Public Health Nutrition: 13(5), 688–694 doi:10.1017/S1368980009993119

Testing consumer perception of nutrient content claims using conjoint analysis

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Submitted 2 April 2009: Accepted 4 December 2009: First published online 15 January 2010

Abstract

Objective: The US Food and Drug Administration (FDA) proposes to establish standardized and mandatory criteria upon which front-of-pack (FOP) nutrition labelling must be based. The present study aimed to estimate the relative contribution of declared amounts of different nutrients to the perception of the overall 'healthfulness' of foods by the consumer.
Design: Protein, fibre, vitamin A, vitamin C, calcium and iron were nutrients to encourage. Total fat, saturated fat, cholesterol, total and added sugar, and sodium were the nutrients to limit. Two content claims per nutrient used the FDA-approved language. An online consumer panel (*n* 320) exposed to multiple messages (*n* 48) rated the healthfulness of each hypothetical food product. Utility functions were constructed using conjoint analysis, based on multiple logistic regression and maximum likelihood estimation.
Results: Consumer perception of healthfulness was most strongly driven by the declared presence of protein, fibre, calcium and vitamin C and by the declared total absence of saturated fat and sodium. For this adult panel, total and added sugar had lower utilities and contributed less to the perception of healthfulness. There were major differences between women and men.
Conclusions: Conjoint analysis can lead to a better understanding of how consumers process information about the full nutrition profile of a product, and is a powerful tool for the testing of nutrient content claims. Such studies can help the FDA develop science-based criteria for nutrient profiling that underlies FOP and shelf labelling.

Keywords
Nutrient content claims
Conjoint analysis
Healthfulness
Food and Drug Administration

Front-of-pack (FOP) labelling is intended to convey the nutritional attributes of a food product at a glance. It rests on sets of nutritional criteria developed by researchers(1), food manufacturers(2), grocery stores and health organizations. FOP summary symbols, based on nutrient profiles(3), are intended to communicate the overall nutritional quality of the food product to the consumer, whereas nutrient-specific symbols provide information on selected nutrients, generally calories (energy), fats, sugar and sodium(4,5).

Concerned that the proliferation of FOP labelling will make people less likely to read the full Nutrition Facts Panel, the US Food and Drug Administration (FDA) has moved to ensure that the new FOP labelling schemes not be false or misleading(4). A proposed regulation will define the nutritional criteria that will have to be met by manufacturers making claims about the nutritional quality of foods, whether expressed as symbols or as text(4). In order to assemble the evidence base, the FDA plans to use an online consumer panel, established by a contractor, to study how different nutritional attributes of a given product, presented with or without FOP symbols, influence perceived product healthfulness(4). To help understand consumer reactions, the FDA plans to collect data on the participants' background, health literacy and health status. In the meantime, the FDA will proceed with enforcement action against products that bear FOP labels that are implicit nutrient content claims and are inconsistent with the FDA's existing requirements.

At this time, the Nutrition Facts Panel is still the chief means of conveying information about the nutrient composition of foods to the American consumer(6). Mandated by the 1990 Nutrition Labeling and Education Act (NLEA), it was intended to promote healthier food choices. Manufacturers were permitted to post nutrition claims on the front of the package, a form of advertising regulated by the FDA(5). Stringent guidelines exist as to what nutrition claims are permitted and how they must be communicated(5).

The present experimental study used an online consumer panel and a within-subject design to collect information on how different nutrient content claims, couched in

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FDA-approved language, affected consumer perceptions of the overall healthfulness of a hypothetical food product. Conjoint analysis, a mathematical technique used to assess the key influences on consumer choice[7], was then used to determine whether consumers were more influenced by the presence of nutrients to encourage, such as protein, vitamins and minerals, or by the declared absence of nutrients to limit. The FDA's stated intent is to develop uniform nutrition criteria on which FOP nutrition labelling must be based[4]. Studies on how consumers perceive the overall healthfulness of a food, using modern online techniques, can help the FDA develop science-based criteria for nutritional profiling, leading to a standardized approach to food labelling[5,8].

Experimental methods

Participants

The study was conducted using an online marketing i-Novation panel. Three thousand invitations were sent to potential participants by email. Panellists were recruited by a double opt-in method, where the prospective panellist had to affirm interest in participating in two different portions of a panel questionnaire. Approximately 70 % of the respondents completed the 15–18 min survey, consistent with previous studies on health and well above the 40 % completion rate for studies on the use of financial services. A summary of panellist demographics is provided in Table 1.

