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# Youth peers put the “invent” into NutriBee’s online intervention

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## Abstract

**Background:** Early adolescents perceive peers as credible and relatable. Peers therefore have a unique conduit to engage early adolescents in positive health behaviors through nutrition learning such as that recommended by the U.S. Institute of Medicine (IOM).

**Purpose:** We developed an online, peer leader component to an existing in-person preventive nutrition intervention called NutriBee. We reasoned that youth ages 13–18 could create intervention materials that could remain engaging, credible and relatable to younger peers ages 10–12 online. Peer leaders could potentially derive health benefits from their service-learning experience.

**Methods:** From 2013–2014 youth could apply online to relate a personal interest to nutrition, an opportunity promoted at NutriBee pilot sites and through social media. The peer leaders with diverse backgrounds honed original ideas into tangible projects with the support of adult subject-matter experts chosen by the youth. Nutrition expertise was provided by NutriBee staff who then also converted the youth-invented projects from various media into an online curriculum.

**Results:** 19 of 27 (70%) of selected youth from 12 states and diverse backgrounds, created an online curriculum comprising 10% of NutriBee’s 20-hour intervention. All 19 online projects modeled 1 or more of NutriBee’s 10 positive health behaviors; 8 evoked the chemosenses; 6 conveyed food texture; and 13 provided social context. Peer leaders perceived career advancement and service learning benefits. The dose, pedagogic approach, and project content align with the IOM recommendation.

**Conclusions:** Youth created intervention materials which communicate positive health behaviors online in ways peers can adopt. In a customarily sight-sound digital platform, youth leveraged the senses of smell, taste and touch and social context important for food selection. Peer leaders derived health benefit, as indirectly assessed by IOM criteria.

**Keywords:** Peer group, Adolescents, Attitude to health, Food preferences, Nutrition, Service-learning, Chemosensory perception, Institute of Medicine, Diffusion of Innovations

## Introduction

In order to create impact, nutrition interventions for early adolescents must identify ways to make nutrition concepts relevant and engaging [1,2]. Incorporation of peers into intervention design and delivery is one strategy for achieving this, as peers are seen as a credible and reliable source of information [3], particularly slightly older (cross-age) peers [4]. Peers are especially important

for early adolescents, as developmentally this is a time-frame in which youth are most susceptible to peer-influence [5].

Peers promote adoption of positive behaviors by helping younger peers connect learning of new material to prior experiences [6], make the abstract concrete [7] and, through collaborative learning, promote higher levels of problem solving [8]. Health interventions place increasing emphasis on narrative forms of communication such as storytelling, entertainment-education, and testimonials, approaches which lend themselves to leveraging peer-influence [9].

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Peer-led nutrition interventions have demonstrated improvements in anthropometric measures [10–12], reduced consumption of snack foods and desserts [10], increased intake of fruits and vegetables [13] and improved psychosocial factors [11,12]. Peer leaders are often used to encourage uptake of novel foods by incorporating taste tests of food items as an intervention strategy [13–17].

Nutrition eHealth interventions are beginning to incorporate peer-leaders using social marketing [18] and video [19]. Electronic platforms can greatly expand reach [20,21], thereby enabling viewers with specialized interests to find compatible peers. However peer credibility of in-person interventions isn't necessarily retained in the transition to electronic platforms. Nutrition interventions may be at a distinct disadvantage in the e-transition since food selection is heavily influenced by non-digital media such as olfaction, gustation, texture and social-cultural context [22], a challenge currently unaddressed in the education and medical research. Nutrition studies in a recent systematic review of electronic health interventions [20] were not peer-led. Furthermore, few peer-led nutrition interventions with strongly positive findings are electronic platforms, a finding which influenced the Institute of Medicine (IOM) to emphasize active learning approaches to nutrition [23].

Because of their inherent relatability and credibility, cross-age youth peers may be uniquely suited to serve as proxy for the taste, smell, texture of foods and the social milieu around which food selections are made. In theory youth-led intervention materials using electronic platforms could retain multisensory and social elements, which could be evaluated alongside behavior change constructs outlined by Diffusion of Innovations [24].

