Article:
Downs, JS, Bruine de Bruin, W, Fischhoff, B et al. (1 more author) (2015) Behavioral Decision Research Intervention Reduces Risky Sexual Behavior. Current HIV research, 13 (5). 439 - 446. ISSN 1570-162X

https://doi.org/10.2174/1570162X13666150511145328

Behavioral Decision Research Intervention Reduces Risky Sexual Behavior

Accepted for publication in Current HIV Research

Julie S. Downs PhD[1], Wändi Bruine de Bruin PhD[2,3],

Baruch Fischhoff PhD[1,3], & Pamela J. Murray MD MPH[4]

[1] Department of Social and Decision Sciences, Carnegie Mellon University

[2]Centre for Decision Research, Leeds University Business School

[3]Department of Engineering and Public Policy, Carnegie Mellon University

[4]Department of Pediatrics, West Virginia University

Running title: BEHAVIORAL DECISION INTERVENTION

Corresponding author:

Julie S. Downs

Department of Social and Decision Sciences

Carnegie Mellon University

Pittsburgh PA 15213-3890

downs@cmu.edu

412-268-1862

Abstract

Although adolescents are at disproportionate risk for sexually transmitted infections, most sex education programs have shown little effect on sexual behavior. An interactive video intervention developed by our team has been identified as one of a few programs thathave been documented to reduce sexually transmitted infections in this population. Building on behavioral decision research, we used a mental models approach to interview young women about their sexual decisions, finding, among other things, the strong role of perceived social norms. We based our intervention on these results, aiming to help young women identify and implement personally and socially acceptable decision strategies. A randomized controlled trial found that the video reduced risky sexual behavior and the acquisition ofchlamydia infection. We recently revised the video to suit more diverse audiences, and upgraded it to modern standards of cinematography and interactivity. It is now in field trial.

Keywords: Adolescents; Behavioral Intervention; Decision Science; Interactive Video; Sexual Health

Background

Prevention is the hallmark of public health research and practice. Avoiding or ameliorating a health-related problem is usually medically and ethically superior to treatment[1] and is often financially advantageous. This paper reviews the development and effectiveness of an intervention aimed at reducing adolescents' risky sexual behavior [2], detailing its foundation in behavioral decision science research methods. An early version of the interventionwas further refined using results from a pilot evaluation, resulting in an award-winning interactive video intervention that can hold adolescents' attention while delivering critical content on sexual health at extremely low cost to broad populations [3].

Healthy People 2020 objectives, citing the United Nations Report on Population and Development [4],identifyprevention of sexually transmitted infectionsas part of essential primary care for improving reproductive health [5]. These goals require particular focus on adolescents [6].In the US, adolescents and young adults (15-24 years) account for nearly two-thirds of new chlamydia infections and 70% of new gonorrhea infections [7,8]. Young women are at especially high risk, due to age-related physiological vulnerability [9,10], limited knowledge [11,12], inadequate condom use [13]and frequent condom failures [14,15].

These infections cause significant morbidity, extending beyond the adolescent period when they were first contracted.*Chlamydia trachomatis*and *Neisseria gonorrhea* can cause pelvic inflammatory disease (PID), resulting in chronic pelvic pain, ectopic pregnancy, and infertility [16-18], and also

increasesusceptibility to HIV [19,20]. Human papilloma virus plays a role in the development ofmost cervical cancers[21]as well as other genital cancers [22] and cancers in the mouth and throat[23], with rising rates of the last due in part to the increasing practice of oral sex in younger populations [27]. Although non-viralinfections can be cured once diagnosed, many are asymptomatic in their early phases and others, perhaps most notably HIV, have no cure [25-27].

The U.S. will spend over $15 billion on lifetime medical care to treat the sexually transmitted infections contracted in a single year[28], meaning that even fairly intensive prevention efforts have the potential to be cost-effective. Interventions might focus on the daunting challenge of preventing sexual behavior itself, ormight set a more modest goal of changing aspects of behavior associated with higher risk.In particular, they might encourage greater condom use, a relatively effective means of preventing sexually transmitted infections and unwanted pregnancies[29].

Even those less intrusive behavioral changesface significant barriers, especially for young women. Theymay feel too little control over sexual situations to ask partners about condoms[30,31], especially when those partners are older [32,33] or give them monetary or other valuable gifts[34].Even when they are inclined to ask, young women who have fewer communication strategies at their disposal are less likely to convince their partner to use a condom[35]. No single strategy appears to be best, as different strategies work better with different partners, and reactions to communication attempts can vary widely. For example, male partners most resistant to condom use are also those most likely to react

angrily to female partners' proposals of condom use[36].Perhaps in anticipation, women tend to be indirect about condoms[37], with many young women unable to discuss the topic at all, even when they would prefer to use one [38].

