

An overview of current and potential use of information and communication technologies for immunization promotion among adolescents

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Abbreviations: CDC, Centers for Disease Control and Prevention; EU, European Union; GPS, global positioning system; HPV, human papillomavirus; ICT, information and communication technology; MMR, measles-mumps-rubella; MMS, multimedia messaging service; NHS, National Health Service; SMS, short message service; Tdap, Tetanus-diphtheria-acellular pertussis; US, United States; WHO, World Health Organization

Information and communication technologies (ICT), such as the Internet or mobile telephony, have become an important part of the life of today's adolescents and their main means of procuring information. The new generation of the Internet based on social-networking technologies, Web 2.0, is increasingly used for health purposes by both laypeople and health professionals. A broad spectrum of Web 2.0 applications provides several opportunities for healthcare workers, in that they can reach large numbers of teenagers in an individualized way and promote vaccine-related knowledge in an interactive and entertaining manner. These applications, namely social-networking and video-sharing websites, wikis and microblogs, should be monitored in order to identify current attitudes toward vaccination, to reply to vaccination critics and to establish a real-time dialog with users. Moreover, the ubiquity of mobile telephony makes it a valuable means of involving teenagers in immunization promotion, especially in developing countries.

Introduction

One of the most cost-effective ways of promoting global welfare is to expand immunization coverage.¹ Vaccination programs have mainly focused on infants and children, and over the years these have drastically reduced morbidity and mortality due to several diseases. However, teenagers and young adults go on to be affected by many vaccine-preventable diseases.² Therefore, teenagers should be targeted for vaccination;² indeed, health promotion during adolescence must be viewed as crucial, as teenagers constitute the future health and social infrastructure of countries³ and number about 1.2 billion worldwide.⁴

Immunization programs among teens should include three major areas of interest: catch-up vaccines for subjects not fully

immunized previously (such as against hepatitis B, measles-mumps-rubella [MMR], poliomyelitis), booster doses of vaccines received in childhood (e.g., tetanus-diphtheria-acellular pertussis [Tdap]) and primary vaccination with new vaccines specifically targeting teens (such as meningococcal conjugate and human papillomavirus [HPV] vaccines).⁵ Another important issue regards immunization for travel, in view of the fact that many teenagers undertake “bare-backing back-packing” travel and, consequently, could be exposed to greater health risks.⁶

However, current adolescent health promotion programs and interventions often produce only modest benefits. For instance, the 2011 vaccination coverage rate among United States (US) adolescents aged 13–17 y was 34.8% for ≥ 3 doses of HPV vaccine.⁷ In Italy, although HPV vaccination coverage is relatively high (66% for 3 doses among girls of the 1997 birth cohort), it is far from the national objective of $\geq 95\%$.⁸ Therefore, efficacious programs for adolescents require new ways of reaching teenagers and influencing their attitudes.⁹

One way of improving vaccine communication among teens, and thus potentially increasing immunization rates among these subjects, could be to apply information and communication technologies (ICT) to health and healthcare through eHealth, which has seen an exponential increase over the last two decades¹⁰ and has revolutionized the processes of gathering, spreading and utilizing health information among healthcare providers, citizens and mass media.¹¹ Given that the young usually adopt innovative technologies promptly¹² and are particularly receptive to education programs and behavioral modeling,¹³ eHealth provides several opportunities in the field of teenage prevention campaigns.⁹

A large number of eHealth prevention programs targeting adolescents have successfully been implemented. For example, these interventions have proved to be efficacious in obesity prevention,¹⁴ smoking prevention¹⁵ and cessation,¹⁶ reduction of heavy drinking¹⁷ and cannabis use.¹⁸ Conversely, very little research has been conducted on ICT-based interventions aimed at promoting vaccination among teens.¹⁹ In the present paper, we have tried to summarize the main findings of the few studies conducted in this area and to examine the continuing development of ICT—which

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is manifested by the growing number of programs, applications, widgets, etc.—and their potential impact, both positive and negative, on immunization promotion among teenagers. We also describe popular applications and technologies, provide examples of their practical implementation and make some suggestions for how to use them effectively in the future.

