

## DENTAL CARIES IN AMERICAN INDIAN TODDLERS AFTER A COMMUNITY-BASED BEVERAGE INTERVENTION

**Objective/Setting:** The Toddler Overweight and Tooth Decay Prevention Study (TOTS) was an overweight and early childhood caries (ECC) project in the Pacific Northwest. It targeted American Indian (AI) toddlers from birth, to effect changes in breastfeeding and sweetened beverage consumption.

**Design/Intervention/Participants:** The intervention cohort was children born in three communities during 12 months; expectant mothers were identified through prenatal visits, and recruited by tribal coordinators. The local comparison cohorts were children in those communities who were aged 18–30 months at study start. A control longitudinal cohort consisted of annual samples of children aged 18–30 months in a fourth community, supplying secular trends.

**Outcome measures:**  $d_{1-2}mfs$  was used to identify incident caries in intervention, comparison, and control cohorts after 18-to-30 months of follow-up in 2006.

**Results:** No missing or filled teeth were found. For  $d_{1t}$ , all three intervention cohorts showed statistically significant downward intervention effects, decreases of between 0.300 and 0.631 in terms of the fraction of affected mouths. The results for  $d_{2t}$  were similar but of smaller magnitudes, decreases of between 0.342 and 0.449; these results met the .05 level for significance in two of three cases. In light of an estimated secular increase in dental caries in the control site, all three intervention cohorts showed improvements in both  $d_{1t}$  and  $d_{2t}$ .

**Conclusion:** Simple interventions targeting sweetened beverage availability (in combination with related measures) reduced high tooth decay trends, and were both feasible and acceptable to the AI communities we studied. (*Ethn Dis.* 2010;20:444–450)

**Key Words:** Caries, American Indian, Child, Community Intervention, Soft Drinks, Sugared Beverages

From Department of Preventive and Community Dentistry, Indiana University School of Dentistry, and The Regenstrief Institute, Inc. (GM) and Kaiser Permanente Center for Health Research (NK) and Department of Family Medicine, University

Gerardo Maupomé, PhD; Njeri Karanja, PhD; Cheryl Ritenbaugh, PhD; Tam Lutz, MPH; Mikel Aickin, PhD; Thomas Becker, PhD

### INTRODUCTION

While dental caries (tooth decay) prevalence for many children in the United States has stabilized,<sup>1</sup> the brunt of the disease is borne by a small group. Low income, low education, and being a racial/ethnic minority are associated with worse dental outcomes and/or fewer dental visits for both adults and children, in particular under 6 years of age.<sup>2,3</sup> Caries may progress considerably in a short time, and if left unattended, children with caries are likely to develop additional lesions.<sup>4,5</sup> Early childhood caries (ECC) is a public health prob-

of Arizona (CR, MA) and Northwest Portland Area Indian Health Board (TL) and School of Medicine, Oregon Health and Sciences University (TB).

Address correspondence to Gerardo Maupomé, PhD; Department of Preventive and Community Dentistry; Indiana University School of Dentistry; 415 Lansing Street; Indianapolis, IN 46202-2876; 317-274-5529; 317-274-5425 (fax); gmaupome@iupui.edu

Abbreviations throughout:

$d_{1-2}mfs$ : number of tooth surfaces in primary teeth that are decayed (both incipient and cavitated carious lesions), missing, or filled

$d_{1t}$ : number of primary teeth that are decayed (only incipient carious lesions)

$d_{2t}$ : number of primary teeth that are decayed (only cavitated carious lesions)

$dmf$ : primary teeth that are decayed, missing or filled

$d_{1-2}mf$ : primary teeth that are decayed (both incipient and cavitated carious lesions), missing, or filled

$d_{1t}$  and  $d_{2t}$ : number of primary teeth that are decayed (incipient and cavitated carious lesions)

lem,<sup>6</sup> and it is a very expensive problem to solve when clinically advanced.<sup>7,8</sup>

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*Low income, low education, and being a racial/ethnic minority are associated with worse dental outcomes and/or fewer dental visits for both adults and children, in particular under 6 years of age.*<sup>2,3</sup>