Table 1 A summary of participant characteristics: volunteers in an online consumer panel

	n	%
Gender		
Male	71	22
Female	249	78
Age category		
Under 45 years	107	33
45 years and over	213	67
Highest level of education		
Less than high school	12	4
High school graduate	66	21
Some college	123	38
College graduate	94	29
Postgraduate degree	25	8
Number of children aged <10 years in the household		
None	257	80
At least one	63	20
Number of children aged 11–18 years in the household		
None	242	76
At least one	86	24
Self-reported health status		
Excellent	30	9
Very good	162	51
Fair	110	34
Poor	16	5
Don't know	2	1
My current diet is		
Not at all healthy	17	5
Somewhat healthy	129	40
Healthy	133	42
Very healthy	34	11
Don't know/not sure	7	2

FDA nutritional criteria

For a food to be considered 'healthy' by the FDA, it has to contain at least 10 % of the Reference Daily Intake (RDI) or Daily Value (DV) of one or more of these six nutrients: protein, fibre, vitamin A, vitamin C, calcium or iron per reference amount and prior to fortification. The present study therefore used protein, fibre, vitamin A, vitamin C, calcium and iron as the six nutrients to encourage.

A 'healthy' food also has to be low in total fat (<3 g), saturated fat (<1 g), cholesterol (<60 mg) and sodium (<480 mg), also per reference amount. The present study therefore used total fat, saturated fat, cholesterol and sodium as nutrients to limit. Given concerns about the high sugar content of several food products, total and added sugars were also included for a total of six nutrients to limit. Twelve nutrient elements were the initial input for the study. With the exception of added sugars, all these nutrients are currently listed on the Nutrition Facts Panel.

FDA-approved nutrient content claims

A nutrition claim is defined as any representation, stated, suggested or implicit, that a food has particular nutritional properties, including but not limited to its content of macronutrients, vitamins and minerals[5]. Although such claims are based on information provided on the Nutrition Facts Panel, mere declaration of presence or quantity of a nutrient does not qualify as a nutrition claim[5].

Nutrition claims can be divided into nutrient content claims, describing the level of a nutrient contained in a food (e.g. 'low in fat'), and comparative claims that compare the nutrient level to a pre-defined standard (e.g. 'reduced in fat'). The descriptive language of nutrient claims must be approved by the FDA. Foods that provide 10–19 % of the DV per serving amount can be called 'good sources', whereas foods that provide >20 % of the DV can be called 'excellent sources' of a nutrient. Foods that contain more than 20 % of the DV for protein, fibre, vitamins or minerals are also entitled to terms such as 'high' or 'rich in'. The FDA language guidelines specify that the terms 'good source of' or 'excellent source of' can only be used to describe protein, vitamins, minerals, dietary fibre or potassium.

Conversely, such terms as 'free,' 'low' or 'reduced/less' apply only to calories, total or saturated fat, sodium, sugars or cholesterol. These too are based on serving sizes; or on 50 g if the serving size is small. Depending on amounts per serving, foods can be described as being 'low in' or 'free of' calories, total fat, saturated fat, cholesterol, sugars and sodium. Each of the twelve nutrient elements was presented at two nutrient content levels, using FDA-approved claim language (see Table 2), for a total of twenty-four nutrient elements in all.

Table 2 Nutrient content claims tested (FDA definitions[5])

Level	Nutrient content claim	Nutrient content per reference amount
	Nutrients to encourage	
1	Good source of; contains; provides	Contains 10–19 % of the DV. Used to describe protein, vitamins, minerals, dietary fibre or potassium, but not carbohydrate
2	Excellent source of; high; rich in	Contains 20 % or more of the DV. Used to describe protein, vitamins, minerals, dietary fibre or potassium, but not carbohydrate
	Nutrients to limit	
1	Low; little; few; low source of	Energy <40 kcal* (<167 kJ*); total fat <3 g*; saturated fat <1 g†; cholesterol <20 mg*; sodium <140 mg*; sugars not defined
2	Free; zero; no; without	Energy <5 kcal (<21 kJ); total fat<0·5 g; saturated fat <0·5 g; *trans* fat<0·5 g; cholesterol <2 mg; sodium <5 mg; sugars <0·5 g (per reference amount and per labelled serving)

FDA, US Food and Drug Administration; DV, Daily Value.
*Per 50 g if reference amount is small.
†With <15 % of calories from saturated fat.