Use of the Web for Health Purposes

More than 90% of young people in the US²⁰ and the European Union (EU)²¹ are regular Internet users. Nowadays, the World Wide Web has also become one of the most important eHealth drivers for laypeople;^{22,23} indeed, 72% of Internet users search the Web for health-related information.²⁴ This trend is also seen among the young; in Europe, more than three-quarters of 15–25 year-olds use the Internet to investigate health issues.²⁵ Indeed, surfing the Internet for health information is easier and more convenient, especially for the teenagers, than reading specialized medical literature or visiting a health professional.^{26,27} This “convenience” is chiefly due to the relatively recent transformation of the Internet from a static to a dynamic modality that has enabled the creation of Web 2.0. This new generation of the Internet differs from the previous Web 1.0 in that it has improved interaction and communication among the users of social-networking technologies. The use of the Web 2.0 by health workers and laypeople has generated new terms, such as medicine 2.0 and health 2.0.^{28–30} In other words, Web 2.0 has transformed users from passive consumers to active creators of digital content.³¹ Therefore, Web 2.0 has several advantages for healthcare workers because of the influence of health information acquired online on users’ health choices³² and the opportunity to deliver health information to a large population in an interactive and individualized manner.³³

Health Literacy and ICT

Health literacy is a “constellation of skills, including the ability to perform basic reading and numeric skills required to function in the healthcare environment.”³⁴ Health literacy may influence vaccination decision-making; it has, for example, been documented that persons with an inadequate level of health literacy display lower acceptance of influenza vaccines.³⁵ The term eHealth literacy has also been introduced; this has been defined as “the ability to seek, find, understand, and appraise health information from electronic sources and apply the knowledge gained to addressing or solving a health problem.”³⁶ The Internet has a great potential to improve health literacy³⁷ by means of e-learning, which includes different forms and methods of learning and teaching supported by ICT.^{38,39} This is a promising tool for improving health literacy, as it removes barriers of time and distance, promotes interactivity and learning-on-demand opportunities and reduces costs.⁴⁰ An excellent example of an educational site is the e-bug[®] project (www.e-bug.eu), which was launched in 2006 with the aim of educating children and teenagers about microbiology, hygiene and the spread, treatment and prevention of infectious diseases. It has separate access for

junior students, senior students and teachers, contains various interactive sections, ranging from disease fact-sheets to games and quizzes,⁴¹ and has proved efficacious in improving students’ knowledge.⁴² Specifically, the most downloaded resource document in 2009 was a swine flu fact-sheet.⁴³ The e-bug[®] project has been implemented (in school curricula) in several European countries: Spain,⁴⁴ Portugal,⁴⁵ Italy,⁴⁶ Greece,⁴⁷ Poland,⁴⁸ the Czech Republic,⁴⁹ France,⁵⁰ Belgium,⁵¹ Denmark,⁵² and England.⁵³

An interesting opportunity is also represented by webinars, which are online lectures or presentations⁵⁴ that can be accessed by both medical staff and the young. Indeed, a brief intervention by webinar among healthcare providers has been seen to increase vaccinations among adolescents.⁵⁵

Potential of the Internet to Reduce Disparities in Health Communication

The ability of new technologies to overcome demographic, social, cultural and other barriers enables disparities in health communication among different adolescent subgroups to be smoothed out. For example, immigrant teenagers in Belgium know less about vaccines than native-born adolescents, and the parents of migrant teens constitute a lesser source of information on immunization.⁵⁶ Vaccination coverage among teenagers from ethnic minorities in Canada and the US has been found to be lower than the national averages.⁵⁷ On the other hand, although Internet use tends to be lower among immigrants than among natives, all teenagers in developed countries have almost universal Internet access at school or in public libraries.⁵⁸ Indeed, in a recently published survey on the acceptance of influenza vaccination among ethnic minorities, recipients of a flu vaccine stated that Web 2.0 applications such as Facebook[®] (www.facebook.com) and Twitter[®] (www.twitter.com) had been useful vaccine communication channels for them.⁵⁹

Undoubtedly, the above-described positive features of the Web are can be successfully employed in industrialized societies with high Internet penetration rates. By contrast, in several African and Asian countries, Internet diffusion is still less than 10%.⁶⁰ However, as the use of the Internet is steadily growing in the developing world,⁶¹ this digital divide between developed and developing countries is expected to narrow in the near future.

