

Perspective

Yoga Kernels: A Public Health Model for Developing and Disseminating Evidence-Based Yoga Practices

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Abstract

Many people are drawn to yoga for its potential health benefits. With its rising popularity, yoga could become a widely used public health intervention, but its success depends on finding evidence-based yoga practices that are acceptable and feasible for a large segment of the population. Complexity and variability create barriers to the adoption and maintenance of yoga practices. In an effort to improve the study, adoption, and maintenance of therapeutic practices used in the context of public health interventions, we introduce the concept of “yoga kernels,” defined as discrete, evidence-based yoga practices that are amenable to scientific study and can be effectively disseminated as a public health intervention. Yoga is reviewed from the standpoint of a public health intervention using the Reach Effectiveness Adoption Implementation and Maintenance (RE-AIM) model. This model is designed to improve the successful adoption and maintenance of generalizable, evidence-based interventions. In response to the challenges to the adoption and maintenance of yoga practices, we propose that a potentially fruitful direction for yoga research is moving away from studying yoga classes to studying specific yoga practices that are simpler and easier for the general public to use. Yoga kernels could be a unifying concept to identify therapeutic uses of yoga and help people adopt and maintain these practices as part of a systematic public health strategy. *Smith, Lyons, & Esat. Int J Yoga Therapy 2019(29). doi: 10.17761/2019-00024.*

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Introduction

Yoga is an ancient, comprehensive, and heterogeneous set of mind-body practices that often include a spiritual component. Research on the relationship between yoga and health has focused primarily on three aspects of these practices: Movement (asana), breathing (pranayama), and meditation.^{1,2} A growing number of studies have documented specific benefits of yoga practices on health, behavior, and well-being. These potential benefits, combined with the growing popularity of yoga, could make yoga an effective public health intervention. However, surveys show that the adoption and maintenance of yoga practices in the United States are limited, indicating formidable challenges to making yoga a widespread therapeutic public health intervention.

This article proposes an innovative public health approach to yoga that focuses on “yoga kernels”—evidence-based yoga practices taught in a simple and understandable manner. An example of a yoga kernel is belly breathing to manage acute stress. Ample research shows the benefits of belly breathing; best practices in belly breathing have been refined empirically, and there is a plausible rationale for teaching and using this practice.¹ Belly breathing is acceptable and feasible in almost any setting as it does not require any special equipment, clothing, or space. Nevertheless, the science and practice of yoga have not come together to make belly breathing a widely adopted public health intervention. The 2012 National Health Interview Survey (NHIS) found that only about 11% of Americans reporting using belly breathing.³

The present article is a call for scientists, the yoga community, and public and private institutions to work together to identify therapeutic yoga practices that meet pressing public health needs and to substantially increase the adoption and maintenance of evidence-based yoga kernels in everyday life.

The Rising Popularity of Yoga

One of the most important justifications for developing a public health approach to yoga is the tremendous rise in popularity of yoga in the United States. The U.S. yoga industry has experienced considerable growth in recent years, making it more accessible to people of all ages.³ The NHIS found that the percentage of U.S. adults who practiced yoga increased from 6.1% in 2007 to 9.5% (i.e., 22.82 million people) in 2012. Statistically significant increases were found for every age group,³ including children under the age of 18.⁴

Similar to the NHIS, a series of surveys commissioned by the Yoga Alliance show considerable growth in the percentage of Americans practicing yoga. In 2008, a Yoga Alliance-sponsored survey estimated that about 6.8% of Americans (15.8 million) were active yoga practitioners.⁵ In the 2016 version of the survey, an estimated 15% of Americans (36.7 million) had practiced yoga in the previous 6 months, and 28% (68.5 million) Americans had practiced yoga at some point in their lives. Furthermore, the authors of the 2016 survey estimated that 34% of Americans were likely to practice yoga in the next 12 months, including 23% of current nonpractitioners who said they were likely to try yoga in the next year.⁵ Thus, the number of persons practicing yoga has increased substantially and is expected to continue to grow. However, almost as many persons have stopped practicing yoga as have practiced in the past 6 months, so efforts are needed to support and maintain the use of yoga in everyday life.