We developed a youth-led component to an existing preventive nutrition intervention called NutriBee [25], reasoning that youth ages 13–18 could creatively direct projects relating their personal interests to nutrition – projects that buttress NutriBee's positive nutrition behaviors and retain elements online that make them credible and relatable to younger peers ages 10–12. A secondary research question is if the youth leaders could derive health benefit through their service-learning endeavors.

## Methods

NutriBee is a middle school-aged (10–12 years of age) nutrition intervention developed at The Johns Hopkins University Center for Human Nutrition to align with the nutrition education characterized by the IOM [23]. NutriBee's primary intervention is a 20-hour IOM-aligned camp and club being disseminated nationally to early adolescents in partnership with community-based organizations and health care providers [25]. Among its engagement strategies are household reach thru child-as-change-agent activities aimed to strengthen impact at

the household level impact, a planned national team-based bee-style game show, and the peer component called Bee Quest (Figure 1) [26].

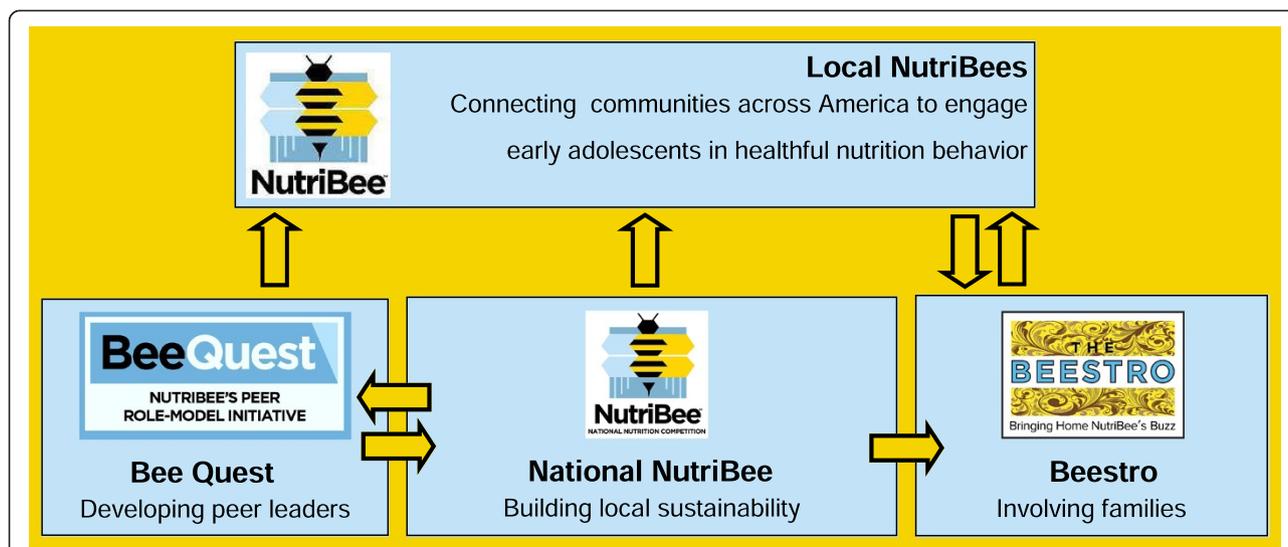
Bee Quest involves high school-aged (ages 13–18 years) peers developing questions for the bee game through an original project (quest) that relates their interest, talent or hobby to nutrition. Promotional material and recruitment for Bee Quest emphasized that youth choose projects based on an activity they are passionate about, however remotely it may initially seem related to nutrition. While some examples were given, youth ultimately developed their own project ideas and were the creative directors, choosing the project deliverables and an adult coach as a subject-matter expert. Each project required three parts: Original project in the form of a video, slide presentation, essay, artwork, or computer application; a biosketch from the peer inventor(s); and a project-specific quiz called "Bee Questions" [26]. Developing quiz questions for the game show was intended to deepen the peer leaders' nutrition knowledge and service-learning reflection.