Anti-Vaccination Movement on the Internet

Despite its advantageous educational opportunities, the Internet could have a negative impact, in that it can spread incorrect and potentially dangerous information on immunization. Indeed, viewing an anti-immunization site for 5–10 min increases the perception of the risk of vaccination and reduces the perception of the risk of disease and its complications.⁶² Moreover, Davies et al.⁶³ discovered that, when the search term “vaccination” was keyed into common search engines, 43% of the first ten results were anti-vaccination sites. Anti-vaccination sites commonly claim that vaccination causes illness; that vaccines are inefficacious, unsafe, toxic, or “unnatural”; that medical,

pharmaceutical or government agencies are involved in conspiracies; that mainstream medicine is corrupt, and so on.²⁶ Anti-vaccination sites usually present a strong emotional component, citing stories of children harmed by vaccines and displaying photos of menacing needles, accompanied by tips on how to avoid vaccinations legally and hyperlinks to other anti-vaccination sites.⁶⁴ Furthermore, unlike institutional sites, the style of writing of anti-vaccination sites is often narrative rather than scientific and quantitative.^{65,66} Indeed, the more technical the publication is, the smaller its potential readership will be.⁶⁷

It has been shown that inputting more complex and specific search terms on vaccines and vaccination turns up fewer anti-vaccination sites.⁶⁸ Thus, typing the single word “vaccination” during a web search yields 60% of anti-vaccination sites, while the term “immunization” turns up only 2%.⁶⁸ Similar results were also obtained by Kata.²⁶ Hence, people with less knowledge of vaccines are more likely to access an anti-vaccination site than more educated persons.^{65,68} Teenagers could therefore be more exposed to incorrect information, as their knowledge of vaccine-related issues has been found to be low.⁶⁹ In a study conducted in 5 European countries, adolescents aged 14–17 y considered themselves not well informed about vaccines and vaccination, and more than 60% said they would like to receive more information on the subject.⁷⁰

The problem of low-quality health information on the web can be partially solved by tagging. Indeed, a social bookmarking service enables users to share hyperlinks to health information sites and rate their quality.⁷¹ Howbeit, as social bookmarking is open to all, there is no supervision of how online resources are organized and tagged, which can lead to inconsistent, incomplete or pejorative descriptions of resources.⁷² Healthcare professionals, in collaboration with laypeople, should prepare and share bookmark lists of useful web resources concerning health issues or adopt a social bookmarking approach for discovering, tagging, sharing, rating and recommending relevant web resources, using vocabulary and terminology that can be understood by all.⁷² Furthermore, as Google[®] (www.google.com) is the most frequently used search engine worldwide,⁷³ a valuable opportunity for screening low-quality web pages is provided by freely downloadable Google Toolbars’s PageRank[®] (www.toolbar.google.com). Google PageRank[®] is an indicator of the importance of a web page and assigns values from 0 to 10, a higher score indicating greater importance. Such a scoring is rather complex and considers the number and importance of pages that link to a web page; the importance of pages linking to a website is assessed, in turn, with accordance to the number and importance of sites linking to those pages.⁷⁴ Griffiths et al. have shown a significant level of association between PageRank[®] and evidence-based websites quality scores. Moreover, this tool requires minimal time and expertise to be used by everyone.⁷⁴

Web 2.0 Applications

The spectrum of web 2.0 applications continues to grow and includes, for example, social networking, wikis, blogging and microblogging, podcasting and content hosting, etc.⁷²

Social networking sites

In 2012, nearly 85% of young people in the European Union posted messages on social media sites.⁷⁵ Social networking services enable users to build their own public or semi-public profile, create a list of other site-users (“friends”) with whom to share connections, and view theirs or others’ lists of connections within the bounded system.⁷⁶ Social networking sites also allow discussion groups to be created, and it has been demonstrated that these virtual groups are also used for health purposes.⁷⁷ It has been suggested that individual health behaviors can be modified by social networks.⁷⁸ Indeed, more than 20% of social network users keep track of updates or their online friends’ health experiences on network sites, 11% post medical queries, and 9% join a health-related group on a media site.⁷⁹ Moreover, it has been shown that even medical students are more inclined to use social network pages on influenza vaccination in an informal language,⁸⁰ rather than the highly technical language that is often used by the websites of official health authorities.⁸¹ The above considerations indicate that social network sites are potentially efficacious in delivering vaccination and health promotion messages to teenagers. For example, in the area of sexual health, the use of Facebook[®] has proved to be at least as effective as the use of other eHealth sources.⁸²