Consumer elements

Twelve additional control elements, six related (in a non-specific way) to nutrients and six related to lifestyles and eating, were selected. The intent was to test whether general concepts about healthful eating, including some featured in the 2005 Dietary Guidelines for Americans and the 2005 MyPyramid[9], would contribute to the perception of healthfulness.

Creation of forty-eight composite test messages

The combination of nutrient elements (*n* 24) and consumer elements (*n* 12) yielded a total of thirty-six elements in all. These are summarized in Table 3. The thirty-six elements were sampled in such a way that a test message never contained two elements of the same type that might be contradictory. For example, a test message could not simultaneously include such statements as: 'This product is a good source of protein' (A1) and 'This product is an excellent source of protein' (A2)[10]. Composite test messages (*n* 48) were then created using two, three or four elements each[11].

All of the elements appeared across the different test concepts in a statistically balanced, independent fashion. All thirty-six elements were randomly permuted, independently of each other[12]. Each element appeared exactly three times in each set of forty-eight test messages[10], allowing us to observe how different elements influenced the response to the test message by each respondent. Different permutations of message elements were tested across multiple respondents, with each respondent providing forty-eight different ratings. As the permutations varied across respondents, any sequence effects or biases that might be caused by a specific juxtaposition of elements were cancelled out.

Online panel procedures

The orientation page set up the panellists' expectations about the study, while providing relatively little detail. Panellists were told that they would be given nutritional information for a hypothetical food product. The instructions read:

> Providing nutrition information on food and drink product labels is an important way of conveying the message about diets and health to the consumer. It is important that such information accurately reflect the nutrient composition of the product in a simple manner that is easily understood. However, nutrition labels do not always get the right message across. You are invited to review a selection of messages and rate each product on a 'healthfulness' scale.

Panellists were asked to rate the product using a nine-point category scale, anchored at each end with labels '1 = least healthy' and '9 = most healthy'. Each new message was to be rated independently of any previous message that had just been presented. The specific combinations and the order of presentations were systematically permuted across respondents. Panellists then completed a questionnaire detailing who they were (demographics) and what aspects of foods were important to them (attitudes). A total of 320 panellists completed the 15–18 min survey, a completion rate in line with previous studies on consumer panels[13]. Following completion of the survey, they were entered into a prize draw.

Panellists were instructed to inspect the entire test message and to react to the message in its entirety, much as what happens in the supermarket at the point of sale. Panellists were not permitted to parse the message into its components, and had to assign a rapid overall rating to each particular combination of concept elements. Although such panels may begin the task by reading and responding to each element in a message, they soon adopt a holistic attitude, inspecting the concept and quickly integrating the information to provide their rating[10]. One advantage of within-subject design and conjoint analysis is that the rules underlying the response need not be articulated by the respondent and indeed often cannot be.

Conjoint analysis

Healthfulness ratings obtained along a 9-point scale were first converted to binary form, a prerequisite for logistic regression. 'Healthy' was defined as ratings of 7–9, whereas

https://doi.org/10.1017/S1368980009993119 Published online by Cambridge University Press

