Because the average 8- to 12-year-old child plays ≈ 13 hours of video games every week, supplanting the content of these media with stroke education may represent a powerful way to improve stroke knowledge. Stroke treatment is time-dependent, and activation of the emergency medical service plays a critical role. Knowledge of stroke symptoms and the importance of calling 911 (collectively termed actionable stroke knowledge) is low among adults and children living in high-stroke-risk communities. Although stroke knowledge does not necessarily imply rapid action in all lay public, there may be a sex-specific impact among women. Moreover, bystanders and family members may play an important role in calling 911 for suspected stroke, and some of these individuals may include young children.

We previously showed that increasing stroke knowledge of children may lead to increased knowledge in their parents (most of whom were women). As part of that program, we developed a clotbuster stroke video game for the purpose of improving actionable stroke knowledge of children, which we explored as an independent tool in this study. We hypothesized that: (1) the stroke video game will improve stroke knowledge of children after a single, 15-minute game round; (2) children will access an online version of the game as a leisurely activity; and (3) children who access the online game will demonstrate greater stroke knowledge during delayed testing compared with those who do not.

**Methods**

**Setting and Study Population**

We enrolled a convenience sample of 210 fourth- and fifth-grade children from 1 elementary school in Bronx, New York, located in a low-income, high-stroke-risk community. Student ages ranged from 9 to 12 years (mean age, 10 years), and 52% were girls. School-level demographic data revealed a student body comprising 65% Hispanic, 18% Asian, 13% black, 2% white, and 2% Native American/Alaska Native. The Columbia University Institutional Review Board approved this study.

**Design**

We used a quasiexperimental pre-test post-test design in which we compared individual’s scores between pre-test, immediate post-test (IP), and an unannounced delayed post-test of gamers using instruments that assess actionable stroke knowledge. We hypothesized that: (1) the stroke video game will improve stroke knowledge of children after a single, 15-minute game round; (2) children will access an online version of the game as a leisurely activity; and (3) children who access the online game will demonstrate greater stroke knowledge during delayed testing compared with those who do not.

**Intervention**

Development of the stroke video game (Figure 1) was influenced by social cognitive theory. The video game involves navigating a clot-busting spaceship intra-arterially, shooting down clots that occlude the passage of blood to the brain, while avoiding large atherosclerotic plaques on the arterial wall. When clotbuster medicine runs out, the
gamer must answer stroke knowledge questions in order to refill it and continue playing. Correct answers are provided for incorrect responses, and the game is synced to a hip-hop song with educational lyrics about stroke that also contain the correct answers. This incentive reward circuit is designed to motivate gamers to learn, creating a loop that increases the gamers’ confidence in his or her mastery or self-efficacy of the stroke information being taught.

Gaming Protocol
Children were assembled in a school computer laboratory and were informed that test scores will not affect their class grades. After a baseline survey (pre-test), all children played the video game for a prespecified 15-minute duration (a single game round), immediately after which they were given an IP. After IP, each child was given a Hip Hop Stroke Hero card, which contained a unique identifier access code for logging onto our website to play the stroke video game at home as a leisurely activity. The children were then encouraged to play the game for fun at home. An unannounced delayed post-test was administered 7 weeks later.

Assessments
Stroke action (calling 911) was assessed using hypothetical stroke scenarios in which the diagnosis is not revealed such as: “You are eating lunch with a friend and suddenly pieces of his sandwich start falling out of the right side of his mouth and you notice that the right side of his face is drooping down. What should you do?” Knowledge of symptoms was assessed using a multiple choice format, which included the 5 suddens stroke symptoms (except that facial droop was taught in the context of unilateral face, arm, and leg weakness; facial droop was selected on the basis that it is a specific component of the face-arm-speech test, and slurred speech was used as a surrogate for speech disturbance in general, which includes incomprehensible speech), and a distracter (chest pain). A composite score was created for knowledge of stroke localization in the brain and the term brain attack (a stroke alias).