Bee Quest 2013 recruitment was directed to NutriBee's 9 pilot communities – ethnically-diverse, low-income areas in Maryland, Michigan, New Mexico and Guam – where community leaders held information sessions and sent emails. Bee Quest 2014 was promoted nationwide January through March of 2014 on NutriBee's website, organizational list-serves (The Explorers Club, The Johns Hopkins Center for Talented Youth, Math Tree, Here There Everywhere Kids News), Linked-in nutrition interest groups, and word-of-mouth plus social media from past participants. The one-page applications were evaluated on the youth-coach team's area-specific qualifications; project feasibility within the budget, timeframe and web-application parameters; and ability to expand nutrition's perceived breadth. All completed applications were selected.

Upon project completion participants received a stipend, certificate, service learning credit and technical expertise for adapting their unique projects to NutriBee's website. Coaches received a stipend, collaboration with NutriBee, access to resources and youth service-learning that directly benefits their organization.

A focus group taking place on 4/12/14 at the Cosmos Club in Washington DC was led by IK and involved 3 youth participants, 2 parents and 5 coaches (N = 10). The in-person focus group was limited by the program's nationwide spread. Its aim was to generate discussion on the perceived benefits of participating in Bee Quest to guide the collection of process data.

Program metrics, media coverage, process evaluation, the focus group and educator assessment were used to assess Bee Quest on the following objectives:



**Figure 1** Bee Quest is NutriBee's peer-led intervention where youth develop questions for the National NutriBee and online project materials for the otherwise in-person 20-hour nutrition intervention implemented in partnership with community programs.

#### Diversity of topics and youth backgrounds

Geographic, gender, socioeconomic and ethnic diversity among peer leaders was reasoned to generate projects likely to be compatible with the correspondingly diverse early adolescent viewers.

#### Service impact

The primary service is the youth projects presented online to be viewed by early adolescents. The 19 youth projects presented online were independently viewed by five (5) health and education professionals with the following backgrounds: Preventive medicine physician; doctor of social anthropology; nutrition education specialist who is also the vice president of academic affairs at a university with community service in its mission statement; university professor specializing in online and virtual education materials for early adolescents; and a doctoral candidate in behavioral health. The potential of the intervention materials to promote adoption of positive behaviors among early adolescent peers was characterized by the presence of the NutriBee's predefined key health behaviors; inclusion of chemosensory, tactile and social elements; and the five (5) constructs comprising Diffusion of Innovations.

#### Health impact on peer leaders

The health benefit to peer leaders was assessed indirectly by achievement of IOM recommendations for high school students [23]. These are an annual dose of 20 hours, hands-on (active) learning with adult guidance, and focused on nutrition and/or fitness.

#### Service-learning benefit

Service learning benefit to peer leaders was assessed by process evaluation. Youth completing Bee Quest were asked how they felt that they had most benefitted, by selecting the 2 top benefits from the list of 5 developed with the focus group. Health benefits were not listed since these were indirectly assessed separately.

The Johns Hopkins Bloomberg School of Public Health IRB reviewed and approved NutriBee pilot research (IRB #4821) and the photo release form used for Bee Quest project participants.

Bee Quest webpage's layout was designed in such a way that future NutriBee viewer audience's interaction with the page can be analyzed using Google Analytics. Clickable thumbnail images of the projects are alphabetized by subject matter to minimize potential bias associated with page placement. A generic template (macro) was implemented to unify the projects' various forms of media and styles, yet retain their originality.

#### Results

Bee Quest participants hailed from 12 states and online projects were from NutriBee pilot areas. Participant photos accompany 18 (95%) of online projects and are anticipated to help connect with middle-school age viewers of diverse gender, race and ethnicity. The 27 project topics presented in Table 1 are varied: 5 (19%) art, 5 (19%) athletics, 4 (15%) culture, 4 (15%) ecology, 4 (15%) journalism, and 5 (19%) STEM (science technology engineering math).

