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Abstract

Supplementing patient education content with pictographs can improve the comprehension and recall of information, especially patients with low health literacy. Pictograph design and testing, however, are costly and time consuming.

We created a Web-based game, Doodle Health, for crowdsourcing the drawing and validation of pictographs. The objective of this pilot study was to test the usability of the game and its appeal to healthcare consumers. The chief purpose of the game is to involve a diverse population in the co-design and evaluation of pictographs.

We conducted a community-based focus group to inform the game design. Game designers, health sciences librarians, informatics researchers, clinicians, and community members participated in two Design Box meetings. The results of the meetings were used to create the Doodle Health crowdsourcing game. The game was presented and tested at two public fairs.

Initial testing indicates crowdsourcing is a promising approach to pictograph development and testing for relevancy and comprehension. Over 596 drawings were collected and 1,758 guesses were performed to date with 70-90% accuracies, which are satisfactorily high.

Introduction

Patients, especially those with limited health literacy skills, often experience difficulty understanding health information[1,2]. Some health information can be represented efficiently using graphics that are easier to understand. In consumer health informatics research, pictographs have been used to improve patient comprehension and recall. In their review of the literature regarding the role pictures play in improving health communication, Houts et al. found that "pictures closely linked to written or spoken text can, when compared to text alone, markedly increase attention to and recall of health education information"[1].

We have conducted several studies related to the development and testing of pictographs to be used in patient instructions[3-5]. Our findings confirmed the value of enhancing patient education materials with pictographs for health communication. At the same time, generating informative and comprehensible pictographs for a diverse population is a time consuming and costly process.

People from diverse cultural backgrounds have different communication styles and standards. Some health topics or

images that are part of the vernacular for one group of people may be offensive or culturally taboo for others[6]. Individuals can be challenged to interpret pictures from various cultural and educational backgrounds[4]. The symbol for *prescription*, commonly seen on medication labels, for example, was taken to mean *rubbish bin* by a low-literate South African population with limited English proficiency[7]. A library of high quality, culturally appropriate pictures could address these differences.

The Doodle Health crowdsourcing game was designed to engage a diverse population, including under-represented, vulnerable, and disadvantaged populations, to elicit and test health-related pictures in an effort to build this library. By engaging under-represented minorities in the co-design and evaluation of pictographs, thereby getting their active involvement in the production of the health education material intended for their use, we hope to increase the likelihood that the information they receive will be relevant and meaningful[8].

Methods

Focus Group

At the beginning of the design process, we conducted a focus group study to assess the health information needs of group members from under-represented communities, and to obtain their thoughts regarding development of the crowdsourcing game. We recruited 11 participants from a partnership representing five diverse demographic communities residing in the Salt Lake Valley and scientific researchers from the University of Utah and the Utah Department of Health.

The focus group demographics included African Americans, refugees from Africa, Hispanic members, Pacific Islanders, and Native Americans. The participants ranged from 30 to 69 years of age. The majority had acquired education beyond the 12th grade. By race and ethnicity, two American Indians participated (18.1%), as well as five Black or African Americans (45.4%), and two Pacific Islanders (18.1%). English was the primary language spoken by the majority (72.7%), while one person reported knowing English and Tongan equally well (9%); there were two native Spanish speakers (18.1%), and one person told the study team that "African" was their first language.

The two-hour focus group discussion was transcribed and qualitatively analyzed. The focus group helped us identify points of cultural sensitivity. For instance, health-related images or topics that are part of the vernacular for some groups may be offensive or culturally taboo for others. In a healthcare setting, topics of sexuality, conception, and reproduction must be approached delicately.

The group expressed their interest in long-term community health. They wanted to prevent common diseases in their populations, namely heart disease and diabetes, and they wanted to promote healthy behavior, diet and lifestyle choices. They noted that socioeconomic (and sociogeographic) factors are crucial to consider when tailoring health education materials, and they desired information for their communities about the health insurance market and other financial resources to help them overcome barriers to receiving quality healthcare.

