G4H-2015-0026-ver9-Baranowski_1P
Type: white-paper

GAMES FOR HEALTH JOURNAL: Research, Development, and Clinical Applications
Volume 4, Number 6, 2015

DOI: 10.1089/g4h.2015.0026

White Paper

White Paper: Games for Health for Children—Current Status and Needed Research

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Abstract

Videogames for health (video-G4H) offer exciting, innovative, potentially highly effective methods for increasing knowledge, delivering persuasive messages, changing behaviors, and influencing health outcomes. Although early outcome results are promising, additional research is needed to determine the game design and behavior change procedures that best promote G4H effectiveness and to identify and minimize possible adverse effects. Guidelines for ideal use of different types of G4H by children and adolescents should be elucidated to enhance effectiveness and minimize adverse effects. G4H stakeholders include organizational implementers, policy makers, players and their families, researchers, designers, retailers, and publishers. All stakeholders should be involved in G4H development and have a voice in setting goals to capitalize on their insights to enhance effectiveness and use of the game. In the future, multiple targeted G4H should be available to meet a population's diverse health needs in developmentally appropriate ways. Substantial, consistent, and sophisticated research with appropriate levels of funding is needed to realize the benefits of G4H.

Videogames have the ability to engage players in ways different from other media.[1] About 29 percent of videogame players are 18 years old or younger.[2] Games for health (G4H) are an exciting arena for scientific inquiry and a promising intervention modality. In ways unimaginable a generation ago, we are now using sophisticated technology for promoting and assessing health and well-being. Many G4H are built on platforms already familiar to players (such as personal computers, Web browsers, game consoles, and smartphones), making them readily accessible and easy to

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use. Games are believed to provide engagement and enjoyment to encourage repeat gameplay, to facilitate making choices, risky or otherwise, without immediate personal consequences, and to embed behavior change procedures needed to make individual positive health changes.[3]

G4H are being developed and tested across a broad set of diseases (for both prevention and treatment) and health problems. Research has been published on games for medical conditions (e.g., human immunodeficiency virus infection, cystic fibrosis, pain management, Parkinson's disease, obesity), psychiatric conditions (e.g., posttraumatic stress disorder, anxiety, depression, autism spectrum disorder), rehabilitation (e.g., burns, stroke, traumatic brain injury), health-related social issues (e.g., violence, bullying, race bias), public health (e.g., increasing physical activity via active videogames [or exergames], dietary changes, sexual health), employee wellness, corporate wellness, medical staff interpersonal skills training, and medical education,[4] and pediatric cancer patients and survivors.[5]

Although G4H have been developed for all age groups, this report is focused on children and adolescents. Children and adolescents vary in their game genre preferences and ability to master the nuances of particular types of games. Developmental stages are not clearly defined in regard to appropriate gameplay. Little is known about the types of game design elements that appeal to children and adolescents during the developmental periods that children form the requisite cognitive sophistication and executive functioning to appreciate content and game choice options (e.g., in elementary and middle school[6]) or avoid making risky decisions (e.g., in high school[7]).

Pamela Hurst-Della Pietra, MD, Founder and President of the Institute of Digital Media and Child Development (www.childrenandscreens.org), initiated a review of diverse digital media in regard to child health and development. Her goal was focusing the attention of the research, health, and policy communities, as well as the general public, on important and complex G4H issues. Her Institute solicited several White Papers to review research in each of these areas and to report what is known and not known in regard to child health and development, to identify key stakeholders and priority research issues, and to articulate guidelines for relevant media use and further development. This White Paper follows this structure. Many of the leading G4H researchers were invited to contribute to address these important issues.

What Do We Know About G4H?

Games are a form of play or recreation. Play is generally considered beneficial to child development.[8] At their simplest, games have rules, objectives, choices, challenges, points, and criteria for winning or losing,[9,10] but there are variations. Digital games include characteristics of traditional games, as well as other features such as nonplayer characters, deep story or narrative, avatars, interactivity, simulation, virtual or online communication with other players, and feedback on game choices made.[11] Research on games has divided the understanding of playing of games into aspects of ''game design'' (e.g., genre, gestalt, user interface, game mechanics), types of ''interactivity'' between games and player (also called dynamics or gameplay), and the user's ''experience'' of playing the game (also called esthetics [e.g., cognitions, emotions]).[12] Positive experiences from playing a game (e.g., ''fun'') maintain game interest and attract players to return.[13]