Of the 27 projects 25 (93%) contributed to NutriBee overall (Table 2) and 19 (70%) are featured on its webpage, where they collectively comprise 2 hours

**Table 1 Youth projects supported through Bee Quest 2013 and 2014**

| 2013 | Project title  | Category of student's chosen topic |
|------|--|------------------------------------|
| 1    | Food as symbolism in a Nigerian wedding                                    | Culture                            |
| 2    | Sound nutrition: Theme music for NutriBee performed on kitchen instruments | Art                                |
| 3    | Nutrition-themed scavenger hunt at the Walters Art Museum in Baltimore     | Art                                |
| 4    | I salute you, you feed me: Nutrition in the military                       | Journalism                         |
| 5    | Nutrition in action: Nutrition-themed field games                          | Athletics                          |
| 6    | Competitive gymnast interviews athletes on hydration                       | Athletics                          |
| 7    | What owl digestion teaches us about human nutrition                        | STEM                               |
| 8    | Not-so-trivial nutrition quiz kickball                                     | Athletics                          |
| 9    | Fishing in the Anishinaabe tradition                                       | Culture                            |
| 10   | Preparing an Ojibwe feast.   | Culture                            |
| 2014 | Project Title  |                                    |
| 1    | Ballet: Nutrition expressed through movement                               | Athletics                          |
| 2    | Comic strip illustrating a recipe called Prime Number Parfait              | Art                                |
| 3    | Card game for preteens promoting food selection and portion sizes          | STEM                               |
| 4    | The origins of Peking Duck   | Culture                            |
| 5    | An app for apt hydration   | STEM                               |
| 6    | Transforming a dietary restriction into an opportunity                     | STEM                               |
| 7    | Good for you and good for your planet: A grocery store scavenger hunt      | Ecology                            |
| 8    | An edible wild plant scavenger hunt in West Virginia's mountains           | Ecology                            |
| 9    | Geocaching for health  | Ecology                            |
| 10   | Illustrating pet nutrition   | Art                                |
| 11   | A journalistic news story on trending towards nutritious foods             | Journalism                         |
| 12   | A news story on food blogs   | Journalism                         |
| 13   | Pottery: Life extension for fruits and vegetables                          | Art                                |
| 14   | Nutrition-themed game for a baby shower                                    | STEM                               |
| 15   | Wilderness food preparation for scouts                                     | Ecology                            |
| 16   | Interviewing Verron Haynes, Superbowl XL Champion                          | Journalism                         |
| 17   | Running hydrated   | Athletics                          |

**Table 2 Process evaluation parameters**

| Parameter   | n  | Percent (%) |
|---|----|-------------|
| Project ideas submitted   | 27 | 100         |
| Bee Quest 2013 and 2014 awarded projects                                | 27 | 100         |
| Projects completed  | 24 | 89          |
| Projects incorporated into NutriBee online curriculum                   | 19 | 70          |
| Projects contributed to database of game show questions (Bee Questions) | 25 | 93          |
| Solo versus team projects   | 23 | 85          |
| Project coach directs a youth program                                   | 16 | 59          |
| Coach is a friend or relative of participant                            | 9  | 33          |
| Presented project in person at NutriBee pilot (2013 only)               | 5  | 50          |
| Featured in the media   | 9  | 38          |

of online activity, 1/10<sup>th</sup> of NutriBee's intervention materials.

The educator and health professional reviewers (IK, PG, LS, EAS, KR) report their assessment in Table 3. Collectively the 19 projects address each of NutriBee's 10 positive nutrition behaviors, and 2 or more of 5 reviewers found that all projects reference at least 1 of these 10 behaviors. Despite the conventional limitations of digital media, 2 or more of the 5 reviewers found that 8 (42%) projects modeled chemosensory aspects of food, 6 (32%) exhibited tactile interaction with food such as its texture or touch and 13 (68%) guide viewers through an aspect of the social milieu influencing food choices.