We consulted with community representatives after the focus group concluded at regular intervals throughout the game development process. Researchers attended monthly meetings with them in order to report on study progress and obtain feedback.

The Design Box

Informed by the results of our focus group, we conducted two iterative Design Box meetings. The Design Box is a conceptual tool for brainstorming and refining game design ideas[9]. The four constraints, presented as four sides of a square, were: Technology, Aesthetics, Audience, and Theory. Technology refers to the digital technical systems of the game. Aesthetics are the formal elements of the game content the game user will interact with, and this category focuses on the emotions they may encounter. The Audience wall of the Design Box is concerned with those who will

play the game. In this case, the target audience is the under-represented communities. Theory refers to the research problem: crowdsourcing pictographs for under-represented populations through gaming.

The Design Box setting encouraged interaction among collaborators. In one Design Box meeting, the Entertainment Arts and Engineering team dialogued with informatics researchers, health sciences librarians, and clinicians. In a separate session, individuals from the five communities recruited for the initial focus group session completed the process. The meeting participants worked together to define the purpose of the crowdsourcing game and to focus the constraints of the Design Box.

Game Design

Our game design was based on general game design principles as well as the results from the focus group and Design Box meetings. A key consideration for us was to keep the design simple. In our target audience, many are occasional gamers who require easy-to-use gaming mechanisms. The popularity of games such as Angry Birds™ and Draw Something™ also showed us that simple interface design is attractive to consumers. Short, gradually increasing levels of difficulty, interesting sound effects and colorful graphics are also factors in successful games. The final Doodle Health design is modelled after the Draw Something™ app and the board game Pictionary™, both of which engage participants in the drawing and guessing of pictures. In addition, Pictionary™ is well-known to most of our target audience, and many in the younger audience are also familiar with the Draw Something™ app.

Implementation

The Doodle Health game was implemented to run on a variety of mobile devices, standard desktop and laptop computers. The front-end user interface was written in HTML5, CSS3 and Javascript. The Bootstrap framework was selected to make the web pages have a standard appearance across different browsers. jQuery was used to add additional AJAX and dynamic interactivity to the web pages. The canvas element of HTML5 was used for the drawing page, making it so that very little needs to be downloaded to a browser in order for a user to create drawings. PHP scripts were created for the backend of this web application. These PHP scripts used the standard MySQLi library to connect to a MySQL database. Seed image files were uploaded to the server through one of these PHP pages as a stream in order to control what could be uploaded. The result of this architecture (Figure 1) is an adaptable application that can be run on any web browser.

Two versions of the Doodle Health game exist online presently. We tested the version that is open to the public at two local fairs, while the other version was tailored to meet the needs of our individual community partners (Figure 2).

Game Flow

For the purposes of the pilot testing, the game first asks the user to self-identify with a community. In the game testing, we listed seven racial/ethnic groups which allows us to link drawings with racial/ethnic backgrounds. Following the advice of our minority community partners, there is no user name or password created and as such players have total anonymity. The player continues by selecting “Draw”, or they can choose to “Guess” a health-related term. For either function there are easy, medium, and hard levels as options.

Upon selecting “Draw”, a player is prompted to draw a word or a phrase (Figure 3). Players working on a touchscreen device, such as a tablet, use a stylus or finger for drawing, while those on a non-touchscreen computer use a mouse to draw. There is a palette of colors and line thicknesses to choose from on the left bottom corner of the drawing screen, and a player is given the options to “Skip” a term, “Clear”, or “Save” and submit their drawing. The Doodle Health user can skip terms up to three times if they don’t feel comfortable drawing them, or if they don’t understand them.