As a result of suchcomplications, sexual health has proven a particularly stubborn problem, compared to other health behaviors[39]. From the variety of approaches that have been tried [40-42], certain characteristics of interventions have been identified as being especially effective [42,43]. The next section reviews this record, with particular attention to the challenges of replicatingeven seemingly successful programsin wide-scale dissemination, outside the controlled conditions of clinical trials.

Intervention efforts

The main sources of sexual education for adolescents are school, parents,friendsand the media, especially the Internet [44,45].School-based sex education programs, especially those meeting specified process and content standards,have been found to reduce sexual risky behavior[46,47]. However,many fail, and even successful ones may lack the consistent funding needed for proper implementation [48]. Communication with parents has also shown promise [49], although it often occurs after the initiation of sexual activity [50] and tends to convey parents' out-of-date information to their teens [51].

Extracurricular programs offer an alternative to school and family education, especially for high-risk youth[52], and can be incorporated into clinicalcare, after-school programs, and non-profit outreach, or delivered on the Internet [53].Evaluations of multiple interventions have identified a few key

predictors of success.In particular, programs are more likelyto reduce sexual encounters when they do not focus on abstinence as a goal, and are more likely to improve condom use when they provide more condom skills training or motivational training[42]. Unfortunately, overall effectiveness of implemented programs seems to have dropped in recent years, chiefly due to neglecting these identified predictors[42]. The drift away from effective programs may be related to political pressure [54,55]and lack of fidelity in delivery [56], perhaps due in part to educators'limited understanding of adolescent sexual decision making.

Many interventions are grounded in social cognitive modelsof behavior, such as the theory of reasoned action[57,58] or the health belief model[59,60]. Using these models as a guide to design an intervention has been found to promote effectiveness[61], compared to interventions based on no more than well-meaning intuitions and hopes [62,63]. However, none of these models has shown consistent superiority over the alternatives[62]. Moreover,each offers such general concepts that researchers face a serious challenge in applyingthem to specific behaviors, contexts and target audiences [64,65].That application can be especially challenging with sexual behavior, whereadolescents' concernsand preferred language may differ substantially from those of educators, policy makers, and researchers[2,66,67].Interventions that neglect their audience's concerns, use technical jargon, or impose a culturally foreign perspective may destroy the credibility needed for effective communication.

A recent review commissioned by the U.S.Department of Health and Human Services in 2009, with findings later updated in 2012[68],reviewed

452program evaluations conducted between 1989 and 2011. The review identifiedjust 31 programs that had shown evidence of favorable impactwith a moderate or high-quality evaluation design; only five demonstrated a reduction in sexually transmitted infections. One of those is a program that we developed,which we describe here. This intervention focuses on known obstacles to healthy sexual behavior, as revealed and measured empirically with female adolescents. It was developed through multiple, iterative pretests with members of its target audience,refining the content and tone of material in order to reduce the barriers to such communications.

A substantial effort is currently underway, funded by the Department of Health and Human Services, to evaluate the large-scale replicability of programs that have shown promise in research trials [68]. The failure of replications in the pasthas prompted pessimism about the viability of allbehavioral interventions[69,70].One key barrier to replication is implementingan intervention faithfully under normal field conditions[69], particularly when it requires trained, motivated personnel – a common feature of most interventions with success inclinical trials [68]. Indeed, almostall of the successful interventionsidentified by the reviewdeliver their content through group discussion sessions, facilitated by instructors or other trained personnel.Such programs are costly under the best of conditions, and particularly vulnerable to reduced fidelity as they scale up with less closely supervised personnel and delivery.For example, teachersmay feel that they know their students better than the creators of a program do, leading them to alter materials based on their own intuitions[71], especially when they

lack confidence in the program's goals or effectiveness[72]. Perhaps as a result of poor fidelity, replications often fail to reproduce initially promising results, with problems arising from lower adherence and inconsistent delivery[72-74].

One wayto achieve fidelity is to standardize as much of an intervention as possible. High quality, user-friendly media technology now allowspresentation ofinteractive material consistently to wide audiences, with low distribution costs once the initial investment has been made in their creation[75,76]. Computer-based HIV prevention programs have been found to have similar efficacy to in-person interventions[77,78]. Indeed, even before digital video made accessibility and interactivity trivial, video interventions were found to be particularly effective in changing knowledge and attitudes about sexual risk [79] and other precursors to behavior change [80]. More generally, videohas beenfound effective in changing a variety of behaviors, especially ones requiring modeling of new behavior [81].