Serious games are designed to achieve a purpose besides entertainment[14] (e.g., ''ReMission'' was designed to enhance pediatric cancer regimen compliance[15]). G4H are a subcategory of serious games designed to influence a person's health. At the current time, there are at least five different types of G4H (Fig. 1). Five components are needed to understand the ◀F1 first four game types, including design (e.g., the change procedures incorporated into the game), targeted behavior determinants (i.e., influences on behavior usually specified by behavior theory such as self-efficacy and attitude), targeted behavior (e.g., vegetable intake, smoking), targeted health precursors (e.g., relaxation or anxiety reduction before surgery), and targeted health aspects (e.g., adiposity, lung cancer risk, postsurgical recovery time). Some games have been designed primarily to increase health-relevant knowledge, some have been designed to change health-related behaviors by changing behavioral determinants, some change behavior by incorporating the behavior (e.g., physical activity) into the game design to advance gameplay (e.g., exergames), and some influence health by changing health precursors (Fig. 1). A fifth category includes games to train health professionals in delivering care.[16]

Game design features with cross-age group appeal include the following:

1. *Interactivity:* Players' opportunity to initiate actions and receive evaluative information about their actions.[17]
2. *Feedback:* The often immediate information players receive about the efficacy of their game actions.[18,19]
3. *Agency or control:* The player's ability to manage aspects of gameplay such as the use of control mechanisms and influencing story line.[20]
4. *Identity:* The player's opportunity to become a game character via an avatar and/or to form relationships and linkages with game characters.[21]
5. *Immersion:* A player's sense of presence, transportation, or integration within the game.[22,23]

G4H to increase knowledge

The intersection of experiential (games) and knowledge learning has shown promise for engaging students in academic, health, and societal topic areas.[24–26] Games offering learning opportunities via student-centered learning[27] were more effective than traditional instruction for both student learning and retention in a meta-analysis of 39 studies.[28] Teachers reported that serious games were particularly motivating for low-performing students[29]; however, increased knowledge alone may not influence subsequent health behaviors.[30]

Although adoption of instructional technology within classrooms is not widespread,[31] a recent survey indicated 55 percent of teachers used games for education in classrooms at least once per week.[29] Reported barriers to using games in the classroom included insufficient time, high cost, and lack of technology resources.[29] Lack of clear standards and guidelines for game developers makes it difficult to claim a game meets learner requirements.[32]