Table 3 Elements contributing to the test message

Code	Level	Element
		Nutrients to encourage
A1	1	This product is a good source of protein
A2	2	This product is an excellent source of protein
A3	1	This product is a good source of vitamin C
A4	2	This product is a excellent source of vitamin C
A5	1	This product provides vitamin A
A6	2	This product is high in vitamin A
B1	1	This product contains fibre
B2	2	This product is high in fibre
B3	1	This product contains calcium
B4	2	This product is rich in calcium
B5	1	This product provides iron
B6	2	This product is rich in iron
		Nutrients to limit
C1	1	This product is low in total fat
C2	2	This product is fat free
C3	1	This product contains little saturated fat
C4	2	This product has no saturated fat
C5	1	This product is a low source of cholesterol
C6	2	This product has zero cholesterol
D1	1	This product is low in total sugar
D2	2	This product is sugar free
D3	1	This product is low in added sugar
D4	2	This product is free of added sugar
D5	1	This product is a low source of sodium
D6	2	This product is without sodium
		Consumer control elements
E1	nutrition	Wholesome food that gives you more nutrition per bite
E2	nutrition	Is a good way to balance your diet to keep it nutrient rich
E3	nutrition	Is a total nutrient package with more nutrients than calories
E4	nutrition	Naturally packed with nutrients for better health
E5	nutrition	Meets your daily nutrient needs without too many calories
E6	nutrition	Puts more nutrient power on your plate
F1	lifestyle	Is a great way to enjoy your healthy lifestyle
F2	lifestyle	Takes the stress out of healthful eating
F3	lifestyle	Lets you eat well to live well, starting today
F4	lifestyle	You and your family can eat right – for life
F5	lifestyle	Be at your best…enjoy good taste and good health
F6	lifestyle	You can trust the nutrition label to guide smart eating

'not healthy' was defined as ratings of 1–6. The equation is written as

$$\text{Rating}\,(0,1) = b_0 + b_1A_1 + b_2A_2 + \cdots + b_{36}F_6$$

The statistics of primary interest in logistic regression are the beta coefficients. The interpretation of the beta coefficients for dichotomous independent variables A_i with values of 1 or 0 (present, absent) is that the beta coefficients represent the log odds that a food is perceived as healthy or nutritious when the message is present ($A_i = 1$) as opposed to when it is absent ($A_i = 0$). In a multivariate model, this beta coefficient is the independent effect of variable A_i on Rating (0, 1) after adjusting for all other covariates in the model.

The coefficients b_i are a measure of the conditional probability or percentage of respondents who considered the hypothetical food to be 'healthy' if the element A_i was present. The constant, b_0, was the baseline probability or percentage of respondents who may think that the food is 'healthy' even if there are no elements present. The logistic regression model allowed us to rank the relative contribution of the thirty-six elements to the perceived healthfulness of foods.

Results

Online consumer panel

Consistent with the FDA's future plans, the present study collected data on consumer demographics, nutrition attitudes and practices, and self-reported health status. Table 1 shows that the 320 participants were predominantly female (78 %), middle-aged (57 % in 45–64 year age range), educated (75 % had at least 'some college'), and most had no small children or adolescents living at home (76–80 %). More than half of the participants reported being in very good or in excellent health (60 %). More than half (53 %) stated that their diets were healthy or very healthy. However, 62 % were overweight and 42 % were on a calorie-restricted diet at the time of the study.

Survey responses were first tested for goodness-of-fit to the individual-level models. Most of the 320 respondents showed an $R^2 > 0{\cdot}80$ for the individual models, suggesting that the data from the respondents were consistent. Similar goodness-of-fit values have been shown in many other studies[7,10].

Table 4 Performance of nutrient elements among respondent segments

	Total sample	Male	Female	Age under 45 years	Age 45 years and over
No. of participants	320	71	249	107	213
Maximum utility	17	15	18	15	17
Minimum utility	3	−6	4	1	2
Additive constant	22	35	18	25	21
This product is a good source of protein	**17**	**13**	**18**	**15**	**17**
This product is an excellent source of protein	**16**	6	**18**	**14**	**16**
This product is high in fibre	**14**	**15**	**14**	**15**	**14**
This product has no saturated fat	**12**	**12**	**11**	**11**	**12**
This product is without sodium	**12**	2	**15**	**14**	**12**
This product is a excellent source of vitamin C	**11**	7	**13**	**14**	**10**
This product is rich in calcium	**11**	6	**12**	7	**13**
This product has zero cholesterol	**11**	9	**12**	9	**13**
This product is fat free	**10**	7	**11**	6	**12**
This product is free of added sugar	**10**	4	**12**	5	**12**
This product is high in vitamin A	9	1	**11**	9	9
This product is a good source of vitamin C	9	0	**11**	**11**	7
This product contains fibre	9	3	**11**	7	**11**
This product is a low source of sodium	9	3	**11**	**10**	9
This product is sugar free	9	**10**	8	6	**10**
This product contains calcium	8	5	9	5	**10**
This product is low in total sugar	8	2	9	8	8
This product is a low source of cholesterol	7	9	6	7	7
This product is low in total fat	7	2	8	6	8
Puts more nutrient power on your plate	7	6	7	**10**	5
Be at your best enjoy good taste and good health	7	5	8	**11**	5
This product provides vitamin A	6	1	8	9	5

Important elements (≥10) in bold.