Positive Research with a Major Limitation

The rising popularity of yoga is driven, at least in part, by the presumption that yoga practice improves physical health and overall well-being. Many people are practicing yoga with the goal of self-improvement. For example, about 90% of Americans said they were familiar with yoga, and 80% said they thought yoga was good for you.⁵ The expected positive physical and mental health benefits were among the main factors predicting the likelihood of practicing yoga.⁵

Confidence in yoga's putative health benefits is bolstered by empirical research demonstrating the practice can improve a wide range of disorders, biomarkers of health, and quality-of-life indicators. It is beyond the scope of this article to review all of these findings, so below we survey several reviews that illustrate the range of empirical evidence for the benefits of yoga. Interested readers are encouraged to keep current with the vibrant, growing literature on the therapeutic effects of yoga.

Some of the physical benefits of yoga have been known for years. Evidence indicates beneficial effects of yoga on blood pressure, body composition, and glucose and lipid profiles.⁶ Some reviewers have argued that, compared to

other forms of exercise, the benefits of yoga are consistently as good as or better on most outcomes.⁷ Taken together, these biomarker and exercise findings indicate that yoga may improve overall physical health.¹

In addition to the physical benefits of yoga, research strongly supports the mental health improvements associated with the practice. There is strong evidence that yoga can reduce anxiety and depression in adults.⁸ Yoga appears to improve symptoms of attention-deficit/hyperactivity disorder (ADHD) in children.⁹ Mindfulness-based interventions, which stem from yoga, can reduce stress and anxiety in children.¹⁰ Yoga has also been identified as an intervention that improves executive functioning in children.¹¹

Another research finding is that yoga is relatively safe. A systematic review of adverse events in yoga studies found no elevated risk compared to exercise control or care-as-usual comparison groups.¹² This is an extremely important finding because safety is a key component of a public health intervention.

Despite these encouraging findings, heterogeneous effects of yoga have been observed. One of the most striking examples is research on the effects of school-based yoga designed to improve socioemotional or school-related outcomes. A review of high-quality studies found that, on average, the effect sizes of yoga equaled 0, but that specific studies report effects ranging from large and negative to large and positive.¹³ None of the studies found the same size effects. Similarly, the research on mindfulness-based interventions for posttraumatic stress disorder (PTSD) demonstrates wide variability in the direction and strength of yoga's effects.¹⁴

We contend that one major reason for these contradictory findings is that researchers have devoted limited attention to describing key aspects of yoga classes, such as attendance, engagement, content, and quality. For instance, in a review of school-based yoga, only 4 of 12 studies reported attendance; only 1 study out of 12 reported having a systematic description of the yoga class, and this was the only study to report on the quality of yoga classes.¹⁵ This situation illustrates that one of the biggest challenges in yoga research is defining and measuring yoga.¹⁶ If yoga is to be used as a therapeutic public health activity that is likely to have consistent positive effects across persons and places, we postulate that some components need to be standardized to allow for rigorous empirical investigation of effectiveness and to facilitate clear communication about these practices to the general public.

A New Term for a New Approach to Yoga

From a scientific and public health perspective, simplicity and efficiency contribute to the study and widespread use of

an intervention.¹⁷ Therefore, keeping practices as clear and simple as possible should be a guiding principle in creating standardized yoga interventions to be used in a public health approach. For the purposes of a methodical simplification of an intervention, Embry and Biglan¹⁸ proposed a focus on fundamental units of behavioral change. They called these fundamental units “evidence-based kernels,” which have two defining features. First, research must show that the kernel has a beneficial effect on the desired outcome. Second, the kernel must be complete in the sense that deleting any component of it will render it inert. Thus, behavioral kernels are complete interventions that capture the essence of the practice in the most efficient way possible and have scientific support for evidence of effectiveness.

Drawing on the concept of behavioral kernels, we propose that researchers consider the concept of yoga kernels when developing and implementing yoga-based practices. We define yoga kernels as brief, complete yoga practices that have scientific evidence of a reliable benefit, and must be practiced with integrity to have a positive effect. Some examples of yoga kernels are provided in Table 1. The criteria for sufficient evidence for therapeutic practices vary by discipline. We propose that at least two well-controlled studies should both find benefit, and neither find harm, to support the adoption of a yoga kernel.