With Diffusions of Innovation constructs the five reviewers successfully characterized how each project is likely to lead to behavior change. In Table 3 projects were characterized in terms of: 1. Advantage of the new approach

**Table 3 The health behaviors, sensory and social elements, and Diffusion-of-Innovation constructs which youth incorporated into their Bee Quest projects**

| Youth-developed Bee Quest Projects   |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |
|--|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|
| The abbreviations are the project topics as listed alphabetically on <a href="http://NutriBee.org/BeeQuest">NutriBee.org/BeeQuest</a>  |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |
|  | ac | ah | cg | ca | cc | cz | cp | ec | fb | ge | il | jo | mh | mu | np | po | ph | ru | sj |
| <b>NutriBee's Key Health Behaviors</b>   |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |
| N= 5: Experts independently reviewed the 19 projects for the presence of the following health behaviors.   |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |
| Mindful eating   | 5  | 0  | 2  | 4  | 4  | 4  | 0  | 2  | 2  | 2  | 1  | 2  | 2  | 2  | 2  | 4  | 1  | 1  | 1  |
| Balanced portions  | 0  | 0  | 5  | 2  | 0  | 0  | 0  | 2  | 0  | 0  | 0  | 5  | 0  | 0  | 1  | 1  | 4  | 1  | 2  |
| Less sugar   | 1  | 2  | 3  | 0  | 0  | 0  | 0  | 2  | 1  | 1  | 0  | 5  | 0  | 0  | 1  | 1  | 2  | 4  | 5  |
| More fiber   | 1  | 2  | 2  | 1  | 0  | 0  | 0  | 2  | 1  | 1  | 4  | 1  | 0  | 0  | 1  | 1  | 2  | 1  | 1  |
| Plant-based  | 2  | 2  | 4  | 4  | 1  | 0  | 0  | 3  | 1  | 1  | 1  | 5  | 0  | 0  | 5  | 4  | 5  | 2  | 2  |
| Better fats  | 1  | 0  | 1  | 1  | 0  | 0  | 0  | 2  | 1  | 3  | 1  | 4  | 0  | 0  | 1  | 1  | 1  | 0  | 5  |
| Hydration  | 0  | 0  | 0  | 0  | 0  | 0  | 5  | 0  | 0  | 5  | 0  | 0  | 5  | 0  | 0  | 0  | 2  | 5  | 4  |
| Breakfast  | 0  | 4  | 1  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 1  | 0  | 0  | 0  | 0  | 1  | 0  | 0  |
| Connect food with nature   | 3  | 4  | 0  | 4  | 4  | 0  | 0  | 4  | 2  | 0  | 4  | 2  | 0  | 1  | 5  | 2  | 1  | 3  | 0  |
| Food safety  | 3  | 0  | 4  | 0  | 2  | 0  | 0  | 4  | 2  | 4  | 0  | 0  | 0  | 2  | 1  | 5  | 5  | 1  | 1  |
| <b>Multisensory Constructs</b>   |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |
| N=5: Experts independently reviewed the projects for use of sensory and social elements.   |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |
| Chemo-sensory  | 5  | 0  | 2  | 0  | 4  | 3  | 0  | 4  | 4  | 4  | 0  | 0  | 0  | 0  | 0  | 3  | 0  | 1  | 0  |
| Touch and Texture  | 5  | 0  | 2  | 0  | 5  | 3  | 0  | 4  | 0  | 0  | 0  | 0  | 0  | 1  | 0  | 4  | 0  | 1  | 0  |
| Social context   | 5  | 4  | 4  | 1  | 4  | 0  | 0  | 4  | 5  | 2  | 1  | 3  | 5  | 4  | 0  | 0  | 4  | 4  | 5  |
| <b>Diffusion of Innovation Constructs</b>  |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |
| The data is a sum ranging from 5-15: 5 reviewers independently considered the 19 projects using a 1-3 Likert scale, where 1 indicates that the construct was minimally represented and 3 indicated the construct was strongly represented. |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |
| Relative advantage   | 5  | 10 | 7  | 9  | 8  | 5  | 9  | 14 | 9  | 10 | 5  | 15 | 5  | 9  | 10 | 15 | 9  | 14 | 15 |
| Simplicity   | 11 | 13 | 14 | 11 | 12 | 12 | 5  | 13 | 9  | 9  | 6  | 10 | 11 | 15 | 15 | 15 | 11 | 14 | 11 |
| Compatibility  | 10 | 9  | 13 | 13 | 12 | 7  | 9  | 14 | 14 | 14 | 9  | 12 | 7  | 13 | 12 | 5  | 8  | 12 | 15 |
| Observability  | 9  | 7  | 14 | 13 | 13 | 7  | 12 | 14 | 11 | 12 | 10 | 7  | 11 | 12 | 10 | 10 | 10 | 10 | 8  |
| Triability   | 11 | 11 | 10 | 6  | 8  | 8  | 5  | 12 | 11 | 9  | 11 | 12 | 6  | 13 | 12 | 14 | 10 | 15 | 15 |

over the currently used one. 2. Simplicity. 3. Compatibility with viewers. 4. Observable results. 5. Triability which is how easily the approach can be experimented with before fully used.

