discrepancies between girls and boys may be due to developmental differences. Little information is presently available on such differences in dietary recall ability in early elementary-school children, but other recall studies suggest that gender differences may exist. Among 3–5-year-olds, boys scored higher than girls on a visual–spatial working memory task³⁷, while a study with older children and adolescents 9–21-years-old found that girls outperformed boys on a verbal memory task³⁸, although in another study gender differences in memory test performance were not apparent³⁹. A fuller understanding of the cognitive processes involved in food recall would be helpful in improving methods for assessing intake in children⁴⁰. Careful training of interviewers and use of standard protocols and assistive materials will maximise the effectiveness and minimise the bias of the checklist.

Study limitations included a small population size, possible recruitment bias into the validation analysis group, the short time interval between administration of the instruments and not accounting for partial servings consumed in the checklist. All interviews were conducted at least 1 h but no more than 2 h because of time constraints. Possibly when children were interviewed for a second time they remembered their response from the first rather than recalling this information from memory; however, other studies have also used this same time period in their study designs and have not reported an adverse event⁴¹. In addition, the reliability study was limited to an assessment of differences in recall of food eaten over one 24-h period. Travel burden on the part of the subjects prevented multiple recall points, so whether the same results would be demonstrated using a second 24-h period remains to be seen.

The use of standard serving sizes for the checklist may lead to under or overreporting of actual calcium intake. For example, the average milk serving size among girls according to the parent-assisted recall was approximately 6 oz, while the serving size in the checklist was specified as 8 oz, the NSLP standard. Similarly, boys and girls reported drinking approximately 8 oz of juice per serving

on the recall, yet the checklist utilised the NSLP standard of a 6 oz serving.

We conclude that this is a reasonably valid, rapid and reliable calcium checklist that can be used to evaluate calcium intake among groups of early elementary school-aged children in field settings without parental assistance. It performed consistently over time and reliably assessed calcium intakes among the group of girls in comparison to the mean calcium derived from the 24-h recall. However, the accuracy of the checklist needs improvement, especially when it is used among young boys. Further refinement of the checklist may include prompts to improve the accuracy of reported servings of individual food items such as milk or juice, and an option to allow modification of the reference serving sizes of individual foods.

Acknowledgements

Sources of funding: This research was funded by the National Institutes of Health, 5R01H037752-5 with additional support from the National Dairy Council.

Conflict of interest declaration: C.D.E. serves as a member of the 3-A Day Dairy Advisory Panel.

Authorship responsibilities: L.M., E.H., J.D., J.P.G., E.N.N. and C.D.E. designed the study. L.M., E.H. and C.D.E. were responsible for collection of the data. L.M., E.H., R.R.H., E.N.N. and C.D.E. conducted the analysis. L.M., E.H., J.D., R.R.H., J.P.G., E.N.N. and C.D.E. interpreted the analysis, contributed to writing the manuscript and made substantial conceptual contributions and revisions.

Acknowledgements: We thank Kyla Shea, Eliza Lawson, Andrea Pelletier, Michelle Pacis and Gloria Yu for their assistance with the study.

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