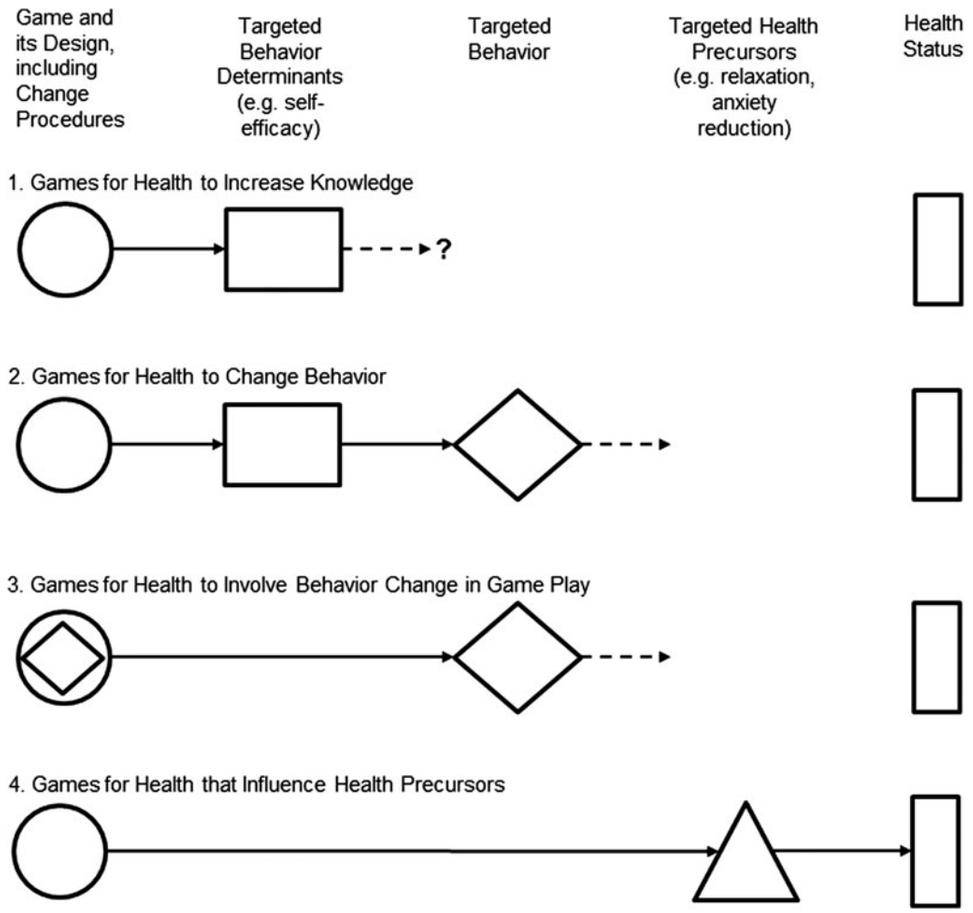

FIG. 1. Four types of games for health.

G4H to change behavior

An early systematic review of 25 diverse G4H revealed that all but one had a positive effect on a learning outcome, but the outcomes were diverse and noncomparable.[33] Since then, substantial numbers of studies have appeared, allowing ensuing reviews to include more circumscribed content.

A recent meta-analysis of 64 games promoting healthy lifestyles revealed games had statistically significant effects on behaviors, stronger effects on behavior determinants, and even effects on health outcomes, although these effects were weaker.[34] A systematic review of 11 videogames for diabetes education revealed nine had a positive impact on knowledge, disease management, and/or clinical outcomes.[35] A systematic review of 19 studies on changes in health or safety behaviors among young persons revealed 17 studies reporting at least one statistically significant effect on behavior.[3] A review of virtual reality and videogames for traumatic brain injury rehabilitation found mostly positive outcomes for balance, upper extremity function, and various cognitive functioning tests; attitudes toward the games were more positive than for traditional therapy, and there were no differences in outcomes between games and traditional therapy.[36] A meta-analysis of seven games promoting sexual health behavior found desired effects on determinants but not the behaviors (but only two studies reported tests of effects on behavior).[37] A systematic review of 64 studies of exergames for therapeutic use revealed promising results for enhancing health among patients who were ill or in rehabilitation.[5] A systematic review of 28 games for obesity prevention found 40 percent of studies had a desired effect on an adiposity-related variable.[38]

Thus, substantial evidence supports game efficacy in influencing diverse knowledge, psychosocial behavioral determinants, behavior, and health outcomes.

G4H that involve physical activity in gameplay

Exergames require physical activity to advance game progress. In the face of a worldwide obesity epidemic, there has been substantial interest in exergames.[39] Dance games, which started in arcades and progressed to living rooms, evolved to use both upper body sensors and lower body mats, capturing both arm swing and fancy footwork. Energy expenditure from exergames performed in the laboratory was higher than in sedentary games.[40] However, when exergames were offered in unstructured places (i.e., children's homes) as part of a rigorous randomized clinical trial, there was no evidence the exergame increased physical activity intensity or duration in a sustained way.[41,42] Exergames did not beat pedometers to motivate increased physical activity over

time.[41] Alternatively, at least five studies indicated exergames could impact body mass index and weight.[15,43–46] Integrating exergaming into more standard pediatric obesity programs showed added benefits for reducing body mass index,[15,45] increasing moderate to vigorous physical activity,[15] and reducing screen time and soda intake.[45] Children (6–11 years old) who played a game linked to their home stationary cycle had higher energy expenditure than those without the game; because this did not result in higher exhaustion, they were able to keep it up longer.[47]

Schools may provide valuable opportunities for exergaming[44,48–50] because of their wide reach in terms of socioeconomic status and ethnic backgrounds.[51] Children and adolescents spend most of their time in school sitting. ''Mobile Class,''[52] an active videogame with school lessons, decreased sedentariness. Active games might enhance interest and competence in physical education.[53–55]

The benefits of gaming (e.g., high appeal, motivation, and fun) may be combined with the benefits of being outside. Because parents prefer their child play outside,[56] outdoor play facilities with game elements, ''Swinxs''[57] and ''YalpSona,''[58] have elicited energy expenditure between 7 and 10 metabolic equivalents of task. No research has been reported on their long-term effects on physical activity behavior change.

Substantial numbers of reviews have appeared in the exergame literature. Some have been very positive, suggesting that exergames provide an important tool to obesity prevention and treatment,[59,60] whereas others have been critical,[40] and some very critical.[61,62] A review of reviews of G4H, but mostly of exergames, indicated the quality of such reviews needed to improve, especially assessments of the quality of studies.[63] It appears that exergames can stimulate moderate to vigorous physical activity under controlled conditions and have led to meaningful physical activity, weight, and cognitive changes under some field conditions, but the contexts in which these changes have appeared have not been clearly determined.