Secondary service impact was noted: Youth contributed 180 questions to NutriBee's "Bee Question" database. Sixteen projects had coaches affiliated with youth organizations who received service benefit from the youth projects. Nine participants were interviewed or had their projects featured in the six newspaper and magazine articles citing Bee Quest [27-32].

Participants averaged 20 hours of project-related nutrition learning and received guidance from two or more adults, usually coaches, mentors, school teachers, parents or NutriBee's team.

Focus group participants identified five benefits (Table 4), other than the health benefits assessed separately. All 22 (100%) Bee Quest participants responded to the process question on the two non-health benefits of participation

that most related to them: Strengthening college application 17 (77%); service-learning 10 (45%); resources and coach 9 (41%); stipend 5 (23%); and original work featured on website 3 (14%). Having their original work featured on the website was of great interest to youth participants, but

**Table 4 Bee Quest youth responses to benefits of participation**

| Perceived benefits of participation  | n  | Percentage |
|--|----|------------|
| Strengthen college application   | 17 | 77%        |
| Help others while doing what I enjoy (service learning)                    | 10 | 45%        |
| Resources and coach to further develop my personal interest or career path | 9  | 41%        |
| Stipend (Amazon gift card)   | 5  | 23%        |
| Original work featured on NutriBee's website                               | 3  | 14%        |

Participants selected the 2 of 5 benefits, other than health, which most applied to them. All 22 (100%) participants responded.

primarily as a way of strengthening their college application and helping people.

The health impact of participating in Bee Quest was indirectly measured. Bee Quest meets the criteria for service learning which is a form of hands-on learning highly correlated with lifelong learning and behavior change [33]. The exposure level or dose was 20 hours of hands-on learning as recommended by the IOM [23], with at least two adults involved in guiding the youth participants' learning process. The findings are corroborated by the five (5) parents and coaches attending the focus groups, and by the process evaluation respondents who indicated that nutrition's relevance to their career choice and personal interests was strengthened.

Web analytics for NutriBee are as follows: from 9/1/14 thru 3/10/15 NutriBee had 3,037 views of which 2,143 (71%) were in the U.S. and 618 (11%) were visits to the Bee Quest webpage. Coding will need to be embedded into each student thumbnail project to assess project-specific analytics for future data collection.

## Discussion

The creative directorship from NutriBee's peer leaders and the online accessibility of the youth-developed materials are benchmarks for peer-led nutrition interventions. Our findings support our primary research question, that ultimately the creativity and innovation modeled by the youth peer leaders would enable their service-learning projects to retain relatability and credibility when transferred to a digital platform. Peer-created intervention materials have potential to reinforce positive nutrition behaviors among early adolescents, based on their infusion of the health behaviors emphasized in NutriBee, retention of sensory and social elements, and the presence of Diffusion of Innovations adoption factors [24].

Other appropriate health behavior change models for nutrition include Social Cognitive Theory, Theory of Reasoned Action/Theory of Planned Behavior, Integrated Behavior Model, and Transtheoretical Model [34]. Bee Quest materials were not evaluated for social cognitive learning because they are intended as interventions rather than learning *per se*, and social learning theories stop short of explaining the motivations for learning which are ultimately what prompt behavior change [21]. Similarly, the Transtheoretical Model focuses upon stages of change for risky or addictive behaviors for adults and adolescents, rather than taking a broader, ecological approach to understanding factors influencing lifestyle nutrition, which are youth-relevant behaviors not pertaining to addiction medicine [35].