We acknowledge the important distinction between yoga kernels and holistic yoga practices. Yoga kernels are the building blocks of yoga and are discrete yoga activities that can have a therapeutic effect. In contrast, the practice of yoga is comprised of many components that are linked together, often in meaningful sequences.¹⁹ Thus, the whole of the components of yoga, such as yoga kernels, is greater than the sum of the parts. Nevertheless, these parts can be

therapeutic in and of themselves, and easier to study and implement than complicated yoga classes or even more involved systems of yoga.

The term *yoga kernel* might strike some readers as odd, which is a deliberate effect. We intentionally created a neologism to evoke curiosity and encourage a novel approach to yoga. Furthermore, the term *kernel* is chosen to sustain continuity in the language of behavioral science, specifically the behavioral kernels described by Embry and Biglan.¹⁸ Eventually, the term yoga kernel might be replaced by a phrase that better fits the scientific and public perceptions of these discrete therapeutic practices. For example, *gem* could be an appealing metaphor for these discrete yoga practices. Gems are the precious components of jewelry; because of its artistic presentation and purpose, the whole of the jewelry is more valuable than the individual gems embedded in it. Furthermore, a collection of jewelry representing a certain design would be more valuable due to the expertise expressed through it.

The notion of gems helps to illustrate a key point related to the science of yoga. Although the standards for the value of jewelry are affected by a large number of subjective values including art, sentiment, and history, the values of individual gems and the criteria for evaluating them are standardized and systematic. Thus, yoga kernels are conceptualized as the gems found in multiple collections of yoga jewelry. These gems have greater value when they are part of a work of art, yet they have universal value as discrete components. Consequently, we propose that it is appropriate to identify discrete evidence-based yoga practices and study them as distinct, stand-alone therapeutic interventions. The relative simplicity of these yoga kernels (or yoga gems, if you prefer) makes them

Table 1. Examples of Yoga Kernels

Kernel Example	Description	Therapeutic Outcomes	Research Support
Belly breathing	Person engages the diaphragm when breathing to reduce stress	Reduced stress, prevention of panic, lower blood pressure, better test performance	Stutz and Schreiber ²⁴ Paul et al. ²⁵
Child's pose	Person holds the pose and engages in subverbal self-coaching to calm down	Reduced aggression	Heffner et al. ²⁶ Robin et al. ²⁷
Power poses	E.g., person holds mountain pose with arms extended	Improved interview performance	Cuddy et al. ²⁸
Progressive muscle relaxation	Person tenses and releases a sequence of muscles	Elimination of phobias, reduced head and body pain	Embry and Biglan ¹⁸
Lovingkindness meditation	Person thinks of positive thoughts about others	Cascade of positive mind-body effects	Kok et al. ²⁹

more amenable to scientific study, adoption, and maintenance over time.

The RE-AIM Model

The ultimate goal of the yoga kernels concept is to stimulate research, teaching, and support for yoga to dramatically improve the use of yoga practices as therapeutic public health interventions. The Reach Effectiveness Adoption Implementation Maintenance (RE-AIM) model is a widely accepted framework developed for public health researchers to consider how to implement effective and generalizable interactions.²⁰ Embry and Biglan¹⁸ provided a detailed discussion of how the RE-AIM model applies to discrete, evidence-based practices such as yoga kernels. Briefly, in the RE-AIM model professionals promoting a therapeutic practice should first consider the target population (i.e., who they want to *reach*). Next, proponents should consider the theory and research regarding the effect of the intervention on the desired outcome (i.e., *effectiveness*). For example, if the target population is people experiencing acute stress, an appropriate yoga kernel would be belly breathing, which has robust theoretical and empirical support, including research refining best practices (Figure 1). As mentioned previously, although belly breathing is an acceptable, feasible, well-understood therapeutic yoga kernel, only about 11% of Americans use it.³ Thus, even when the reach and evidence for effectiveness of a therapeutic intervention are clear (i.e., the R and E in RE-AIM), a widespread public health benefit often requires systematic promotion of the *adoption, implementation, and maintenance* (i.e., AIM) of the therapeutic intervention.