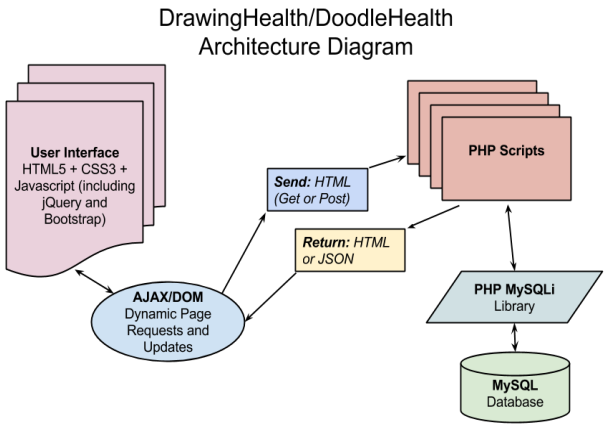

Figure 1: Gaming System Architecture

Figure 2: The Healthy Teen Edition of Doodle Health

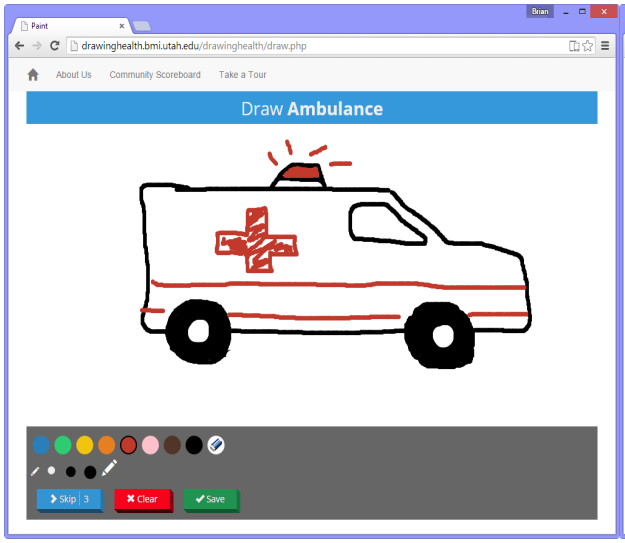

Figure 3. Draw Screen

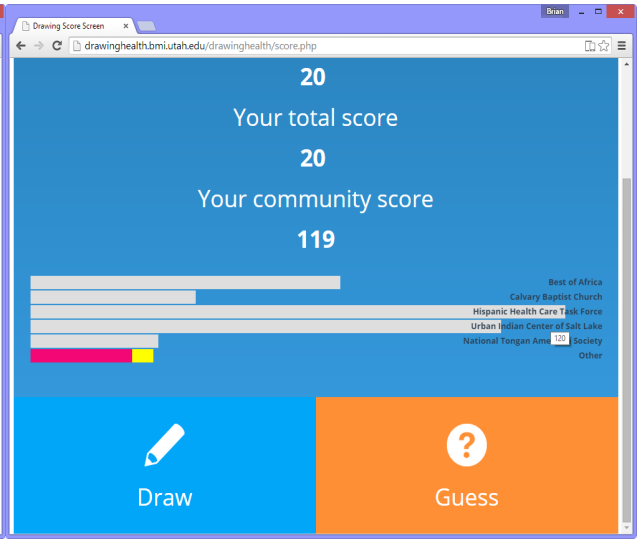

Figure 4. Drawing Progress Screen

Once a drawing is submitted a progress screen is displayed (Figure 4) showing the points they have earned for their community. The player may continue by selecting “Draw” or “Guess” again.

A player guesses what an image represents by clicking on the corresponding term from a multiple-choice list. The person views a screen showing if their guess was correct and the points earned for their community so far (Figure 5). Because some users make wrong guesses because the pictograph was not easy to understand, they are also given the option of contributing their own drawing for the same term.

To jump start the game, we originally uploaded a set of 50 professionally drawn seed images (from our previous pictograph studies) for guessing. Drawings from the crowdsourcing participants themselves were added to the pictograph library as the game progressed. Because obscenity is a concern when anonymous players are allowed to submit content for others to view, all drawings must be reviewed and approved by a moderator.