In the domain of sexual health, interventions incorporating video have been found to increase condom-related intentions [82], proximal behaviors such as condom coupon redemption and HIV testing [83,84], longer-term behaviors including self-reported condom use several months following initial intervention [85-87], and clinical outcomes [88,89]. However, even these interventions typically incorporate video as part of facilitator-led group sessions, leaving them vulnerable to the challenges of cost and fidelity [90]. Our intervention seeks to overcome the replicability problem with an interactive video-onlyintervention [2].

In addition to the physiological vulnerabilities and communication challenges described above, adolescents also face psychological barriers that lead to increased risk taking. In particular, they tend to lack the proficiency in risk-averse, gist-based cognitive processing that adults use to identify risky situations,leaving adolescentsmore reliant on deliberative processing, hence morevulnerable to peer influenceand emotionally charged situations [91].Although more systematic information processing on the part of adolescents may seem desirable, it leaves their reasoning more vulnerable to limitations of cognitive capacity. In contrast to adults'simple heuristic retreat from situations perceived as risky, adolescents tend to have a less developed gist response to risk, forcing them to consider each situation anew, in real time [91].

Our program directly addresses these barriers by integrating cognitive, social, and emotional processes prior to sexual encounters, guiding adolescents in risk-evaluative deliberative processing while they have time to think, thereby facilitating gist-based processing later when sexual situations arise [66].We thus hope to afford adolescents proficiency in identifying and evaluating such situations, so that they can generate and implement strategies that allow them to have the kind of sex that they want, including none at all.

We sought to make the intervention compatible with adolescents' intuitive perspectives on sexual behavior, in order to build on their strengths and address their weaknesses in terms meaningful to them. To gain these insights into both contexts and decisions, we used the mental models approach to guide intervention development [92].

The Mental Models Approach to Decision-Making

The mental modelsmethodologycontrasts a target population's beliefs about a situation with experts' beliefs based on the scientific literature. In the terms of behavioral decision research [93], the approachbegins with a *normative* analysis of the factors relevant to making choices that best achieve decisionmakers' desired outcomes. It proceeds with*descriptive* studies that examine how people actually view their decisions and *prescriptive* approaches designed to improve decision makingby closing the normative-descriptive gap. The approach builds on other mental models approaches in cognitive psychology, adapting them to the complex, open, uncertain situations often facing decision makers [94-97].The approach has been applied to diverse topics,including many health-related challenges such as HIV [98], vaccination [99], mammography [100], health risks of paint stripper [101], cancer [102], and Cryptosporidium in water supplies[103].

By addressing individuals' beliefs about the costs, benefits, and social context of their decisions, mental models studies address the key elements of the social cognitive models of behavior change discussed above, with the detail and the languageneeded to connect with individuals' lives. The normative analyses underlying its applications identify the key features of specific domains, and its descriptive approaches facilitate identification of critical misconceptions and barriers to implementing decisions and changing behavior. Thus, the mental models approach picks up where general models leave off, providing a systematic approach to identifyingthe context-specific aspects of behavior most

relevant to the decisions of the target population andthose most in need of treatment.

Mental models interventions require intensive and extensive discourse with diverse experts in the domain to identify relevant data, and with members of the intended audience to identify missing and misunderstood elements of the puzzle. Audience members are treated collaboratively throughout the research, to ensure that the intervention is clear, credible, useful, and culturally appropriate [92,104]. Each of its steps is described in more detail below.

Normative:Expert Model Development. A formal analysis of the decision domain based on expert input guides the research by creating a structured summary of the scientific literature in decision-relevant terms. That knowledge is translated into a qualitative formal expert model, summarizing the key factors and their interdependencies [105]. Thismodel is reviewed by experts and revised to incorporate their feedback, iterating as needed. Once complete, the expert model shows the expert-identifiedfactors contributing to the risk and the qualitative relationships between these factors, organized as a directed graph akin to an influence diagram, with the factors as nodes and causal links connecting them [106-108]. The expert model defines the factors that shapeindividuals' behaviors and outcomes, guidingthe descriptive research and the subsequent intervention design.