According to the 2016 Yoga in America Study, about 1 in 6 Americans (15%) had practiced yoga in the previous 6 months, and about 1 in 3 Americans (34%) expected to practice yoga in the next 12 months.⁵ This survey result, plus the NHIS, suggest that barriers to adoption of yoga are decreasing. Nevertheless, despite the many known health benefits, the Yoga in America Study suggests that almost 2 out of 3 Americans are not planning on doing any form of yoga in the near future. The perceptions of yoga associated with not planning to practice were that yoga is spiritual, too boring/too quiet, for young people, for really flexible people, or not physical enough.⁵ Thus, most Americans do not associate yoga with a specific therapeutic benefit or target population, as would be recommended by the RE-AIM model. Indeed, most people practice yoga out of personal interest or at the recommendation of friends and family. Only 11% report trying yoga at the recommendation of a health professional.⁵ In summary, most Americans do not view yoga as a therapeutic activity, although about 80% report that yoga is good for you.⁵

Barriers to the Therapeutic Use of Yoga

Based on the Yoga in America Study, one of the major barriers to the adoption and maintenance of yoga practices is lack of appreciation of the benefits of yoga. Many people perceive yoga as less rigorous and less effective in comparison to other wellness activities like jogging or aerobics. This may be true for some outcomes (e.g., aerobic fitness and weight loss) but not others (e.g., control of blood pressure).¹ If yoga teachers and yoga studios, public institutions (e.g., schools and public health departments), and private institutions (e.g., Yoga Alliance, Centers for Disease Control, National Heart Association) promoted the specific health benefits of yoga for specific problems, this might help overcome one of the biggest barriers to adopting and maintaining a yoga practice. Information about yoga kernels that specify reach and effectiveness are one way to efficiently communicate the health benefits of yoga.

Another barrier to yoga found in the Yoga in America Study is the spiritual nature of the practice.⁵ The exact concerns were not articulated by the survey; however, it seems that many shy away from yoga because they expect that a yoga practice requires a dedication to the underlying philosophy. Many people do not have the desire to commit to the spiritual values offered by yoga. The discrete and scientific differentiation of yoga kernels, compared to yoga in a studio or retreat setting, may make yoga more palatable and acceptable to the general public.

Another barrier to the widespread adoption of yoga is the direct cost, such as the fee to attend class, and the indirect costs, such as expenses for yoga clothes, transportation, and time devoted to classes taking away time from possible work time. These costs can easily amount to thousands of dollars per year or more. According to the Yoga in America Study, in 2015 persons in America spent an estimated \$5.8 million on yoga classes, \$4.6 million on yoga clothes, and \$3.6 million on yoga equipment. In contrast, yoga kernels can be provided at little or no direct cost and relatively low indirect costs (e.g., just the time need to practice the skill). Thus, yoga kernels may help overcome some financial and logistical barriers to adopting therapeutic yoga practices.

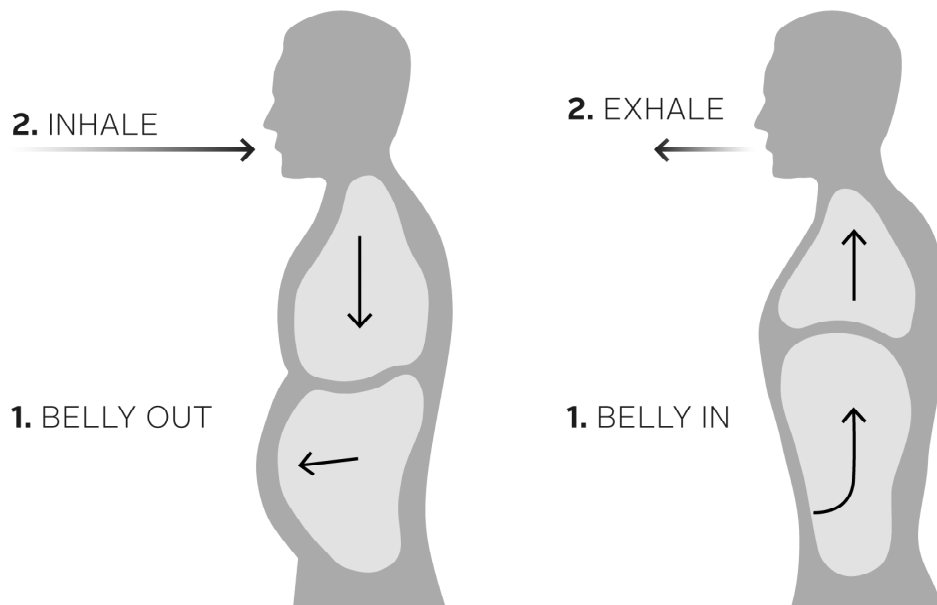
One more barrier to practicing yoga is the complexity of yoga and lack of information about yoga.⁵ From a public policy perspective, adoption and implementation is a function of the simplicity and clarity of the instructions. Yoga classes can consist of hundreds of different poses in an innumerable variety of combinations and sequences. This can overwhelm a new practitioner. We propose that it is easier to implement yoga kernels with fidelity than it is to implement yoga classes. Specific, well-defined, and repeatable yoga kernels can increase participation in yoga.