G4H that influence health precursors

Playing some videogames just prior to surgery reduced anxiety (a health precursor), which was associated with better and quicker health outcomes and reduced stay duration in the hospital.[64] Empowerment during gameplay has been proposed as a method for inducing physiological changes that can enhance resilience, reduce fear and anxiety, and enhance health among cancer patients.[65] The interactivity of games (not simply their vivid dynamic sensory stimulation) activated the mesolimbic projection and hippocampal regions of the brain, which were related to more positive attitudes toward cancer chemotherapy.[66] This line of research may identify more health precursor influence pathways (type 4 in Fig. 1).

Processes of change in G4H

Little is known about how children and adolescents learn during gameplay,[67,68] despite demonstrated cognitive benefits of videogames for visual attention,[69] executive functioning,[70] and learning preparation (i.e., learning how to learn).[71] There is also limited demonstration of learning transfer from gameplay to more traditional academic tasks.[72] Complex models have been proposed on how games may influence behavior change,[73–76] which include some combination of attempting to enhance engagement by increasing game ''fun'' (although we may not know what that is),[77] story or narrative immersion,[78–80] successively more difficult levels (sometimes referred to as inducing scaffolding),[81] involving end-users in the game design,[82] and incorporating a variety of behavior change procedures (e.g., goal setting,[83] feedback on aspects of game performance[84,85]). Although some researchers believe G4H may be more fun[86] and gameplay extended[78] through incorporation of a story, the game industry is divided over the success of blending traditional narrative, such as film, with videogame interactivity, believing cut scenes can disrupt gameplay.[86,87] Offering companion stories (e.g., comic books or novellas) may capitalize on the benefits of narrative without disrupting game play.[88]

Despite this promising research on processes of change in G4H, an outcome moderation meta-analysis of 68 lifestyle behavior change game studies revealed many surprises: None of the outcomes (behavior determinants, behaviors, or health indicators) was affected by use of a story, degree of interactivity, rewards, immediate feedback, or tailoring to user characteristics. Degree of challenge (no challenge versus challenge based on level of gameplay) influenced behavioral precursors, but not behavior or health outcomes.[89] Games using personal goal setting and planning were less effective in influencing determinants than games not including goals, and these personal goal-setting games had no effect on behaviors or clinical outcomes.[89] There was no significant effect of the number of behavior change techniques used on any of the outcomes.[89] A separate meta-analysis of these studies revealed that developing a game using principles of participatory design (i.e., participants as informants or codesigners) led to lower effectiveness on behavior or self-efficacy change than using participants as testers or no participant involvement in design.[90] A limitation of these analyses is that each game design element is determined to be present or not, one at a time, and assessed against outcomes. Impact on outcomes may require combinations of techniques, but that will also require more studies and another analysis. A potential explanation for the lack of effect from narrative may be nonprofessional stories due to funding constraints. Although games are emerging as a promising method for behavior change, extensive additional research and more sophisticated game design are needed to identify ways to enhance engagement, learning, and behavior change.

Implications for Child Development

Entertainment games have been demonstrated to develop psychomotor, cognitive, behavioral, and social skills across developmental periods.[91] The It's Your Game curriculum impacted executive cognitive function.[92] Acute executive functioning enhancements were observed in a within-subjects study of 6–10-year-old children after playing an exergame versus a sedentary video activity.[93] An acute bout of Wii™ (Nintendo, Tokyo, Japan) exergame play within a 20-week exergame intervention improved executive function among African American adolescents who were overweight or obese and from a low-income inner city neighborhood.[46] Principles for enhancing working memory using videogames have been proposed.[94] Among children with attention-deficit hyperactivity disorder, a specially designed videogame enhanced inhibitory performance, working memory, and visuospatial

short-term memory.[95] Exergaming reduced repetitive behaviors and enhanced cognitive control among children with autism spectrum disorder.[96] Computer-based training enhanced neuro- and social cognition among schizophrenics.[97] Thus, videogames, and specifically serious games and G4H, can positively influence developmental, especially cognitive, outcomes among healthy children and among those with various illnesses and disabilities.[5] Serious games may be targeted to child developmental level, thereby enhancing potential effectiveness and appeal. These effects should be further verified, and effective contexts should be determined. Broader applications could include impacting life skills and enhancing self-management among healthy and targeted other children.