However, some possible shortcomings of social networking sites must be borne in mind. First of all, such sites, particularly Facebook[®], host hundreds of anti-vaccination groups and discussion forums whose aim is to inform the public of the dangers associated with immunization. Incorrect information posted by such groups can spread rapidly, reaching thousands of users.⁸³ Further potential hazards concern the possibility of privacy violations⁸⁴ and the posting of unprofessional content on healthcare workers’ profiles.⁸⁵

Wikis

A wiki is a hypertext Website that enables online users to create and modify the information available to the public. Wikipedia[®] (www.wikipedia.org) is one of the most widely used Web 2.0 applications; available in 285 languages, it has become the largest and most popular general reference source on the Internet.^{86,87} Although there are special search engines for health information, general search engines, such as Google[®] or Yahoo![®] (www.yahoo.com), are the most common starting-points for laypeople searching for health-related information. General search engines, in turn, usually lead to Wikipedia[®].⁸⁸ Indeed, Wikipedia ranks among the first ten results in more than 70% of general Internet search engines, exceeding specific medical Internet encyclopedias such as MedlinePlus (www.nlm.nih.gov/medlineplus/) and NHS Direct (www.nhsdirect.nhs.uk/). This makes it a prominent source of information on health-related topics.⁸⁹ However, owing to the fact that any user can modify information, the accuracy of some articles may be suspect. On the other hand, this openness makes it somewhat peer-reviewed, which enables articles to be kept unbiased, appropriately referenced and updated.²⁶ Indeed, a Wikipedia[®] article on the 2009 influenza pandemic appeared almost instantaneously, while traditional peer-reviewed articles require some time to be published.⁸⁸ It has also been shown that a Wikipedia[®] article “Vaccine controversy”

is the most credible, well-balanced and free from misinformation in comparison with other websites.²⁶ Wikis should therefore be seen as an important tool for global public health promotion and education; healthcare workers should contribute to them by creating high-quality pages, editing and adding information to existing health-related articles.⁸⁸

Blogging

The number of informational and discussion sites (blogs) has increased significantly over the past few years, partly on account of the fact that they can easily be created and maintained even by non-technical users.⁹⁰ Research has shown that most blog readers and creators are young.⁹¹ Blogs focusing on healthcare, i.e., the health blogosphere, can provide interactive support networks, give rise to online discussions of health-related topics, extend social mobilization efforts, and offer healthcare providers an alternative forum for collaboration and consultation.⁹² Thus, blogs may be a useful means of online communication regarding vaccine risks. A recent study has revealed that, in comparison with college students exposed to blogs containing positive information on HPV vaccination, those who viewed blogs that conveyed a negative message regarded the vaccine as less safe, displayed more negative attitudes toward vaccination and expressed less intention to be immunized.⁹³ The use of blogs in planning and managing immunization interventions or specific educational programs could help public health authorities to identify current trends in attitudes toward vaccines, to reply to vaccination critics and assess their reception among users,⁹⁴ bearing in mind that bloggers usually prefer to disseminate ideas rather than prompt interactions and discussions.⁹⁵ Establishing a real-time dialog with bloggers may enable an anti-vaccination sentiment to be rapidly assessed and “neutralized” before it spreads widely and becomes viral.^{94,96}

Microblogging

Microblogging is a relatively new and rapidly spreading form of communication that enables its subscribers to describe their current status by means of short posts, analogously called “micro-posts.”⁹⁷⁻⁹⁹ Twitter[®] is a mobile microblogging and social networking service that allows its users to send and read messages of up to 140 characters, named “tweets.” The popularity of Twitter[®] is also linked to its easy access through a number of platforms (the official website, applications for smart-phones and tablets, and through Short Message Service [SMS] from mobile phones).¹⁰⁰ The large number of Twitter[®] users allows official public health authorities to launch chats with health consumers. Thus, during the last H1N1 pdm09 influenza pandemic, health authorities in North America took steps to update information on vaccines and vaccination clinics and to disseminate government alerts through Twitter[®].¹⁰¹ Moreover, during the 2012 European Immunization Week, WHO-Europe organized a Twitter[®] chat with the aim of answering questions on immunization.¹⁰² Indeed, Twitter[®] may be an important vehicle for health promotion messages because of its ability to share content rapidly and to reach a large number of people through “re-tweets.”¹⁰³