In some cases, a simple solution can produce satisfactory outcomes without the inconvenience and limitations of

Figure 1. Tip Sheet Example

Belly Breathing for Calm Focus

Belly breathing is a self-calming tool useful in a variety of situations.



CHECKLIST FOR SUCCESS

- Sit upright, back and neck straight
- Rest palms on thighs
- Close eyes or soften gaze
- Close mouth, inhale through your nose
- Focus attention on your breath sensations
- Involve the diaphragm (i.e., stomach expands and bulges out during inhalation, stomach moves towards the spine during exhalation)
- Exhale through the mouth
- Make the exhalation progressively longer than the inhalation
- Repeat ten to twenty times or more

SUGGESTIONS FOR PRACTICE

- Like most skills, deep slow breathing improves with practice. It may not work the first time, or in highly stressful situations, without practicing first.
- Picking a daily time that is calm and quiet to practice is recommended.
- When you are first learning to engage the diaphragm it is helpful to put a hand on the belly to feel the movement of the belly, and then learn body sensations and breathing that leads to the most belly movement while keeping the chest relatively still.

Research Support

- Nasal breathing reduces the “fight or flight” response and encourages a restorative state (Matanoros et al., 1988)
- Focused, deep breathing (i.e., belly breathing combined with a focus on breath sensations) reduces anxiety and improves academic performance in medical students (Paul et al., 2007).

more complex interventions.¹⁸ Complex interventions may require lengthy training of instructors (e.g., 200 hours of yoga teacher training) and a substantial amount of time to implement (e.g., an hour to travel to and from a 60-minute yoga class). In contrast, yoga kernels can be much more accessible to the general public. For example, belly breathing—an effective intervention to improve parasympathetic and sympathetic nervous system balance to reduce stress—could be taught quickly without the support of a highly trained yoga teacher (Figure 1). Also, belly breathing can be used at the point of performance (e.g., in the classroom just prior to a stressful event like a midterm exam). Thus, when compared to a yoga class, belly breathing is the preferred method to teach students to calm down before a test.

Standardization and Dissemination of Yoga Kernels

To increase the adoption, implementation, and maintenance (i.e., AIM) of yoga kernels, we recommend that yoga researchers and practitioners collaborate to create standard yoga kernel instructions. Collaborative development of standards by scientists and yoga practitioners should increase the practices' acceptability among the public as well as enable communication between researchers and practitioners in the field, in turn, leading scientists to develop relevant, applied studies. Critical to the standardization of yoga kernels is a checklist of steps that must take place to implement the yoga kernel with complete fidelity; actions must be broken down into steps that are acceptable and feasible for end-users to implement.²¹ The basic, essential kernel components should be described in detail, with the understanding that each element must be implemented for the kernel to be complete and fully active.¹⁸

Another consideration during the standardization process is to anticipate common barriers or challenges to implementing yoga kernels with fidelity and to articulate guidance to help avoid or overcome those barriers. Moreover, an interactive training procedure that encourages sufficient practice for the yoga kernel to be effective should be developed. Additionally, training should set the expectation that implementation of the kernel is an ongoing process that should become a routine—preferably daily—practice.

After collecting the empirical evidence for the effective use of standard instructions leading to desired outcomes, research-based dissemination strategies should be employed. Implementation science studies have found that tip sheets with simple, engaging instructions have the greatest uptake by the intended user and the greatest effect in practice.¹⁸ Shaw describes the most important principles that help to get the message across through tip sheets based on the science of brief knowledge transfer.²¹

The first guiding principle listed by Shaw is to correctly identify the target users, their specific interests, and their

unique needs and match the tip sheet with the intended audience (i.e., the reach of the tip sheet). For instance, the target population for the belly breathing yoga kernel can be students, members of particularly stressful occupations, or people with specific conditions. For each population, their interest to utilize belly breathing would be different and therefore should be described specifically in a manner geared towards the needs of each distinct target population.