Serious videogames intended for children and adolescents are often designed to appeal to an expansive age range with little consideration of formal features that make for developmentally appropriate gameplay.[98,99] Some games are more effective in some age groups but not others[100,101] (e.g., younger children may be more interested in exergaming than adolescents[102,103]). Developmentally appropriate games appear to involve curricular suitability,[104] timely and informative feedback,[10,105] and a balance between players' skills and game challenges.[104] Research is needed to confirm and expand these factors of developmental appropriateness and effectiveness.

G4H Stakeholders

G4H stakeholders are a large and diverse group but can be divided into those who (a) are interested in using G4H to advance their or their organization's agenda, (b) may benefit from playing the games, (c) create G4H for profit, and (d) conduct research on G4H.

G4H users interested in advancing their or organizational health objectives include governments (federal, state, and local), health industry (public health agencies, healthcare providers, hospitals, health insurance agencies, and pharmaceutical companies offering motivational and training opportunities for effective medication use), businesses (interested in offering health educational programming to their customers or specific skills like machine operation safety, business-employee wellness programs), education (health professions schools, schools [K–12], public and private teachers, childcare agencies, parents, and children's educational agencies [e.g. museums, botanical gardens]), and nongovernmental organizations (foundations, faith-based organizations), among others.

Those who may benefit from playing G4H include diverse patients and students (for self-care) and their parents or families, as well as healthcare providers for professional education.

Those who create G4H for profit include owners, managers, and stockholders of G4H companies, game design experts, professional writers, artists, voice artists, animators, programmers, game testers, retailers and publishers.

Those who do research on G4H include computer scientists, game design scientists, educators, health educators, behavior change specialists, psychologists, communications experts, neuroscientists, evaluation specialists, and content specialists (relevant to the targeted content of the game [e.g., nutritionists/dietitians, kinesiologists, medical educators, or rehabilitation therapists]).

The creation of any particular G4H, and research on G4H, especially dissemination and implementation research, would benefit from involving one or more representatives from each stakeholder group to assure meeting their needs and expectations and benefitting from their expertise and insights.

Priority Research Issues

Although there are many types of research that can and need to be conducted, a prioritized research agenda appears in Table 1. Synthesizing the current literature is challenging ◀T1 because most of the studies in systematic reviews and meta-analyses of outcomes included interventions and measures that were diverse (and sometimes unsophisticated). Samples were often small, designs had no control group or no randomization (not including the reviews on lifestyle change[34] or sexual health[37]), and interventions were of short duration. Scientifically rigorous research is needed to understand whether and how G4H may influence desired health outcomes or produce adverse effects. Inadequate levels of scientifically rigorous research conducted over longer durations will only lead to questions and possible dismissal of this innovative intervention procedure.

One of the major difficulties in testing the efficacy of G4H is that the ''gold standard'' intervention design—the placebo-controlled double-blind study—isn't an option. Participants in behavioral studies always know the content of their training and, thus, by definition cannot be blinded (though they may not know the *purpose* of the intervention). Care must be taken to minimize the influence of confounds and maximize the probability of replicable results.[106] This means using a proper control group (where ''proper'' may differ substantially depending on whether the goal of the study is to show efficacy or to identify possible mechanisms), ensuring sufficient time on task (as a null result after an intervention that lasts only a few hours is not informative), using proper spacing of training (i.e., distributed rather than massed practice), and wherever possible taking multiple separate measures of the construct of interest (e.g., if one is interested in aerobic fitness, take measures of maximum volume of O_2 uptake, resting heart rate, recovery heart rate, etc.).

Many answers about efficacious and effective G4H design principles for affecting determinants, behavior, or health outcomes are not known. Although the initial meta-analysis of moderating effects of game design thought to be critical in lifestyle change programs indicated many design features and behavior change procedures, as then used, did not enhance effectiveness,[89,90] additional (experimental) research on innovative and, thereby, potentially more effective ways of using these features and procedures is needed. Effective game design research must address how stories in G4H engage children, what mechanisms mediate this influence, what (combinations of) features make games developmentally appropriate, and which features facilitate game transfer to real-life behavior.