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Early childhood caries prevalence varies widely, from 1% to 85% of children depending on diagnostic criteria, teeth examined, age, race, ethnicity, socioeconomic status (SES), and fluoride exposure.<sup>9,10</sup> Historically, one of the groups most severely affected is American Indians/Alaska Natives (AI/ANs). This fact was established by comparing with non-AI children and teenagers,<sup>11</sup> non-AI children,<sup>12</sup> or non-AN children,<sup>13</sup> the likelihood of prevalence increasing rapidly in the first five years of life among AI children,<sup>14,15</sup> whether these high prevalence figures have failed to improve over the years,<sup>16</sup> or by evaluating ECC prevalence figures.<sup>12,17</sup>

While the backlog of disease is so large that considerable treatment needs remain apparent among AI/ANs, an important question is what effective measures may be undertaken to ameliorate such high caries risk status. Limited

evidence suggests that fluoride varnish is effective among Head Start Navajo children but possible bias because of self-selection cannot be discounted.<sup>18</sup> Ismail found that educational improvement of caregivers to promote healthy dietary habits in infants has been one of the main strategies to prevent ECC.<sup>19</sup> While impact was usually modest, changes in family behavior were important to attain a lower caries risk. A successful strategy may be to eliminate frequent exposure to cariogenic drinks and snacks; increase the judicious use of preventive methods;<sup>20</sup> and tailor the intervention within a wide reaching program to empower changes in knowledge, attitudes, and behavior. Because it is difficult to design an optimal community intervention strategy many studies have merely described ECC clinical or epidemiological presentations or attempted to predict risk situations rather than communicating the results of interventions.

There are few examples of community-based initiatives targeting oral health in AI/AN.<sup>21</sup> We have completed a community demonstration, the Toddler Overweight and Tooth Decay Prevention Study (TOTS). This overweight/obesity prevention and ECC prevention project targeted AI babies/toddlers from birth, relying on effecting changes in breastfeeding and sweetened beverage consumption (including soft drinks) in the Pacific Northwest. This article outlines caries changes after 18-to-30 months of follow-up in children from AI communities who were exposed to family-based and/or community-wide interventions, or served as a regional comparison group.

## METHODS

The Portland Area Indian Health Service Institutional Review Board approved the study. In addition to parental informed consent, each tribal council gave permission to conduct the study in the communities.

## Study Population, Setting, and Overall Design

Four geographically separated tribal groups were selected on the basis of interest, number of births (>64 per year), availability of health services (Women Infants and Children [WIC], Maternal Child Health [MCH] and dental clinics), and tribal readiness. Participating groups could be a single tribe, or a confederation of tribes, and could have one or more towns. We refer to each participating tribal unit as a community since all children on each reservation were served under the same WIC/MCH/dental clinic structures. We have labeled the 4 communities with letters A–D.

The original design called for comparison of two intervention intensities – community only vs community plus family intervention, and the study statistician randomized the four tribes to the two conditions. But early in the study, there were two events that altered the design: 1) one community withdrew for local reasons; and 2) we recognized the need for a no-treatment longitudinal control site for the dental measurements, as there were no other comparable datasets. A tribal group volunteered; it had been eligible at the beginning of the study but had not submitted its registration in a timely manner. Thus the study was completed with communities A–C receiving intervention for one cohort and using another cohort for comparison, while the added community D served as the concurrent longitudinal control site. The basic design was to measure children 18–30 months of age in each community at two time points, measuring one cohort (comparison cohort) prior to any intervention activities, and the second cohort (intervention cohort) after the intervention. This was what occurred in communities A–C. The children of community D (control cohort) were similarly measured, except that there was no intervention in community D.

The intervention cohort was recruited from children born of all women in communities A, B and C with uncomplicated pregnancies. Expectant mothers learned of the study through prenatal visits, and were encouraged to call the TOTS coordinator. Informed consent was obtained. There were no monetary incentives in the study.

The local comparison cohorts consisted of children in the intervention communities A, B, and C who were 18–30 months at the beginning of TOTS, before any intervention activities began. These children formed a unique comparison group that would provide information about the level of ECC in the intervention communities prior to the intervention. This group of children forms part of the pre cohort. The longitudinal control cohort consisted of children in community D aged 18–30 months at the time of each annual measurement visit. Children in community D aged 18–30 months had a dental exam each year in the same month, thus a different group of children was measured every time. These children allowed us to track ECC secular trends. The first wave of children measured in this group contributed to the pre cohort, while those subsequently measured become part of the post cohort.

Both the local comparison and longitudinal control cohorts were recruited from MCH clinics and from WIC and Head Start childcare.