Involving youth peers in food-related chemosensory experiences has been successfully implemented in only a few in-person taste testing [13,15], no community gardening interventions [36,37], and one cooking intervention

[19] published following a review article citing the lack of peer-led cooking interventions [38]. Further we found no eHealth or mHealth (mobile device) interventions specifically intending to evoke the senses that guide food selection beyond the otherwise sight-sound realm of electronic media [39-43].

The importance of chemosensory awareness during early adolescence was first underscored by a pediatrician, Marie Montessori [22]. A century later it is at the nexus of medical research ranging from basic neuroscience to social anthropology [44,45]. Clinical relevance is further punctuated by widespread use of prescription medications with nuanced, individualized and unknown yet preventable effects on food selection among youth [46,47]. Physicians are therefore uniquely positioned to encourage nourishing food selection among their early adolescent patients. Given the limited time that most physicians have with their patients, referral to easily-accessible online intervention materials is a preventive medicine tool meriting further study.

Our programmatic findings appear synergistic with the U.S. public health aim to implement 20 hours of hands-on learning in nutrition annually to school children including at the high school level (ages 13–18). The IOM recommendations represent a 10-fold increase in nutrition education, suggesting an urgent need for partnering organizations and leveraging resources. Since Bee Quest participants can be identified through health clinics as well as schools, health care professionals may want to recommend that their adolescent patients consider participating in future annual Bee Quests as a preventive medicine intervention.

In keeping with the Bee Quest students' perceived benefit, service-learning is widely considered advantageous to otherwise equally qualified college applicants especially when service is part of the institution's mission [48]. The American Association of Colleges and Universities (AAC&U) has identified service learning and community-based learning as one of 11 high-impact educational practices in higher education, because it allows students to apply classroom concepts to community problems and issues and to reflect on their service experience [48]. In Bee Quest high school students address the community issues surrounding junk food and chronic diseases for NutriBee and its virtual community of early adolescent peers. Bee Quest may be able to address the growing demand in U.S. high schools for service-learning opportunities [49], especially initiatives that attract high school talent into health professions, and can involve youth with learning or physical disabilities. Service learning opportunities in low income communities such as those reached by NutriBee are fewer but tend to have greater impact [50].

A study limitation is that the health impact on early adolescent viewers and youth participants has not yet

been directly assessed. Researchers may implement and evaluate the program materials among early adolescents in their community or health center. Bee Quest intervention materials are open access [26] and a piloted NutriBee Youth Impact Questionnaire is available to assess health impact of engaging in the Bee Quest materials [25].

## Conclusions

Our youth-invented online projects model NutriBee's 10 positive health behaviors, and contain elements which foster adoption of these behaviors by early adolescent viewers. Notably despite the conventional limitations of online materials, the intervention materials incorporate multisensory elements and social context increasingly important to clinical practice. Youth leaders derived health and career benefits through their service-learning projects, a synergy which could be further developed to include immigrants and youth with learning disabilities.

## Competing interests

Ingrid Kohlstadt is the founder and Executive Director of NutriBee National Nutrition Competition, a nonprofit organization created to disseminate the NutriBee intervention developed and researched at Johns Hopkins University. Elizabeth Anderson Steeves, Kerry Rice, Joel Gittelsohn, Liane M. Summerfield, and Preeti Gadhoke have no financial or non-financial disclosures.

## Authors' contributions

IK designed and implemented the Bee Quest component of NutriBee, which she developed and researched. She has led the manuscript development. EAS has been instrumental in the study design and literature on peer-led nutrition interventions. KR is a professor of education with expertise in virtual education and online platforms. She researched the education literature for virtual pedagogic approaches to include chemosensory and social elements. She proposed applying Diffusion of Innovation Theory to our analysis. JG is the Principal Investigator of the NutriBee study and has been instrumental in the study design. LS is an Associate Vice President for Academic Affairs at a U.S. university as well as a nutrition educator, two perspectives enabling her to develop the service-learning aspect of the manuscript, given that most Bee Quest participants are college applicants. PG is a nutritional anthropologist who has contributed to the behavior change theories discussion and integrated Bee Quest with NutriBee's household level impact. Note: All coauthors reviewed, approved and commented on drafts of the manuscript.

## Authors' information

Biosketches of all authors are available online: <http://www.nutribee.org/team/>.

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