Another important principle to ease the dissemination of knowledge is that a tip sheet should be engaging for the intended user. Shaw²¹ listed a number of effective practices, such as the use of color, photos, and quotes or metaphors, that may intrigue the user. Two overarching considerations when trying to engage potential tip sheet users are clarity and credibility. The opening message on the tip sheet should succinctly convey meaningful, relevant, and important information.²¹ To further enhance credibility, the tip sheet should also include citations to relevant research. It should also be presented in a manner that the target audience can appreciate, such as providing annotated bibliographies of published research evidencing the effectiveness of the yoga kernel. The tip sheet's appeal and impact can be further enhanced by providing links to videos, blogs, or other online resources designed to teach best practices that would encourage the adoption or further exploration of the yoga kernel. As adoption does not guarantee the maintenance of a specific intervention, the following sources of influence can be promoted to encourage the general public to develop daily practice habits.

Tip sheets for yoga kernels can be generated by a variety of sources, including yoga teachers, researchers, public health agencies, journalists, and organizations such as schools or corporations. The yoga kernels in Table 1 were all identified by examining currently available research. New yoga kernels should emerge in the next few years, as research on yoga is growing exponentially. Yoga kernels can be disseminated as paper handouts, via books and websites, and through interactive social media or phone applications.

The Six Sources of Influence Framework

Once people adopt a yoga kernel, the next challenge is to maintain the yoga practice. One of the revelations of the Yoga in American Study was that maintenance is a major challenge with the practice of yoga. About 28% of the survey respondents had practiced yoga at some point in their lives, but only a little more than half had practiced in the past 6 months.⁵ Thus, almost as many people have stopped doing yoga as were practicing.

Efforts to establish and maintain yoga practices need to consider the influence of motivation and ability. The six sources of influence model considers motivation and ability in the context of personal appraisals, social influences, and

structural influences.²² *Motivation* refers to a person's individual interest, the existence of surrounding people who would encourage the action of interest, and the structural environment that would ease the implementation and continued engagement in that action. *Ability* refers to the belief of the person regarding their capability of engaging in an action, the existence of people who could provide training for and feedback about that action, and the structural environment suitable for the implementation and maintenance of that action.

The authors of *Influencer* argue that at least four of the six sources of influence need to be engaged to prompt behavior change.²² A great example of the six sources of influence is a video—"All Washed Up"—about encouraging handwashing.²³ As is clearly demonstrated in handwashing studies, although the rationale and research for handwashing are strong, logic and instruction are not sufficient for changing behavior. Thus, simply handing out tip sheets will not be sufficient to get people to adopt and maintain yoga practices. Ability needs to be enhanced through coaching and practice. Motivation needs to be enhanced through physical and social structures. Ability and motivation can be enhanced by a variety of sources, including yoga teachers and yoga therapists, other professionals (e.g., teachers, physicians, nurses, physical therapists, psychologists, and social workers), persons in the workplace (e.g., supervisors and human resources personnel), and through social media and public information programs that include virtual and direct contact with influencers.

Conclusions

The basic premise of this review is that yoga has the potential to be a highly effective public health intervention. However, significant changes in how yoga is approached by scientists and practitioners are needed to get the general public to adopt and maintain yoga practices. We propose yoga kernels as a promising, novel concept that could simplify and standardize sharing of yoga consistent with state-of-the-art public health practices. The rationale for yoga kernels is presented in the context of the RE-AIM public health model, brief technology transfer methods, and the six sources of influence framework. If these recommendations regarding yoga kernels and related supports are followed, we expect exponential growth in the use of yoga kernels in everyday life, with substantial benefits to public health.

In addition to promoting the more widespread practice of yoga, a substantial benefit of yoga kernels could be much better understanding and communication among scientists studying yoga. Indeed, operationalizing yoga studies with the help of yoga kernels could lead to a paradigm shift. The

common understanding afforded by yoga kernels can improve the effectiveness of yoga research and teaching, which will eventually contribute to improving public health.

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Conflict-of-Interest Statement

The authors declare that no competing financial interests exist.

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