Video-sharing websites

A video-sharing website is an online platform where users can upload and share video clips with other users. The most

popular free video-sharing website is YouTube[®] (www.youtube.com), which has more than 100 million viewers and counts more than 4 billion visualizations a day.^{104,105} YouTube[®] is often used to search for health-related information, and therefore could influence the decision-making process.¹⁰⁶ Content analysis of videos on immunization has revealed a considerable percentage of negative (32%) and ambiguous/contradictory (20%) videos. Moreover, videos conveying negative information on vaccination are more likely to be viewed, rated and discussed than those carrying a positive message.¹⁰⁷ However, an American study on HPV-related videos found a high percentage of positive clips on HPV vaccination and cervical cancer.¹⁰⁶ Therefore, video-hosting Internet sites are another opportunity for healthcare providers to upload high-quality and up-to-date videos targeting the young.

E-gaming

As about 20% of under-18s play video/computer games,¹⁰⁸ educational games (so-called serious games) can facilitate the acquisition and retention of specific knowledge.¹⁰⁹ Schott and Hodgetts¹¹⁰ have described some of the positive health benefits associated with the use of game technologies with regard to several issues, including physical exercise, health education and community participation. Specifically designed serious video games should be viewed as a potentially effective instrument applicable to health-related topics, in view of their proven efficacy in health education and behavior modification.¹¹¹ Simply designed online flash games could be used to familiarize adolescents with vaccination-related topics. Recently, the Centers for Disease Control and Prevention (CDC) launched the “CDC Flu App Challenge” project,¹¹² which uses innovative mobile and web applications, tools and games to raise awareness and educate people regarding the prevention and treatment of influenza. It is important to note that, during the development of these applications, only data from reputable sources posted on the CDC site must be used. For example, in the game “Flu-Ville” (<http://fluapp.challenge.gov/submissions/3034-flu-ville>) a gamer must protect people against rapidly spreading influenza by vaccinating residents, promoting healthy habits and learning about prevention of the disease. A great advantage of the game is its availability on Facebook[®], which makes it easily accessible to adolescents, and the fact that educational aims are achieved via social gaming.

Chat rooms and communities, message boards, and teenagers’ online clinics

Undoubtedly, some topics, such as sexually transmitted diseases and their prevention, can make teenagers feel too embarrassed to talk about their problems with their parents or teachers. Consequently, specifically developed online clinics and chat rooms have become popular sites, where teenagers can access health information and find answers to their questions.¹² The anonymity of a web nickname allows even shy people to write about their personal fears and frustrations in a frank and intimate manner.¹¹³ It has been indicated that such websites, given their strong emotional and support component, should be viewed as critical for health professionals and pharmaceutical producers.¹¹⁴ Moreover, establishing an online dialog between teenagers and healthcare providers may help in other ways, too; healthcare workers can recommend high-quality sites for specific health

issues, advise on search strategies and provide guidance on the critical assessment of the information found.¹²

The disadvantages of online clinics for teens include the risk of miscommunication due to the absence of non-verbal cues, technological delays that may result in a backlog of online patients in virtual waiting rooms, privacy concerns¹⁵ and the possible difficulty of reaching specific adolescent groups with regard to specific immunizations.

mHealth

In the 27 EU states, the number of mobile phone subscriptions increased from 20/100 inhabitants in 1998 to 125/100 inhabitants in 2009.¹¹⁶ The rapid development of mobile technologies has led to the creation of so-called mobile health or mHealth, a branch of eHealth, which could be defined as medical and public health practices supported by various mobile devices. The application of mobile technologies to healthcare may improve both health and health-related economic outcomes through the utilization of numerous instruments, from SMS to fourth-generation mobile telecommunications (4G system) and global positioning systems (GPS).¹¹⁷