Descriptive: Interviews and Surveys with Target Audience. Using the expert model as a guide, descriptive research is conducted to characterize how the target audience understands the domain. The first step is to conduct semi-

structured interviews to reveal how the target audience thinks about the factors determining the risks and benefits of possible actions and their precursors. Interviewees provide candid descriptions, expressed in their own termsand language. To avoid suggesting topics or wording, the interviews are open-ended and non-judgmental, beginning with very general questions of the form "tell me about…." Interviewees are asked to elaborate on everything that they say, including their explanations. This strategy allows respondents' perspectivesto emerge in their own terms, minimizing the impact of questioning. Once general questions yield no new beliefs, the interviewer uses prompts to tap topics in the expert model that might have slipped respondents' minds or not fit the flow of the interview, such as how to prevent specific negative consequences from happening. Additional questions ask about relevant situations, how they evolve, and strategies for reducing risk.

Each interview is then transcribed verbatim and broken into discrete parts for coding,separately blocking each sentence or thought. These blocks are then coded into the normative expert model, with each concept mapped onto a node or link from the model wherever possible [109].The precision of the expert model typically allows for reliable coding of the interview protocols, such that two independent coders can reach high agreement with adequate training. This exercise is sufficiently labor-intensive that researchers must address the trade-off between the time and resources required to code each additional interview against the knowledge to be gained. If drawn from a diverse population, a sample

as small as 10-20is sufficient to reveal 70-90% of concepts that a larger population would eventually voice [92,110].

When responses cannot be coded into the expert model, a special note is made. Periodically during coding,researchers assess whether these concepts represent areas where respondents are misinformed,new concerns, or even facts that the experts omitted.Additional consultation with expert sources may be needed.

Based on the mental modelsthat emerge from the interviews, structured surveys can be administered to larger samples to estimate the prevalence of the beliefs and their correlations with behaviors. Such a survey would cover the topics represented in the expert model, as well as additional myths and misconceptions revealed in the interviews, using wording similar to that used in the interviews to ensure language and context that is culturally appropriate and relevant [109]. Such a test is more ecologically valid than most standard knowledge tests [98] because it covers decision-relevant information, as defined by the expert model and interviews.

Prescriptive: Comparative Analyses of Normative vs. Descriptive Accounts. Comparing the mental model generated in the descriptive research to the normative expert modelprovides the means to identify information and explanations that the intervention must supply, remove, or reinforce. Even when researchers have strong intuitions and perceived content expertise about intervention content, these comparisons inevitablyproduce surprises. The comparison may reveal incorrect or overly simplistic statements regarding one

concept in the expert model and no attention at all to another. Critically, experts may have definedthe problem differently from the target audience,for example,neglecting outcomes important to decision makers [111]. In these cases, the expert model is revised to incorporate the missing content, and reviewedfor how other relationships are affected.

Concepts in the expert model that are under-developed in the mental models typically represent areas where people need a basic introduction to the issues. Concepts that are misunderstood represent areas where people need help both in seeing where their beliefs are faulty and in acquiring better understanding. Barriers to carrying out desired behaviors, such as lacking skills or strategies, represent opportunities for demonstrations and social modeling.Once the content of the intervention has been determined, it must be translated into meaningfultermsand accessible language that facilitate feasible behaviors. As with the structured surveys, this stepdraws on the interviews for wording and context, with draft versions iteratively reviewed by members of the target audience to ensure proper tone and phrasing. In that way, audience members become collaborators in the project rather than mere research subjects. The cost of thisintensive investment in development is typically small compared to the overall cost of the intervention,and negligible relative to the stakes riding on its success.

Finally, recognizing that understanding is necessary but not sufficient for effective choices, our approach embeds decision-relevant information in the social context driving the target behaviors. That context may include shared

misconceptions about the prevalence of risk behaviors (the focus of much social marketing)as well as the social and emotional pressures that can lead people to act against their best judgment.

Application of Mental Models Approach to Risky Sexual Behavior

We began the development of our intervention with the normative approach, gathering experts in sexual health risks and adolescent sexuality to create an expert model of the factors predicting sexual behavior and its outcomes [112]. We then used this model to guide our descriptive research, examiningyoung women's beliefs, attitudes, and feelings of self-efficacy regarding sexual decisions and behavior. We began with semi-structured mental models interviews, designed to reveal the gaps in young women’s understanding of sexual risk and perceived barriers to acting on that knowledge, by askinginterviewees to describe decisions about whether to engage in sexual behavior. We created avideo intervention entitled *What Could You Do?*[2,3], which addressed the descriptive findings identified by the research including a few key points described below.