Statistical Analysis
\( \chi^2 \) analyses were used for group-wise comparisons for each stroke knowledge question relative to test sequence. Wilcoxon signed-rank tests were used to compare improvement among individual subjects across the testing sequence for overall composite scores of stroke symptom knowledge. Multinomial logistic regression was used to study the effect of website access on composite knowledge scores. All tests were 2-sided, with \( P<0.05 \) considered statistically significant. All analyses were conducted using IBM SPSS version 20.

Results
Two hundred ten children completed pre-test, 205 completed IP, and 198 completed delayed post-test (94% retention). Twenty-five percent of children had a personal experience with stroke victims. Ninety percent of children reported liking the game, whereas 6% did not like the game (4% did not respond). There was significant improvement of stroke symptom composite scores, calling 911, and all individual stroke knowledge items across the testing sequence (all \( P \) values <0.05; Figures 2 and 3). Interestingly, we observed further increases in knowledge of 3 of 5 stroke symptoms from IP to delayed post-test (sudden imbalance, sudden facial droop, and sudden headache). There were no significant sex differences in post-test stroke knowledge composite scores \( (P=0.98) \). Post hoc we explored the possibility of whether accessing our game online after initial exposure improved stroke knowledge scores. Of 156 children (74%) who reported having Internet access at home, 67% reported they were confident or very confident that they would play the game at home. However, only 41 children (26%; of which 25 were girls) played the game remotely between IP and delayed post-test. Composite stroke knowledge scores were not significantly different between children who played remotely and those who did not \((P=0.71)\), although we found a significant increase in knowledge of 1 symptom (sudden imbalance), favoring children who were exposed at home \((P=0.03)\), whereas most other stroke symptoms showed nonsignificant trends that favored increased knowledge among remote players.

Discussion
Our results show that playing a stroke video game for 15 minutes may improve actionable stroke knowledge of children, which may be retained for \( \approx 7 \) weeks. In addition, we found that one quarter of children (mostly girls) accessed the video game from home as a leisurely activity and that these children demonstrated some additional improvement in stroke

Figure 1. Screenshots from Clot Buster stroke video game. The video game can be played at http://hiphoppublichealth.org/#/check-this/ (registration required).
knowledge compared with those who did not access the video game from home.

Although novel to stroke information, incorporating health information into video games is in itself not new. Indeed, educational video games have led to increased nutritional knowledge and eating behaviors,12,13 reduced diabetes mellitus–related emergency department visits by children and adolescents with type 1 diabetes mellitus,14 and improved adherence to chemotherapy and treatment plans by adolescent patients with cancer.15

Our study has several limitations. We used a quasieperimental pre-test post-test design with a relatively small convenience sample size, and our study did not have a control group. We instead compared test performance with baseline measures to minimize disruption of classroom activity by a control program without anticipated educational gain as evidenced by the eighth-grade control subjects in another study16 where only slight improvement or worse performance was found for stroke education outcome measures. We used identical measures at each assessment, which is vulnerable to priming effects. Despite 67% of children reporting confidence that they would play the video game at home, only 26% actually did. We did not quantify the frequency and duration of each remote video game encounter in our analysis, nor did we explore reasons for the discrepancy between children who said they would play remotely and those who actually did. In addition, we did not account for possible contamination of our sample by other local stroke programs and campaigns during our study period, although we were not aware of any. Finally, we did not perform a cost–benefit analysis of the stroke video game.

Overall, our findings demonstrate that a stroke video game may be an innovative method for improving and sustaining actionable stroke knowledge among young children.

Figure 2. Frequency of correct stroke knowledge responses. Pre-test (PT) vs immediate post-test (IP): a, P<0.001; b, P<0.01; c, P<0.05; PT vs delayed post-test (DP, 7 weeks): d, P<0.001; e, P<0.05; PT vs IP and PT vs DP: P values are based on χ² tests. Localization, stroke alias, and calling 911 were all multiple choice questions with 4 possible answers (expected correct=25% if subjects had no knowledge), whereas all others were Yes/No (expected correct=50% if subjects had no knowledge). The localization question regarded in which organ in the body a stroke occurs, the stroke alias question targeted the term brain attack, and the calling 911 question offered 4 options for stroke action.

Figure 3. Stroke knowledge before and 7 weeks after video game exposure.
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None.

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