## Intervention Design

The study uses the ecology of the child to deliver the intervention, by targeting the individual parent, the family network, and the community at large. This is an efficient way of increasing intervention dose, as messages are repeated across these settings. The intervention goals were to: increase breastfeeding initiation and duration; limit the introduction of sugar-sweetened beverages to infants and toddlers; and promote the consumption of water

**Table 1. Sample community intervention plan: item - water**

Approach level of intervention	What is to be done	Collaborators/people involved	Issues to be addressed
Awareness	Write newspaper article describing how water was valued in past. Interviews with elders and cultural leaders.	Site coordinators Cultural leaders	Lost cultural traditions with younger generation
Health education	Provide TOTS water bottles, information on importance of drinking water and water safety to moms	Site coordinator Project director	Community thinks water is unsafe; contamination from pesticides and farming
Behavior change	Taste testing of community water and bottled water at health fairs and events where sugared-beverages are heavily consumed	Site coordinator	City tap water used to taste bad with strong chlorine taste and smell
Behavior change Behavior change	Provide water at events Ask program managers to encourage water consumption at events	Site coordinator Site coordinator	Not enough drinking fountains; unclean fountains, or out of cups
Environment	Increase proportion of water available in vending machines.	Site coordinator	Economic barrier. Pop is cheaper than water

for thirst. Interventions were informed by focus groups and interviews at the beginning of the project.

Community-wide interventions were designed in six-month cycles, using five strategies: 1) raising awareness, 2) providing health education, 3) facilitating individual behavior change, 4) augmenting public health practice, and 5) modifying environments or policies related to breastfeeding, sugar-sweetened beverages, and water consumption. A sample community-wide intervention plan targeting sugar-sweetened beverages is in Table 1. Most interventions were media-based, taking the form of brochures, videos, newspaper articles, flyers, or other media, or focused on environmental changes such as water availability.

Family interventions were delivered in eight visit clusters by community health workers (CHWs) using a home-visiting model. Each visit cluster could have up to three distinct contacts, and only one of these was required to be a face-to-face contact; the other two could be conducted by phone. The CHWs created a client-specific plan for initiating and maintaining breastfeeding along with water and sugar-sweetened beverage interventions in clusters 1–3. Cluster 1 occurred before the baby’s birth, to facilitate counseling that would encourage early decisions to

breastfeed. Clusters 2–4 occurred within 0–3 months of the baby’s birth. Clusters 4–7 consisted of intervention implementation and final data collection was done in cluster 8. The CHWs received training in the delivery of one-to-one counseling, using principles of home visiting and outreach,<sup>22</sup> behavior change,<sup>23,24</sup> and motivational enhancement.<sup>25</sup>

**Dental Measurements**

Dentists or dental hygienists were recruited from the community dental clinics, trained, and calibrated (kappa for inter-examiner agreement  $0.56 \pm 0.31$ , tooth level) in a single two-day group session. We conducted study dental exams in tandem with periodic WIC/MCH examinations.

Teeth were first scored for presence, absence, or missing-due-to-caries status. Presence of incipient (called  $d_1$ ) or cavitated ( $d_2$ ) carious lesions was determined visually, broadly following the procedures for the  $d_{1-2}mf$  index<sup>26</sup> shown to be valid representations of ICDASII codes 1 and 2, and 3+ (respectively) in primary teeth.<sup>27</sup> Teeth were brushed if gross plaque was present, and lightly dried. No radiographs were taken and no treatment was offered; community coordinators channeled messages when urgent treatment needs were noted.

One of the sites in the intervention group had one town receiving intermittent community water fluoridation. Other sites had inconsistent policy initiatives over the years that never led to steady local water fluoridation statuses (written communication 11/07/07, Dr. W. Crow, IHS [Indian Health Service] regional dental consultant). No changes in community water fluoridation took place in any of the sites during the study interval.

**Statistical Design**

*Data Transformation*

Data were collected at the tooth surface level, so that surfaces were nested within teeth, and teeth were nested within mouths. We consolidated information to tooth level measures of  $d_{1t}$  and  $d_{2t}$  (see rationale in next section) by rating each tooth the same as the worst of its surfaces. For the outcome analysis, each child contributed only one measurement, using their latest dental visit in the age range 18–30 months (a 6-month window around a 24-month target).