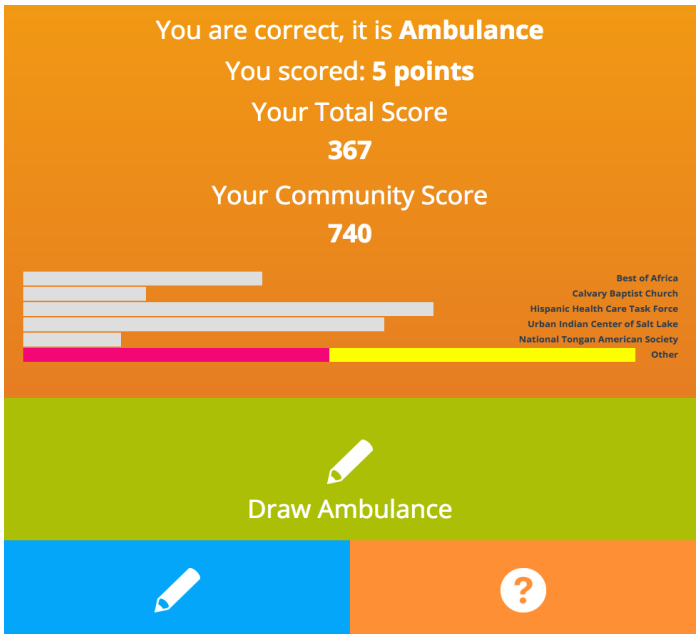

Figure 5. Guessing Progress Screen

Preliminary Testing and Feedback

We tested the Doodle Health crowdsourcing game at two public fairs (Be Well Utah health fair and the Utah State Fair) using tablet computers. A convenience sample was recruited to take part in the study. The participants were asked to play the Doodle Health game for as long as they wanted. Following the play, each participant was asked to fill out an anonymous, Likert-scale survey questionnaire. They were also given the opportunity to provide additional comments about the game. Personal identifying information was not collected from participants and compensation was not provided. Additionally, we kept the Doodle Health game online and invited the fair participants to continue playing the game. We also handed out flyers at the fairs to invite those who could not participate on-site to try out the game at home. To make the testing experience more inviting in this preliminary stage, we did not collect individual demographic information.

Results

A combined total of 114 volunteers were recruited via the fairs. We could not ascertain the number of users during the three-month open testing phase. In all, 596 pictures were drawn. 176 were not approved for guessing because they were poorly drawn, unfinished, or because they contained inappropriate content. The data for the images drawn by the community during this time period is shown in Table 1. Some of the drawings we received from crowdsourcing participants were artistic and complex, while others were rendered as basic stick figures. Commonly understood words, such as *ambulance,* yielded similar interpretations from game users (Figure 6). Stranger terms, such as *pinkeye*, showed more variation among drawings (Figure 7).

A total of 1,758 guesses were made. 1,488 matched the correct terms, while 270 were incorrect. Many more guesses were made than drawings, because guessing appears to be simpler and easier for people to do than drawing. The images we included in the game as drawn by community members were largely recognizable by other players. One game tester commented, "I am comfortable guessing drawings and less effective at drawing." Some of the images, however, were easier for participants to guess than others. The pictures guessed correctly most often were concrete terms like *ambulance*, *loose tooth, vegetables*, and *wash hands*. Those frequently missed were conceptually more difficult words and phrases to interpret, such as *fatigue*, *nausea, depression*, *mealtime*, and *cool down*. This correlates with our prior research in pictograph development. The number of guesses made by community members is shown in Table 2.

Fair participants answered usability questions. Most people were comfortable with the technology used for the game and they were able to play it without difficulty. The details are shown in Figure 8 and 9.

We received 37 additional comments from fair participants. They were sorted into four main groups and qualitatively analyzed (Table 3.). The fair participants also identified a few software bugs. For instance, it was discovered that a vertical screen orientation was necessary to see all of the buttons on a tablet interface without having to scroll down.