Best practices for behavior change intervention and evaluation were recently identified from a review of systematic reviews.[107] Although these should provide guidance to G4H, how best to incorporate these procedures into this innovative medium for different ages needs to be addressed. Different types of stories and games interest different people

Table 1. Prioritized Research Agenda

1. Conduct adequately powered randomized clinical trials using objective measures (where possible) of outcomes to establish a stronger empirical base for G4H efficacy and effectiveness.
2. Conduct adequately powered randomized clinical trials to test hypotheses about the game design and behavior change features, including participatory design, that contribute to changes in behavior determinants, behavior, and health outcomes (e.g., what is the fun in G4H play, and how does it relate to change in desired outcomes?).
3. Investigate the game design and behavior change procedures most appropriate to different developmental stages throughout childhood.
4. Investigate the need for culturally specific G4H and the aspects of cultural tailoring or targeting that maximize the efficacy and effectiveness of G4H.
5. Identify the optimal game design and behavior change procedures most appropriate for, and effective in, different contexts (e.g., schools, fitness centers, nursing homes) and how to capitalize on context in attaining change (e.g., cooperation versus competition with self, others).
6. Exploit the latest advances in relevant technologies (in regard to both game design and behavior change) to maximize efficacy and effectiveness.
7. Identify a profile of neurological responses to effective games to minimize cost in game development such that effects on the neuroprofile become proximal markers of outcome with a high likelihood the resulting game will result in desired changes.
8. Develop games for enhancing mental health and cognitive outcomes and how these game design and behavior change procedures relate to secondary health outcomes (e.g., enhanced memory leads to enhanced regimen compliance, less depression leads to enhanced diet and physical activity).
9. Identify in-game measures indicative of out-of-game outcomes, and the contexts in which this is most likely to occur.
10. Identify (or clearly empirically contradict) adverse outcomes from G4H, especially the possible contribution of G4H to the increasingly well-documented contribution of entertainment games to adverse outcomes (e.g., media addiction, violence, sexual permissiveness, breach of privacy/confidentiality, etc.).

G4H, games for health.

at different times.[88] Knowing which story and game characteristics appeal to specific types of people could help tailor game design and behavior change procedures to maximize effectiveness.

Because participatory design procedures (as used to date) were not effective in increasing behavior change,[90] research must address the optimal role of formative research, including who should be involved, as well as types of involvement that enhance game effectiveness, the optimal role of feasibility studies in game research,[108–112] the definition of feasibility in game interventions (i.e., when is the game considered feasible), sample sizes needed for feasibility studies (i.e., when statistical power calculations are not appropriate), and whether postintervention interviews to assess whether an intervention met user needs and suggestions for enhancement were important, necessary, or helpful. Issues of privacy, confidentiality, and personal risk (e.g., recording illegal activity) associated with real-time data collection must be addressed.

In an international context, G4H may include player restrictions, such as language barriers and culture. For example, exercise intensity and energy expenditure increased when children played select exergames that virtually transported them into traveling through the streets of Hong Kong on the Xavi-X® (San Diego, CA) J-MAT. This game featured Hong Kong celebrity Jackie Chan as an avatar, thereby creating a cultural connection for the children.[113] Games with cultural specificity and language translation may encourage children to engage in more active play. Future research needs to assess the impact of language and cultural specificity in G4H, as well as cross-country differences in player desires and effectiveness of design elements.

Context may influence the long-term effects of games on target and ancillary behaviors. Sustained use of exergames has been challenging in a school setting. New ideas are needed for exergames to achieve sufficient and sustainable use to produce desired outcomes in schools. G4H research should assess the effectiveness of supportive contexts (e.g., informal learning versus formal learning, in-class versus out of class, etc.). G4H may also develop more comprehensive community methods (e.g., combining an intensive primary care approach with school-based intervention and links with community resources, such as Boys and Girls' Clubs, religious organizations, community gardens and dieticians).[114] More engaging narratives involving context[78] and sophisticated feedback targeting elements of context may move G4H to a more sustainable level for mass appeal.

Technology is constantly evolving. A genre of mobile exergames is emerging.[115–117] The intrinsic nature of these games allows the children to be outside, which minimizes inside sitting and may enhance the activity obtained.[118] Applications[119–122] can be linked to mobile exergames and provide tailored feedback and advice at appropriate times and places in real time when it is more likely to affect behavior change.[119] Some of these games incorporate global positioning systems, which facilitates location-based elements in exergaming (e.g., geocaching [finding hidden objects]).[122] One form of mobile exergame involves augmented reality wherein computer graphics are superimposed over smartphone camera images, or narrated audio is played through earbuds while the person is walking outdoors (e.g., ''Zombies, Run!''[123]). In some such games, maps are based on existing streets in the real world, and players are instructed to collect virtual items or treasures or to avoid items/traps placed on the map (thus, requiring movement in the real world). Wearable sensors, such as the Apple (Cupertino, CA) Watch and the Fitbit® (Fitbit, San Francisco, CA), are being gamified and available on social media.