First, young womenrevealed a startling lack of perceived personal and cognitive control over decisions in sexual situations. Mostrespondents could not identify the choice points in the events leading up to sexual encounters, nor did they feel that they had much power to influence events even where they could see choices. To address this finding, our intervention explicitly identifies choice points in the dramatized social-sexual scenarios, and then allows viewers to control the actions of the female character. It also models behaviors in which the

characters actively negotiate sexual risk reduction, such as saying no or using condoms.

These lessons are embodied invignettes presentingsituations familiar to most adolescents as ones that typically lead to sex. Viewers choose one (or more) of the vignettes to watch, and are then given choices for different developments in the storyline. Specifically, they may choose to continue along the highly scripted path toward sex [113], or they may select options that help the character to escapethe script and lower her risk. Each story includes four “choice points,” such as a kiss or a suggestionto go somewhere alone with a potential sexual partner.Each choice point is followed by realistic, user-tested options to break from the script and avoid risky sex. For example, a character might say, “I don’t think I’m ready for that,” or a more evasive, “I told my friend I’d stick around.” The viewer chooses one option and then watches the scene play out based on her selection.By offering options that vary in their directness, the intervention seeks to appeal to viewers with different temperaments and assertiveness.

When the viewer chooses to have the character resist riskier sexual behavior, she is asked to think about herself in that situation and to rehearse how she would personally manage it. The video pauses for 30 seconds while text on the screen encourages the viewer to think and practice.Here, the intervention draws on the vicarious learning and modeling strategies of social learning theory and its use of cognitive rehearsal strategies to change behavior [114,115], hoping to help viewers plan sexual decisions prior to facing emotionally charged

situations.Such repeated planning seeks to make responses to these dramatized situations habitual, so that the actual situations will activate gist triggering of the practiced response.

A second result from the descriptive research was thatyoung women did not appear to considerthe relative risks of different choices and behaviors. Rather, they often lost themselves in tortured deliberations over whether a particular behavior was risky or safe. A corollary confusion was the common concern that because condoms do not reduce risk to zero, there is no point in using them. In response, the intervention focused on relative risk, using the metaphor of a scale with risk going up and down, showing the benefit of lowering risk, even if not to zero.Considering research findings that interventions using eroticized risk-reduction techniques may be more effective [116], condoms were presented in the positive context of increasing pleasure, rather thanthe negative one of preventing disease or unplanned pregnancy.

A third finding was young women's profound lack of knowledge about their reproductive system and sexually transmitted infections other than HIV. In previous research, we documented adolescents' relatively good understanding of HIV, marred by a few key misconceptions [98]. Here, all participants chose HIV as the infection that they knew best.When asked to describe a second infection,they revealed confusion about other transmission mechanisms, treatment options or prognoses, tending to revert back to what they knew about HIV.

Given the number and diversity of common infections, we developed a structuredapproach to organize relevant information. It distinguished viral from bacterial infections, showed how different sexual behaviors affect the disease transmission, and described how different infectionscould be treated and whether they could be cured. Within this framework, young womencould explore transmission, diagnosis, and treatment information regarding specific infections of interest to them,identified as bacteria or viruses. Thus, viewers'choicesreinforce theirknowledge, highlighting opportunities to reduce risks at each stage. We sought to create a mental model that afforded the active mastery needed to absorb future information and experiences, and to make inferences about unfamiliar situations. The interventionis meant to afford a feeling of competence, empowering young women to seek information about the world and their own health, knowing that they have a reasonable chance of making sense of it. To help adolescents master the social aspects of communicating about these sensitive topics, the intervention also modeleddiscussions with sexual partners andhealth care professionals.

Thus, the interactive video intervention addressedcognitive, social, and emotional aspects of sexual risk management, trying to help viewers acquire needed information, along with decision-makingand negotiation skills, as a counterweight to the social pressure in the highly scripted contextsrevealed in our formative interviews. By helping viewers to identify choice points, analyze their impacts, and rehearse potential responses in advance, the intervention

sought to empower young women to create their own, alternative,practiced scripts.

A randomized clinical trial [2]compared the intervention to one of twocontent-matched “usual care” control groups, enrolling sexually active young women and following them for six months. Participants assigned to our intervention were more likely to report having been completely abstinent in follow-up surveys. This increased abstinence is especially impressive because the video did not discouragesexual activity, but merely offered strategies for those wishing to avoid it. Furthermore, among participantswho remained sexually active in the follow-up period and attempted to use condoms, those in the intervention condition reported fewer episodes of condom failures, another topicraised in the interviews and explicitly targeted in the intervention.The intervention was also more effective at preventing acquisition of sexually transmitted infections, as reflected in self-reports and clinical tests,although the latter were underpowered and not statistically significant.