SMS-based interventions are an innovative and useful approach for public health authorities, especially in developing countries, owing to the ubiquity and portability of mobile phones, the possibility of choosing between one-way and two-way communication methods, and the ability to combine these interventions with mass media, such as television or radio, in order to engage in two-way communication.^{118,119} Several studies have evaluated the use of SMS to remind subscribers about vaccination. Kharbanda et al.¹²⁰ showed that sending SMS reminders was an effective way of increasing on-time receipt of second and third HPV vaccine doses; adolescent girls whose parents received text message reminders were 13–16% more likely to receive their next vaccine dose than control subjects. SMS reminders have also proved to be well-accepted, and could be more effective than standard phone-call reminders.^{121,122} SMS-based reminders have also proved effective in improving compliance with viral hepatitis A/B and hepatitis A vaccination schedules in international travelers.¹²³ Recently published results from a randomized controlled trial demonstrated the effectiveness of text-messaging intervention in increasing influenza vaccination coverage among low-income children and adolescents (up to 18 y), who are hard to reach by means of traditional methods; coverage in the intervention group was 4.3% (95% CI 2.3–6.3%, $p < 0.001$) higher than in the control group and relative rate ratio of 1.19 (95% CI 1.10–1.28).¹²⁴

Another interesting type of potential vaccination reminder is the use of various free or commercial tools or widgets for smart-phones and other mobile devices or personal computers.¹²⁵ Indeed, 66% of the young own smart-phones and 24% have downloaded at least one health application. These small-size interactive applications enable users to determine their vaccination requirements by inserting their birth date, sex and previous vaccine doses.¹²⁶ Similar widgets indicate travel vaccination needs when a destination country and the time of the stay are

inserted.¹²⁷ Unfortunately, some mobile applications can only be installed on expensive smart-phones, which are not yet available to all people; however, these types of phones are likely to be adopted more widely as their price falls, as in the case of existing mobile technologies.¹²⁸ Finally, vaccination information can be provided by e-Cards, which are the electronic version of traditional postcards. Accessed by recipients via the multimedia messaging service (MMS), hyperlink or e-mail, these have several advantages, in that they can be highly personalized and contain music, flash animation, videos or games.¹²⁹

Concluding Remarks

The younger generation of today, called “Generation Y,”¹³⁰ is the first to have “grown up online.” For these youngsters, ICT is the main means of acquiring information and an important part of their social life.¹³¹ The familiarity of teenagers with new ICT enables public health authorities to utilize eHealth in order to involve the young in health promotion programs, which is often difficult to do by means of traditional methods. Many public health organizations use numerous Web 2.0 applications not only as a broadcasting platform to amplify messages from traditional media sources but also as an entirely new way of collaborating with users and co-creating content. For the first time, this has allowed relationships to be built between users and organizations.¹³²

From the point of view of equity in health, new technologies offer several advantages, as they are accessible, at least in developed societies, to almost everybody, regardless of social, ethnic and other differences. In low- and middle-income countries with limited Internet diffusion, mHealth programs should be considered, as mobile phones are used more than any other modern technology throughout the developing world.¹³³ Moreover, SMS-based vaccination reminders are less costly than other forms of reminders, such as ordinary mail.¹³⁴

Despite the increasing use of the Internet as a source of information on health-related topics, there are no particular requirements for posting health information on the Web. Consequently, Web pages often contain unbalanced, misleading, inaccurate and out-of-date material.¹³⁵ Websites authors should provide health-related information from reputable sources, such as Medline or official health authorities’ sites, update site content and delete misleading information. Several instruments are available to assist writers and site producers in developing high-quality web pages containing clear, objective medical information.^{136–139} In turn, laypeople, and teenagers in particular, must be able to identify and use only high-quality websites. In order to help laypeople to do this, the Global Advisory Committee on Vaccine Safety has drawn up special criteria for assessing website quality in terms of credibility, content, accessibility and design.¹⁴⁰

There is an urgent need to examine the application of eHealth technologies to immunization in an evidence-based manner, in order to assess its real effectiveness in different socio-demographic and geographic settings. Indeed, most research on this issue has been descriptive. Furthermore, although eHealth interventions are presumed to be cost-saving, it is important to

perform economic evaluations of different strategies in order to support policy decisions.

The use of new technologies should be seen as a prospective means of improving vaccination coverage among teenagers and, in order to be more efficacious, can be combined with traditional methods of health promotion, health education and counseling.

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Disclosure of Potential Conflicts of Interest

The authors declare that they have no competing interests.

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