Table 1. Images Drawn by Community

Community	# of images dr	# of images rejected by m	% of rejected im	% of total images
American Indian/ Alaska	4	0	0	0.76%
Asian	119	31	26.05%	22.67%
Native Hawaiian/ Pacific	7	5	71.43%	1.33%
Black or African Americ	49	14	28.57%	9.33%
Latino	84	23	27.38%	16.00%
White	227	90	39.64%	43.24%
Other	35	11	31.44%	6.67%
Total	**525**	**174**	**33.14%**	**100%**

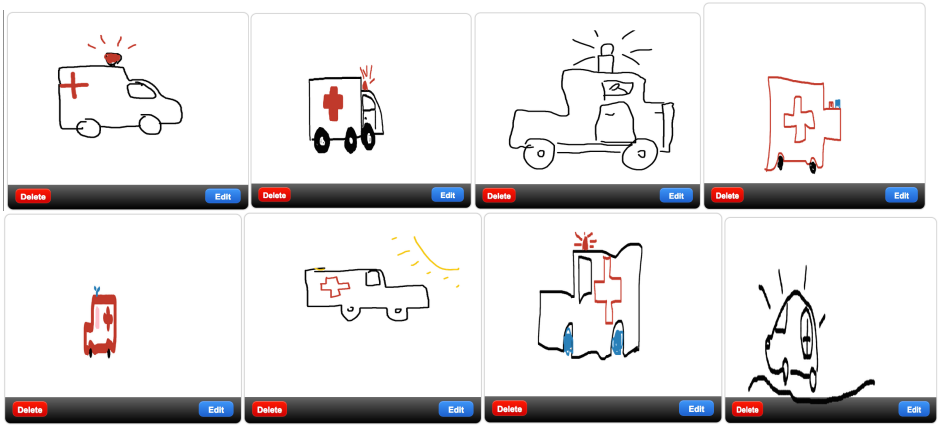

Figure 6. Community Drawings for the Term *Ambulance*

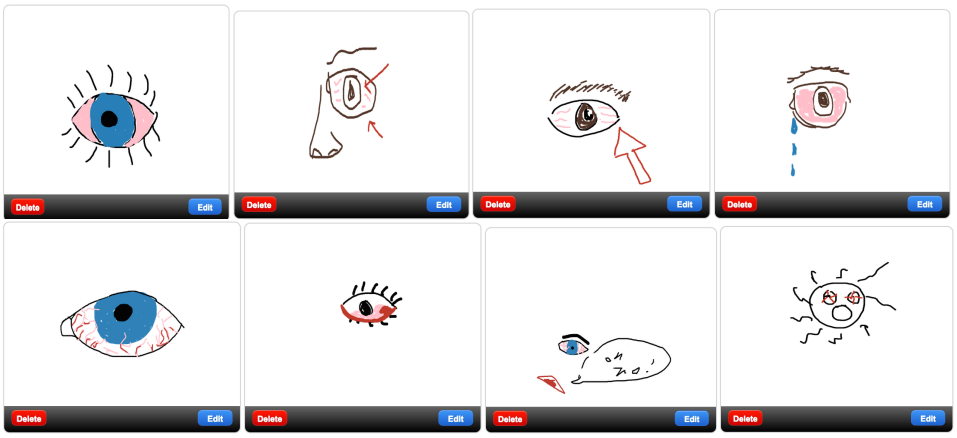

Figure 7. Community Drawings for the Term *Pink Eye*

Table 2. Doodle Health Guesses by Community

Community	Correct Guesses	Incorrect guesses	Total # of guesses made	Accuracy
American Indian/ Alaska Native	23	9	32 (1.82%)	71.88%
Asian	212	46	258 (14.68%)	82.17%
Native Hawaiian/ Pacific Islander	43	8	51 (2.90%)	84.31%
Black or African American	46	5	51 (2.90%)	90.20%
Latino	221	41	262 (14.90%)	84.35%
White	878	149	1027 (58.42%)	85.49%
Other	65	12	77 (4.38%)	84.42%
Total	**1488**	**270**	**1758 (100%)**	**84.64%**