Follow-up analyses revealed viewers’ racial background to be a strikingly important variable. The content had two main vignettes, involving a boyfriend and a new partner. Because young women disproportionately forego condoms with established partners[117], we anticipated that the boyfriend scenario would have greater potential to increase condom use. Aiming for racial diversity, we cast the two roles with one white and one African-American actor. We imagined that viewers wouldchoose the story of the character with the most similar relationship to her own (i.e., with or withouta boyfriend). However, participants were far more

likely to choose the same-race character irrespective of their current relationship. A possibly related result was that the intervention was most effective for African American participants, who had disproportionately chosen to watch the boyfriend scenario, cast with African American actors. Indeed, for this group, our intervention cut biologically confirmedchlamydia diagnoses by more than half compared to controls. This pattern suggests the importance ofconsidering viewer characteristics in intervention design.

Updating the Intervention

In 2011, we updated the intervention, revising the script and taking advantage of technological advances in video production. As with the original, the content was driven by young women'sneeds, and the tone was respectful and non-judgmental, helping teens to make and implement decisions in order to achieve their goals. The interactive structure allowedviewersto select personally relevant content from a larger set of vignettes, created to prevent race from determining the storyline that viewers chose. The scripts were subject to pilot testing to refine language and concepts, and the final video was again designed so that teens could useit privately, reducing any embarrassment around sensitive issues.

Our revised intervention, *Seventeen Days* (www.SeventeenDays.org),can be delivered online,so that it can be used inclinical or non-clinicalsettings, with technology that is now commonplace and ubiquitous. We are currently conducting a wide-scale evaluation, recruiting young women seeking usual care at diverseurban and rural clinics, includingadolescent medicine, family planning

and public health settings,across three U.S. states. These settings serve sexually active adolescent femalesat times when they may be particularly interested in the topic, but at clinics that often lack the staff time needed for detailed information and high-intensity behavioral counseling sessions. The intervention can fill that role at essentially no cost to the clinics, perhaps even keeping patients occupied while waiting for care and providing information that will facilitate patients' discussions with their provider.

Specific Program Updates

The program was changed in four ways: First, we updated the technology, which wasoriginally constrained by the now defunctCD-*i* platform. The new video is optimized for high definition, wide-screen DVD and online streaming, allowing us to use high quality, full-motion video for all its elements.Thedigital editing platform allows us to make content updates easily, as we needed to do almost immediately after its completion when a policy change made emergency contraception available without a prescription for patients under the age of 17.

Second, we updated medical information where the science had changed, includingfacts regarding the prevalence, incidence, symptoms, prevention and treatment of the eight primary infections described (e.g., the availability of a vaccine to prevent HPV). As before, all medical information underwent rigorous internal and external expert review.

Third, we updated social content to be contemporary, with an eye to avoiding elements that would date it. For example, we avoided slang, fashion or fast-evolving technology(e.g.,cell phones, computers, eyeglasses).

Fourth, weadaptedthe content to have African American, Hispanic and non-Hispanic white characters facing each of the two situations, so that viewers could choose race-congruent characters in scenarios involving a steady boyfriend or a potential new partner. Having six such vignettes also allowed viewers to see some of the richness to the relationshipsemerging in the different stories, which they could view in turn.

In the evaluation currently in the field, the video is being delivered on a dedicated website, with participants accessing it on laptop and tablet computers in the clinics or on their home computers or smartphones. In2012, 68% of U.S. households had broadband Internet at home, and most of our participants had such access at home or elsewhere. When participants log in, they are directed to the appropriate video (*Seventeen Days*or a controlvideo focusing on safe driving), which theycan pick up where they previously left off, repeat content that they want to see again, or start something new, just as they could in the clinic. We believe that our combination of technology, research methodology, and respectful presentation can empower individuals to improve their health behavior, here and in other domains.

Conclusions

Behavioral decision science tools, in particular the mental models approach, can guide developmentof interventions to improve decision making and health outcomes. A key strength of the method lies in its systematic approach to identifying content-specific problems interfering with sound decision making. Using such analytical empirical methods to identify and present content

provides a disciplined foundation for creating interventions that addressesindividuals' concerns and help to reduce their risk.

Conflict of Interest

The authors declare no conflicts of interest.