*Statistical Analysis (Stata® V9, College Station, Tex)*

This was a 2×4 design, in which there were two time points (pre and

**Table 2. Characteristics of communities and study toddlers, *n* or mean (SD)**

	Community A		Community B		Community C		Community D†	
<i>N</i> of births in recruitment								
year		90		67		115		
<i>n</i> enrolled		63		62		80		
<i>n</i> completing		53		56		69		
Pre-intervention sample	Male	Female	Male	Female	Male	Female	Male	Female
<i>n</i>	13	16	19	15	17	15	12	6
Age, months	22.5 (3.1)	23.5 (2.7)	22.9 (3.4)	21.8 (2.7)	26.0 (2.3)	26.5 (2.6)	23.5 (3.8)	22.2 (2.3)
<i>d</i> <sub>1t</sub> *	1.69 (2.84)	3.00 (3.74)	.21 (.71)	1.13 (2.47)	1.88 (2.00)	3.40 (3.48)	.75 (1.36)	2.33 (2.25)
<i>d</i> <sub>2t</sub> *	2.00 (3.39)	1.69 (2.80)	.11 (.46)	1.07 (3.08)	1.88 (2.55)	3.53 (3.46)	1.80 (2.55)	1.67 (2.88)
Post-intervention sample								
<i>n</i>	23	23	20	17	27	23	25	17
Age, months	23.0 (3.6)	24.3 (3.0)	22.9 (2.8)	22.6 (2.9)	23.3 (2.7)	23.1 (2.8)	25.1 (3.1)	24.7 (3.3)
<i>d</i> <sub>1t</sub> *	.91 (1.81)	1.43 (2.11)	1.15 (2.10)	.76 (1.44)	2.00 (3.08)	1.78 (2.84)	2.48 (3.12)	2.12 (2.52)
<i>d</i> <sub>2t</sub> *	1.17 (3.11)	1.04 (2.12)	.00 (.00)	.00 (.00)	1.41 (2.56)	.65 (1.23)	1.80 (2.55)	2.24 (3.85)

\* Mean (SD) raw dental indices, representing number of affected teeth per mouth

† Sample sizes in community D are shown below in table.

post) and four communities, with distinct samples in each cell. No children contributed to more than one cell. The control community D was taken as the base in the statistical model. Indicators of the other communities were included to account for overall differences among the communities. Interactions between A, B, and C and time represent intervention effects. Therefore, each of these interactions represents the effect of the intervention in a community, using community D as a control.

The primary outcome variables were the *d*<sub>1t</sub> and *d*<sub>2t</sub> components of the index. The index counted carious teeth per mouth (no teeth were missing or filled) (range 0–13): *d*<sub>1t</sub> and *d*<sub>2t</sub> components were so skewed that instead of analyzing the mean values, we reduced each component to a presence/absence indicator. Thus, for each child we had two 0/1 outcomes that indicated whether or not there were any affected teeth, for the *d*<sub>1t</sub> and *d*<sub>2t</sub> components. This allowed us to present results in terms of the fraction of the study sample with affected teeth. To analyze the affected fractions in terms of potential intervention effects, we used a generalized linear model. In the form we chose, the fraction affected (or proba-

bility of being affected) was represented as a linear combination of effects due to several sources. This model was identical in interpretation to an ordinary linear regression, except that allowance was made for the fact that the outcome was a 0/1 variable, rather than a continuous measurement. Unlike a logistic regression, the coefficients are directly interpretable as proportions affected.

Indicator variables were allowed for each intervention community, A, B, and C (Table 4). An indicator of the post-sample in community D was included to measure secular effects in the comparison community. Interactions between the post-sample indicator and the community indicators were designed to capture the effects of interest; post-pre differences in the intervention communities that differed from the post-pre effect in the comparison community. Since community D had two post samples (one after two years [as in other communities] and another after one year), the post indicator was set to 0.5 in the one-year post-sample in community D. Finally, because the age at dental visit differed among the communities and in the pre- and post-samples, we included age in the model.

## RESULTS

### Description of Study Sample

The basic descriptors of the study sample appear in Table 2, for the intervention communities (A, B, and C) and the comparison community (D). Age was used as an adjustment factor in subsequent analyses. Measures *d*<sub>1t</sub> and *d*<sub>2t</sub> are shown to document prevalence and severity of disease. Because of skewed distributions, analyses based on averages were not carried out.