Results of conjoint analysis

Table 4 shows the best twenty-two elements sorted by their importance. The range of utilities skewed more towards the 'healthy' side and no elements were perceived to be 'unhealthy'. This is what one might expect since all messages were phrased in a manner that connoted health. Based on data from previous studies using conjoint analysis, the important elements were defined as having a utility >8. The unimportant elements were defined as having a utility <−5. In previous studies, differences of five points on the utility scale tended to be significant at the 90 % confidence level.

Nutrient content claims based on the declared presence of protein, fibre, calcium and vitamin C contributed the most to the overall judgement of the food as healthful. Equally influential was the declared absence of nutrients to limit: saturated fat, cholesterol and sodium. Total fat, total and added sugars, and vitamin A had lower utilities and contributed less to the overall perception of healthfulness. The declared presence of iron did not contribute significantly to the perception of healthfulness of the product.

For nutrients to encourage, the declared presence of the nutrient was more important than the amount that was claimed. Comparable utilities were obtained for statements about 'good' as opposed to 'excellent' sources of protein. That was not the case for nutrients to limit. Utilities were higher for statements that described the products as being completely 'free' of saturated fat, cholesterol or sodium. Claims that the food product was 'low in' a nutrient to limit did not alter the perceived healthfulness rating.

Nutrient content claims had much higher utilities than the consumer elements, which were largely based on more generic appeals to lifestyle and to good nutrition. Consumer perceptions of the healthfulness of foods appeared to be based largely on the declared nutrient content of foods rather than by statements than might be found on advertising copy.

Demographic segmentation

There were major differences between women and men. Men were far more likely to call a product healthy even in the absence of nutrition content claims ($b_0 = 35$); whereas women were less likely to do so ($b_0 = 18$). Whereas women showed more consistent judgements, men did not always do so, and their range of utility values was consequently greater (21 *v.* 14). Men were less likely to be swayed by nutrient content claims than were women.

Contrary to expectations, the impact of nutrient content claims on the perception of healthiness was not affected by age. The big exception was calcium. Statements 'good source of calcium' and 'rich in calcium' had higher utilities among older respondents (age 45+ years).

Discussion

How nutrition information on product labels is conveyed to the consumer is subject to stringent regulations by the FDA[5]. FDA regulations specify which nutrients need to be listed on the Nutrition Facts Panel, in what format and in what order. Total calories, calories from fat, and the amounts of total fat, saturated fat, cholesterol, sodium, total carbohydrate, dietary fibre, sugars, protein, vitamin A, vitamin C, calcium and iron

https://doi.org/10.1017/S1368980009993119 Published online by Cambridge University Press

must be included. Mono- and polyunsaturated fats, potassium and other essential vitamins and minerals must be listed only in the event of a nutrient content claim. The Nutrition Facts Panel lists the amounts in grams or milligrams of nutrients per serving, as well as percentage of the DV, based on a diet supplying 8368 kJ/d (2000 kcal/d)[1,5].

New point-of-purchase food labelling schemes developed by manufacturers and grocery stores are based on diverse nutritional criteria. Some are based on nutrients to encourage and nutrients to limit, whereas others are based on calories and nutrients to limit only: fat, sugar and sodium. One important question is whether consumer perception of product healthfulness, based on the elements of the Nutrition Facts Panel, is driven by the presence of beneficial nutrients or by the declared absence of nutrients to limit. A better understanding of how consumers perceive the relative healthfulness of foods would help shape national policies for nutrition education and dietary guidance.

Using online consumer panels and conjoint analysis, the present study showed that the consumer perception of product healthfulness was largely driven by the declared presence of protein, fibre, calcium and vitamin C and by the total absence of saturated fat and sodium. Total fat, iron and vitamin A, all which are part of the FDA definition of healthy foods, had less impact on the consumer utilities. The utilities for total and added sugar were much lower than for either fat or fibre. For nutrients to encourage, the declared presence was more important than the claimed amount ('good' *v.* 'excellent' source). By contrast, for nutrients to limit, participants responded more strongly to the total absence of a problematic nutrient (e.g. 'no fat').