So far, few mobile applications incorporate game strategies. Collaboration among game designers, health professionals,

and behavior change experts is warranted to link games and to incorporate evidence-based behavior change techniques into applications. Research is needed on the efficacy and effectiveness of such games, as well as the optimal combination of game mechanics and behavior change procedures to maximize physical activity[124] or other behavior changes. To complete the loop to health, documented behaviors and health outcomes from games and applications could be digitally linked to electronic medical records and made available to a participant's primary care or other healthcare provider. Child safety is an important consideration in geocaching type games, wherein children's attention to context may be overridden by the excitement of the next find.

Brain–computer interfaces have enabled brain activity to directly control videogame progress (e.g., ''DayDream''[125]). Games may improve brain function,[126,127] and neuroscience research[66] may identify one or more profiles of neurological responses to games that can be used as a proxy for early outcomes to enhance the more rapid design of effective G4H. Although physical fitness and cognitive capacity are strongly related[128,129] and physical activity can be effective as a treatment for moderate depression,[130,131] few studies have measured the effects of G4H on working memory or depression.[132] G4H could be combined with individual psychotherapy or medication to cost-effectively provide care for individuals who suffer from brain disorders but who currently lack regular access to qualified mental health professionals. Exergame play has been related to enhanced academic performance[133]; however, these relationships must be more thoroughly established.

To combat G4H cost and technology barriers, continued research is needed to harness the power of G4H in accessible, low-tech ways[134] and with minimal overhead,[135,136] especially for low budgets.[137] For school use, teachers require a means to show what their students have learned.[138] Gameplay analytics are a relatively common G4H feature. Methods have been identified for extracting such data in G4H.[139] However, many data analytics remain proprietary to gaming companies, including the algorithm to estimate calorie expenditure during exergame play.[140] Research must address how gameplay analytics (e.g., quizzes, assessments) or game achievements can best be harnessed to demonstrate student learning or behavior change and whether objectively measured effects of games on target skills, knowledge, and behavior may encourage teachers to adopt serious games as a standard part of curriculum.[141]

We know of only one article that reported adverse events from gameplay: injuries reported on an independently run Web site.[142] Hand lacerations or bruises were the most common form of injury, and these most commonly occurred using ''Wii Sports Tennis.''[142] No denominator was available from which to estimate incidence or prevalence. There is accumulating research and associated concern that child media use disrupts sleep[143] and also may lead to media addiction,[144] violence,[145] inappropriate sexual practices,[146] cyberbullying,[147] and attention-deficit hyperactivity disorder.[148] The relevant literatures have generally used self-reported measurement methods with known limitations[149] and failed to differentiate type of media[150] or beneficial versus detrimental media content. Therefore, there are no nuanced prescriptions for media use. Given the dizzying array of possible adverse consequences, however, research is needed on the extent to which G4H contribute to possible adverse health outcomes or have other adverse outcomes.

Additional G4H effectiveness issues concern how the medical community can leverage G4H for management and treatment of chronic disease (e.g., tracking and motivating patient compliance to medications/treatment plans), how G4H can be integrated into daily life for sustained/continuous play (e.g., wearable technology for monitoring progress in the game or providing feedback at the end, unlocking or earning gift cards by making and sustaining health behavior changes), the populations that could most benefit from G4H, how G4H could be adapted for specific needs (e.g., persons with physical disabilities or in rehab, persons with obesity or other chronic conditions), and how emerging platforms (e.g., integration with smart watches, mobile phone applications, audio/music, or intelligent personal assistant [e.g., Siri® (Apple)-type audio feedback for ongoing interaction with a virtual trainer]) can incorporate G4H, including the necessary behavior change procedures. Considerations must be given to courses, experiences, and internships that can best prepare the next wave of researchers, developers, teachers, and healthcare providers interested in digital media and behavior change.

Thus, although there is ample preliminary evidence of G4H leading to positive outcomes, further research is needed to better understand mechanisms of effect and contextual factors influencing outcomes. Little research exists on possible adverse effects of G4H (e.g., contribution to sedentariness), which also need to be assessed and, if found, better understood.