Acknowledgements

This research was supported by grant number IU19 AI 38513 from the National Institute of Allergies and Infectious Diseases (NIAID), and grant number TP1AH000040 from the Office of Adolescent Health.

References

[1] Singh S, Darroch JE, Vlassoff M, Nadeau J. Adding it up: the benefits of investing in sexual and reproductive health care. United Nations Population Fund (UNFPA) 2009.

[2] Downs JS, Murray PJ, Bruine de Bruin W, Penrose J, Palmgren C, Fischhoff B. Interactive Video Behavioral Intervention to Reduce Adolescent Females' STD Risk: A Randomized Controlled Trial. Soc Sci Med 2004; 59: 1561-1572.

[3] Downs JS. Prescriptive scientific narratives for communicating usable science. Proceedings of the National Academy of Sciences; in press.

[4] United Nations. Report of the International Conference on Population and Development; September 1994; Cairo, Egypt ; New York: United Nations 1995.

[5] U.S. Department of Health and Human Services. http://www.healthypeople.gov/2020 (accessed April 10, 2013).

[6] Committee on Adolescence and Society for Adolescent Health and Medicine. Screening for nonviral sexually transmitted infections in adolescents and young adults. Pediatrics 2014;134:e302.

[7] Centers for Disease Control and Prevention. Incidence, prevalence, and cost of sexually transmitted infections in the United States. Morbidity and Mortality Weekly Report (MMWR) February 2013.

[8] Centers for Disease Control and Prevention. Sexually Transmitted Disease Surveillance 2012.Atlanta: U.S. Department of Health and Human Services 2013.

[9] Critchlow CW, Wölner-Hanssen P, Eschenach DA, Kiviat NB, *et al*. Determinants of cervical ectopia and of cervicitis – age, oral contraception, specific cervical infection, smoking, and douching. Am J Clin Exp Obstet Gynecol 1995; 173: 534-543.

[10] Moscicki, AB. HPV infections in adolescents. Dis Markers 2007; 23(4): 229-234.

[11] Braverman PK, Snyder BK. CDC survey: Many sexually active females don't know they are at risk for pregnancy. AAP News 2012; 33(5):13.

[12] Hilton S, Smith E. "I thought cancer was one of those random things. didn't know cancer could be caught…": Adolescent girls' understandings and experiences of the HPV programme in the UK. Vaccine 2011; 29(26): 4409-4415.

[13] Eaton DK, Kann L, Kinchen S, *et al*. Youth risk behavior surveillance-United States, 2011. Morbidity and Mortality Weekly Report. Surveillance Summaries 2012; 61(4): 1-162.

[14] Coyle KK, Franks HM, Glassman JR, Stanoff NM. Condom Use: Slippage, Breakage, and Steps for Proper Use Among Adolescents in Alternative School Settings. J Sch Health 2012; 82(8): 345-352.

[15] Crosby RA, DiClemente RJ, Wingood GM, *et al*. Condom failure among adolescents: implications for STD prevention. J Adolesc Health 2005; 36(6): 534-6.

[16] Haggerty CL, Gottlieb SL, Taylor BD, Low N, Xu F, Ness RB. Risk of sequelae after Chlamydia trachomatis genital infection in women. J Infect Dis 2010; 201(Supplement 2): S134-S155.

[17] Gottlieb SL, Brunham RC, Byrne GI, Martin DH, Xu F, Berman SM. Introduction: the natural history and immunobiology of Chlamydia trachomatis genital infection and implications for chlamydia control. J Infect Dis 2010; 201(Supplement 2): S85-7.

[18] World Health Organization. Global prevalence and incidence of selected curable sexually transmitted infections. Overview and estimates. Geneva: World Health Organisation; 2001.

[19] Newbern EC, Anschuetz GL, Eberhart MG, *et al*. Adolescent Sexually Transmitted Infections and Risk for Subsequent HIV. Am J Public Health 2013; 0: e1-e8.

[20] Goldstein MA. Sexually Transmitted Infections in Adolescents. In The MassGeneral Hospital for Children Adolescent Medicine Handbook. Springer New York. .2011; pp. 119-146.

[21] Muñoz N, Castellsagué X, de González AB, Gissmann L. HPV in the etiology of human cancer. Vaccine 2006; 24: S1-S10.

[22] Parkin DM, BrayF. The burden of HPV-related cancers. Vaccine 2006; 24: S11-S25.

[23] Marur S, D'Souza G, Westra WH, Forastiere AA. HPV-associated head and neck cancer: a virus-related cancer epidemic. Lancet Oncol 2010; 11(8): 781-9.