### Unadjusted Results

Table 3 shows the *d*<sub>1t</sub> and *d*<sub>2t</sub> averages for presence/absence across communities in the pre- and post-samples. The comparison community D showed an increase of 34% (0.44 to 0.59) in *d*<sub>1t</sub> and 54% in *d*<sub>2t</sub>. In contrast, in all but one case the intervention communities showed decreases in both caries components (community A, -24% for *d*<sub>1t</sub>, -43% for *d*<sub>2t</sub>; community B, +132%, -100%; and community C, -36%, -36%, respectively). While these figures are not yet adjusted for age at visit, they suggested a secular increase in the comparison community and a counter-trend against increase in the intervention communities.

**Table 3. Mean (SD) of fraction of affected\* toddlers in each community and time period**

	Community A	Community B	Community C	Community D
Pre-intervention sample				
d <sub>1t</sub>	.448 (.506)	.128 (.339)	.656 (.483)	.444 (.511)
d <sub>2t</sub>	.414 (.501)	.128 (.339)	.531 (.507)	.278 (.461)
Post-intervention sample				
d <sub>1t</sub>	.340 (.479)	.297 (.463)	.420 (.499)	.595 (.497)
d <sub>2t</sub>	.234 (.428)	.000 (.000)	.340 (.479)	.429 (.501)

\* Having any d<sub>1t</sub> or d<sub>2t</sub>, respectively

### Primary Analysis

The primary analysis of intervention effects is shown in Table 4. As indicated above, there were significant secular rises for both d<sub>1t</sub> and d<sub>2t</sub> in the comparison community. The intervention effects are interpreted as the post-pre difference in an intervention community, minus the post-pre difference in the comparison community. For d<sub>1t</sub>, all three intervention communities showed a significant downward intervention effect, a decrease of between .300 and .631 in terms of the fraction of affected mouths. The results for d<sub>2t</sub> were similar but of smaller magnitude, a decrease of between .342 and .449;

these results met the .05 level for significance in two of three cases. Overall, in light of an estimated secular increase in caries, all three intervention communities showed substantial improvements in both d<sub>1t</sub> and d<sub>2t</sub>.

## DISCUSSION

### Significance of Findings; Caveats and Strengths

Our study found that overall levels of disease were high, against a skewed distribution of caries in very young children across communities. The children who benefited from the interven-

**Table 4. Intervention effects on fractions of affected mouths for d<sub>1t</sub> and d<sub>2t</sub> (SDE\* and two-sided P), adjusted for age at outcome visit**

	Community A	Community B	Community C
d <sub>1t</sub>			
Intervention effect	-.574 (.159, .000)	-.300 (.140, .032)	-.631 (.157, .000)
Pre-intervention†	.069 (.119, .562)	-.226 (.094, .016)	.214 (.114, .060)
d <sub>2t</sub>			
Intervention effect	-.449 (.180, .013)	-.430 (.153, .005)	-.342 (.181, .059)
Pre-intervention†	.145 (.119, .222)	-.106 (.089, .234)	.178 (.119, .135)

#### Definition of factors (indicator variables) in the analytic model

	Community A	Community B	Community C	Community D
Pre-sample	A	B	C	Constant
Post-sample	A, Post, Post*A	B, Post, Post*B	C, Post, Post*C	Post

Secular effects in community D were .451 (.110, .000) for d<sub>1t</sub> and .232 (.136, .087) for d<sub>2t</sub>.

Age effects (per month) were .20 (.008, .019) for d<sub>1t</sub> and .027 (.009, .002) for d<sub>2t</sub>.

\* SDE = standard deviation of the estimate.

† The pre-intervention effect indicates differences between intervention community and comparison community D at baseline.

Each entry stands for an indicator variable included in the analytic model. The A, B, C indicators capture differences between communities A, B, C from comparison community D in the pre-sample. The post indicator captures secular effects (post-pre) in community D. The Post\*A, Post\*B, and Post\*C interaction terms capture effects in which the post-pre difference in a community differs from the post-pre difference in community D.

tion ended up with fewer clinically detectable carious lesions; those who developed carious lesions, had incipient caries more often than cavitated caries.