The data suggest that an effective nutrient profiling system, broadly consistent with the current definition of healthy foods, can be constructed using a limited number of key nutrients. One important question is whether protein should be included in a nutrient profile model, given that it is not currently a shortfall nutrient in the American diet. The present data clearly show that the protein content of foods is one of the key determinants of the perceived nutritional quality of foods by the consumer.

Numerous systems, including the Nutrient-Rich Foods (NRF) index, have been based on the nutrients studied here. The NRF index is based on protein, fibre, vitamins A, C, and E, calcium and iron as well as potassium and magnesium[14]. The French SAIN sub-score, based on nutrients to encourage, uses protein, fibre, vitamin C, calcium and iron[15]. Both the NRFI and the French LIM score use saturated fat, added sugar and sodium as the nutrients to limit. Showing how each nutrient contributes to the perception of the overall healthfulness of foods in a quantitative manner, has implications for the design of standardized criteria as planned by the FDA.

These findings have major implications for the emerging technique of nutrient profiling, described as a science of ranking individual foods based on their nutrient composition. Nutrient profiling provides a basis to quantify the overall nutrient value of foods and convey it to the consumer at a glance[1].

The FDA is also planning to explore the use of FOP labels by different consumer groups. Different households may use nutrition information in different ways[16,17]. The present analyses by gender showed that women were much more influenced by nutrient content claims than were men. These data are consistent with past studies showing that both women and better educated consumers were more likely to read and use nutrition labels[18–20]. Some studies found that the elderly used nutrition labels less but others did not[21,22]. In the current sample of mostly educated women, education and age played a relatively minor role.

Several previous studies have explored ways in which consumers interpreted favourable nutrition claims for foods that also contained nutrients to limit[23–25]. Participants evaluated a limited number of mock product labels. Typically, such studies featured between-subject factorial designs, followed by ANOVA[23,24]. Other studies explored interactions between the provision of specific nutrient information, consumer demographics, and knowledge[20,26].

The present study represents an application of epidemiological methods to marketing research. Analyses made use of dichotomized variables and an equivalent of logistic regression, with participants making as many as forty-eight rapid judgements, with all stimuli presented online. Conjoint analysis could become the chief tool in the design of FOP signposting, other graphics, or function or health claims, since it can rapidly test the impact of diverse elements on consumer response. Conjoint analysis explores the dimensions underlying consumer perception and their integration into the judgement of nutritional value. Such studies can create prototypes of possible food labels, assess responses and draw conclusions about the underlying dimensions of decision making. All of this can be performed rapidly online.

Some limitations of the methodology must be noted. First, the study was based on a hypothetical food product as opposed to a specific food or beverage. The present results must therefore be treated as a general response to nutrient content claims, and not a response that is tied to a specific product. For example, a much stronger response to added sugars might be elicited with cereals. Future studies will need to focus on specific food categories in turn. Second, the test messages were presented in text format and were not integrated into graphics, labels or logos. Placement of nutrition content claims relative to other advertising copy may well influence consumer response[21]. That too is a matter for future research.

These exploratory data suggest that data collection using online panels followed by conjoint analysis may be a powerful tool for the future testing of nutrition and health claims. Conjoint analysis, a statistical technique that determines how people value different features that make up an individual product, is ideally suited for this purpose. Originating in mathematical psychology[27], it is also known as stated preference analysis or multi-attribute compositional model. The method is used in marketing to better understand consumer reactions to concepts in product development[28,29] and is becoming increasingly popular in consumer research[30]. Conjoint analysis has found applications in studies on the positioning of healthy foods[7]; consumer preferences for logos and labelling formats[31]; consumer responses to the labelling of genetically modified foods[32]; and even to predicting Academy Award winners[33]. In the present version it can be used to deepen the understanding of how consumers process information about the nutrient content of foods.

Acknowledgements

Sources of funding: The data were collected and analysed at the expense of the authors and the studies were not sponsored by any outside source. *Conflict of interest declaration:* There were no conflicts of interest. *Author contributions:* H.M., M.R. and B.K. conceived the study, conducted data and modelling analyses, interpreted the results, and participated in the writing of the report; A.D. participated in the conception and design of the study, interpreted the results, and contributed substantially to writing the report.

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