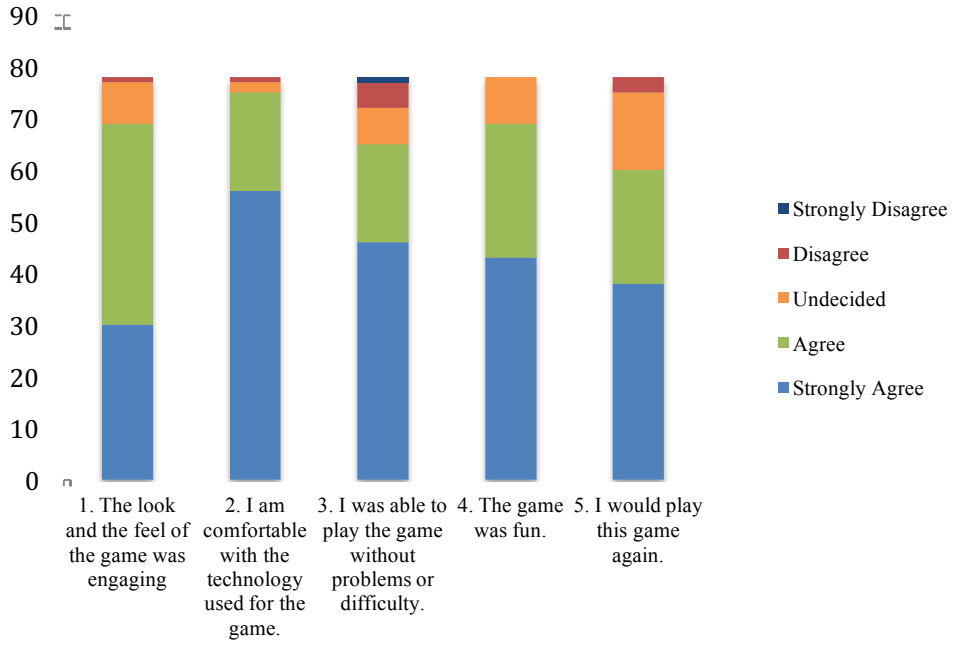

Figure 8. Game Testing Results from the Be Well Utah Health Fair (n = 79)

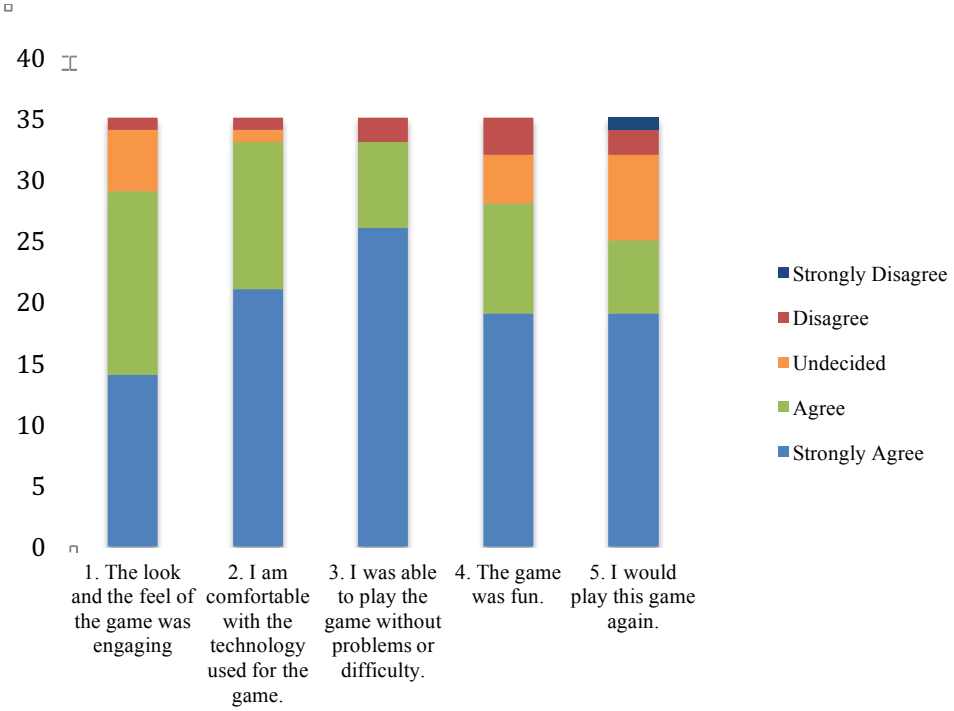

Figure 9. Game Testing Results from the Utah State Fair (n = 35)