*Our study found that overall levels of disease were high, against a skewed distribution of caries in very young children across communities.*

On the one hand, we have adopted a cautious statement with regard to the significance of these results because the size of the improvement was small. We cannot attribute a specified fraction of such positive effect to each one of the components of the intervention(s), ie, prolongation of breastfeeding, family-level advocacy, or reduced availability of sweetened beverages at the environmental level. On the other hand, our results exhibit several strengths that draw a fairly clear scenario of what scope of improvement may be ascribed to a community demonstration that primarily targets improved beverage selections among toddlers at very high risk. Specifically, these strengths were the use of an analytic approach that: compensated for the all-too-common problem of skewed dmf data in small size cohorts;<sup>28</sup> estimated the effect of secular changes by using data from non-intervention communities located in the same region and cultural demographic; and took into consideration the rates of improvement (incident caries) across communities rather than merely contrasting cross-sectional appraisals – thus making the size of change (combined and for each community) the preeminent feature of the results, as opposed to simple differences across localities.

The study also used principles of outreach and tailoring to intervene at the family/community levels; it differs

from a randomized controlled trial in that delivery of the intervention is not completely standardized across sites or families. This apparent lack of standardization may cause differences in intervention dose in different tribes and/or families, which, although not uncommon in lifestyle trials, could be viewed as a weakness in design. It does represent, however, how any such program would be administered in a usual setting.

Because this study began before the current national attention to sweetened beverage consumption that has occurred in recent years,<sup>29</sup> it is unlikely that the trends toward improvement we identified were caused by downward secular trends in sweetened beverage consumption, and in any case this would have been expected to reduce caries in community D. Because the funding mechanism prohibited the implementation of isolated intervention components in separate communities, we could not assess the effects accrued by the various strategies. Building on our strengths and despite some limitations, the present research has demonstrated that these community-based initiatives are feasible in, and acceptable to, AI tribes. More importantly, it also showed that changes in beverage customs through relatively simple interventions (increasing breastfeeding and curtailing consumption of sweetened beverages in favor of water), in conjunction with a modest dental public health informational intervention, attenuated historically high incident caries trends, and ameliorated caries severity presentations.

At a somewhat simplistic level, it is not surprising that a more appropriate selection and availability of beverages in a culturally relevant initiative may have led to caries status improvements. The significance lies in this report depicting a tangible effort in a real life situation, with an emphasis on avoiding disease becoming established among toddlers.

### Current Scenario of Caries among AI Toddlers

We have supplied in the introduction an overview of dental caries epidemiologic features among AI/AN children across all ages. While it is generally agreed that dental caries in America has declined in the last few decades, it has increased among children ages 2–5 years<sup>30,31</sup> and has concentrated in low-income and ethnic minority groups. Even though contrasts with the situation of AI/AN toddlers is lacking, IHS data for prevalence of untreated caries among AI/AN preschool children was 68%,<sup>32</sup> compared with 19% from national data.<sup>33</sup> The AI/AN toddlers experience some of the highest caries rates in the United States, thus starting their dental histories in the worst possible conditions.

What can we learn from a community demonstration whereby toddler consumption of sweetened beverages was greatly decreased in the communities? The implications for AI populations and other groups at similar levels of caries risk must be interpreted from a systems' perspective. In the United States, energy intake from soft drinks increased 135% between about 1977 and 2001 while energy intake from milk dropped 38%.<sup>34</sup> Per capita soft drink consumption among children has increased by nearly 500% over the past 50 years, making soda the most commonly-consumed beverage among children.<sup>35</sup> The overall consumption of added sweeteners still exceeds dietary recommendations, even though more recent changes suggest a deceleration of such trend.

### CONCLUSION

Interventions aimed at infants and toddlers are both feasible and acceptable to the AI communities we studied. Simple interventions targeting sweetened beverage availability, in combination with other, related

measures, may reduce high caries levels.

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**AUTHOR CONTRIBUTIONS**

*Design concept of study:* Maupomé, Karanja, Ritenbaugh, Lutz, Aickin, Becker  
*Acquisition of data:* Maupomé, Karanja, Ritenbaugh, Lutz, Aickin, Becker  
*Data analysis and interpretation:* Maupomé, Karanja, Ritenbaugh, Lutz, Aickin, Becker  
*Manuscript draft:* Maupomé, Karanja, Ritenbaugh, Lutz, Aickin, Becker  
*Statistical expertise:* Maupomé, Karanja, Ritenbaugh, Lutz, Aickin, Becker  
*Acquisition of funding:* Maupomé, Karanja, Ritenbaugh, Lutz, Aickin, Becker  
*Administrative:* Maupomé, Karanja, Ritenbaugh, Lutz, Aickin, Becker  
*Supervision:* Maupomé, Karanja, Ritenbaugh, Lutz, Aickin, Becker