Establish Guidelines for Children, Parents, Educators, Clinicians, Policymakers, and Technologists

Guidelines for application

The American Academy of Pediatrics guidelines[151] indicate child screen media exposure should not exceed a total screen time of 2 hours/day. This 2-hour limit, however, does not discriminate between beneficial and nonbeneficial screen media use. Part of the consideration in the 2-hour limit was a concern for physical inactivity. Exergames that increase physical activity and do not increase calorie intake during gameplay[39] may be acceptable for longer intervals, especially among children in unsafe neighborhoods who may not otherwise be allowed outside to be physically active. Another concern compelling the 2-hour limit was exposure to sexting, bullying, or other aversive outcomes from access to social media. Playing G4H with demonstrated health benefits would not appear to be a concern. We await the American Academy of Pediatrics' current reappraisal of their guidelines. As far as we know, there has been no report of overuse (addiction?) to G4H, but this has not been explored in the scientific literature. Due diligence suggests systematically looking for and documenting possible adverse events from G4H.

At some point it may help to have a ''prescription plan'' (paid by health insurance and coordinated by national healthcare professional groups) to prescribe a specific game or suite of games to achieve given objectives (assuming a given dose for preventive or treatment training effects has been demonstrated) for a given individual (varying on developmental age, game preference, etc.)—a tantalizing hope for the future.

Guidelines for game development

Establishing guidelines on mechanics and development procedures for G4H would be valuable.[152,153] Frameworks for serious game design have been proposed.[4,154,155] Because little is currently known with confidence about principles in effective G4H design, guidelines to deliver games that meet the serious purpose of impacting health while providing motivational appeal appear premature. To be effective, however, serious games must be fun, and much more fun than many serious games currently provide. Focusing on learning, assessment, or behavior change should not detract from the player's enjoyment. Fun is not easy to achieve and should not be assumed by the expertise of designers or deduced from a simple question presented to users. It would seem wise for diverse stakeholders (1) to collaborate in interdisciplinary teams for game development from concept to market, (2) to integrate and apply theories and models from design and development, health communication, gaming, social networking, and behavioral science to guide development, evaluation, and dissemination, (3) to attend to formative evaluation with intermediate and end-users to ensure game usability, desirability and feasibility, (4) to apply rigorous evaluation to raise the credibility of games by establishing efficacy, and (5) to attend to scale and dissemination.[156] Game developers should also pay attention to developmental appropriateness, cultural differences and culturally sensitive issues.[157] Consistent with the medical care dictum of ''Do no harm,'' G4H designers should avoid incorporating violence in light of the evidence that violence in media increases risk of violence among viewers.[158]

Funding for game development

G4H have several structural advantages in the marketplace (e.g., individuals may play the games due to interest in the outcomes of the gameplay, rather than out of a desire to play the game itself; the audiences for some G4H are captive, as in medical or school settings; etc.) and thus do not necessarily need to compete in the same sphere as AAA entertainment videogames in terms of budget (which can run in the tens of millions of dollars). For educational games, high production value was not necessary because games with highly realistic visuals did not outperform the simple textual or cartoon-like games.[28] However, producing effective and compelling G4H nonetheless requires a certain level of budget to ensure effective mechanics and dynamics, art and sound, etc.

G4H development and research to date in the United States have been funded largely by government (e.g., the National Institutes of Health) or foundation (e.g., the Robert Wood Johnson Foundation) grants. The health insurance industry has funded development of G4H,[159] but few studies of these games have appeared in the literature. Inadequate funding is due, in part, to perceived adverse effects of videogames,[160] in part to an inadequate number of sophisticated clinical trials documenting effectiveness and in part to a ''chocolate-coated broccoli'' problem—a challenge to developing truly enjoyable G4H.

Part of the problem is business related. Large successful entertainment videogame development companies have explored the educational game space, but G4H have not become runaway financial successes like entertainment games. As a result, fewer resources are put into G4H than may be necessary to create high-quality engaging experiences. We have yet to reach a tipping/inflection point where industry or healthcare view G4H as viable. As yet, there is no reimbursement for G4H played outside of health settings.[161] A health industry–sanctioned prescription for ''gameceuticals'' for prevention or treatment would be a welcome addition and may be useful in reducing healthcare costs. Effective G4H could be used by practitioners to promote and enhance behavior change. G4H shown to be effective could be distributed broadly for a relatively low cost (once developed), thus increasing reach and potential public health impact.

Concluding Overview

We are still exploring how best to design G4H and the extent to which a game can impact health (e.g., executive cognitive function, physical activity, dietary change, stress reduction). Moderators and mediators of game impact remain to be understood. Substantial amounts and improved quality of research are needed to advance G4H. Please join us in this exciting adventure with potentially large payoffs for our nation's health.

Author Disclosure Statement

No competing financial interests exist. ◀AU1

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