Table 3. Types of Comments Received from Game Testers

Category	Total # of comments	% of Total (n=37)	Sample comments
1. Praise for the game	23	62.2%	*It was very interesting and fun.*
			I think this is a great tool to use, both for non-native English speakers and for kids! […].
			[…] the interface was engaging and easy to use! TECHNOLOGY!!!
			The pictures were very creative.
2. Technical complaints	8	21.6%	*Not being familiar with a scrolling touch screen made me a little uneasy.*
			Would like the [drop down] options not to block the picture/image.
3. Suggested health topics	3	8.1%	*I think it is a good way to invite people to do more activities in our daily life.*
			Topics to help us eat healthy
4. Disinterest	3	8.1%	*Not interested.*
			I don't like games – no time for it.

Discussion

We developed the Doodle Health game to crowdsource the pictograph development and testing tasks while providing entertainment value to players. Without any compensation, and only being marketed at two local public events, the game was able to collect 596 drawings over a three-month testing period. The drawings were evaluated using the same game 1,758 times. Given the 70 to 90% of the guess accuracies, the quality of the drawing and guesses are satisfactorily high.

Based on our prior experience, traditional pictograph creation and testing is a very time-consuming process. Even experienced graphic designers and medical illustrators are limited by their own cultural biases. Using a crowdsourcing game to engage the larger community allows us to rapidly gather and test pictures from diverse backgrounds. Through crowdsourcing, under-represented healthcare consumers are able to contribute to the development of culturally-sensitive and understandable pictographs for health communication.

The results we have gathered show that the Doodle Health game is a promising approach to crowdsourcing for pictograph development and validation. The feedback we collected from those who tested the game was quite positive. Most participants found the game engaging and easy-to-use. Most felt they would like to play it again. These ratings are consistent with the enthusiastic comments we received from the game testing participants.

We hope this game may indeed result in a more meaningful resource library of easily comprehended pictographs for use in health communication materials. The online library of pictographs developed through the crowdsourcing game will be freely available to clinicians and other health care workers to supplement text in patient discharge instructions, for example, and other health-related education materials. The ultimate goal of this project is to have a positive impact on clinical practices by facilitating and enhancing communication between health care providers and consumers [6].

One limitation of the Doodle Health game is that it is not suitable for medical concepts or content that is totally unfamiliar to an audience. For instance, the ability to draw and/or guess the word *defibrillator* requires specialized knowledge. Moreover, it is unlikely that we will be able to incorporate publicly-drawn images directly into the pictograph library, as many people with high representation may not be expert illustrators. We can identify relevant concepts and cultural sensitivities with the game, and we can develop pictographs through iterative cycles of game play and data analysis.

We asked the crowdsourcing participants in this study to self-identify their community affiliation, because African Americans, American Indians/Alaska Natives, Asian Americans, Hispanics, and Native Hawaiian/Pacific Islander populations carry a disproportionate burden of disease, premature death, and disability. They also receive poorer health care overall, as compared to other ethnic or racial groups [10]. On the other hand, the needs of each community vary greatly. A Spanish version of the game is needed, for instance, for non-English speaking Hispanics.

To minimize the burden on our game testers and maximize the number of participants, we did not collect demographic information such as age and gender. At the advice of our community partners, we only asked players to identify one community they would like to play for (to earn points for the community), because some people are turned off by the question of race/ethnicity. At the fair, our observation is that the participants were reasonably diverse in terms of race, ethnicity, gender, and age. In future formal trials, we will offer voluntary demographic surveys for crowd sourcing participants.

We are trying out novel applications for the Doodle Health game and experimenting with various promotional ideas and incentives. We have installed a gallery, to present drawings and award crowdsourcing participants, and we are exploring social networking as a tool for marketing the game within particular communities.

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Conclusions
We created a Web-based game, Doodle Health, for crowdsourcing the drawing and validation of pictographs. Initial testing collected a large number of drawings and guesses, with positive user feedbacks, demonstrating the approach to be feasible and promising.

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