[24] Gillison ML, Broutian T, Pickard RK, *et al*. Prevalence of oral HPV infection in the United States, 2009-2010. JAMA 2012; 307(7): 693-703.

[25] Beauman JG. Genital herpes: a review. Am Fam Physician 2005;

72(8): 527.

[26] Chun TW, Fauci AS. HIV reservoirs: pathogenesis and obstacles to viral eradication and cure. AIDS 2012; 26(10): 1261-68.

[27] Hyman CL, Roblin PM, Gaydos CA, Quinn TC, Schachter J, Hammerschlag MR. Prevalence of asymptomatic nasopharyngeal carriage of Chlamydia pneumoniae in subjectively healthy adults: assessment by polymerase chain reaction-enzyme immunoassay and culture. Clin Infect Dis 1995; 20(5): 1174-78.

[28] Owusu-Edusei Jr K, Chesson HW, Gift TL. The estimated direct medical cost of selected sexually transmitted infections in the United States, 2008. Sex Transm Dis 2013; 40(3): 197-201.

[29] Duerr A, Gallo MF, Warner L, *et al*. Assessing male condom failure and incorrect use. Sex Transm Dis 2011; 38(7): 580-6.

[30] Ulibarri MD, Raj A, Amaro H. Love, sex, and power revisited. HIV Prevention With Latinos: Theory, Research, and Practice. 2012.

[31] Gutierrez L, Oh HJ, Gillmore MR. Toward an understanding of (em)power(ment) for HIV/AIDS prevention with adolescent women. Sex Roles 2000; 42: 581-611.

[32] Kaestle CE, Morisky DE, Wiley DJ. Sexual intercourse and the age difference between adolescent females and their romantic partners. Perspect Sex Reprod Healt**h** 2002; 34: 304-9.

[33] Staras SA, Cook RL, Clark DB. Sexual partner characteristics and sexually transmitted diseases among adolescents and young adults. Sex Transm

Dis 2009; 36(4): 232-238.

[34] Rosenbaum J, Zenilman J, Rose E, Wingood G, DiClemente R. Cash, cars, and condoms: Economic factors in disadvantaged adolescent women's condom use. J Adolesc Health 2012; 51(3): 233-241.

[35] Holland KJ, French SE. Condom negotiation strategy use and effectiveness among college students. J Sex Res 2012; 49(5): 443-453.

[36] Otto-Salaj LL, Traxel N, Brondino MJ, *et al*. Reactions of heterosexual African American men to women's condom negotiation strategies. J Sex Res 2010; 47(6):539-551.

[37] Lam AG, Mak A, Lindsay PD, Russell ST. What really works? An exploratory study of condom negotiation strategies. AIDS Educ Prev 2004; 16(2): 160-171.

[38] Teitelman AM, Tennille J, Bohinski JM, Jemmott LS, Jemmott III JB. Unwanted unprotected sex: Condom coercion by male partners and self silencing of condom negotiation among adolescent girls. Adv Nurs Sci 2011; 34(3): 243-259.

[39] Johnson BT, Scott-Sheldon LA, Carey MP. Meta-synthesis of health behavior change meta-analyses. Am J Public Health 2010; 100: 2193.

[40] Crepaz N, Marshall KJ, Aupont LW, *et al*. The efficacy of HIV/STI behavioral interventions for African American females in the United States: a meta-analysis. Am J Public Health 2009; 99(11): 2069-2078.

[41] Horowitz SM. Applying the transtheoretical model to pregnancy and STD

prevention: A review of the literature. Am J Health Promot 2003;17: 304-328.

[42] Johnson BT, Scott-Sheldon LA, Huedo-Medina TB, Carey MP. Interventions to reduce sexual risk for human immunodeficiency virus in adolescents: a meta-analysis of trials, 1985-2008. Arch Pediat Adol Med 2011; 165(1): 77.

[43] Scott-Sheldon LA, Huedo-Medina TB, Warren MR, Johnson BT, Carey MP. Efficacy of behavioral interventions to increase condom use and reduce sexually transmitted infections: a meta-analysis, 1991 to 2010. J Acq Immun Def Synd, 2011; 58(5): 489-498.

[44] Bleakley A, Hennessy M, Fishbein M, Coles Jr HC, Jordan A. How sources of sexual information relate to adolescents' beliefs about sex. Am J Health Behav 2009; 33(1): 37.

[45] Gray NJ, Klein JD, Noyce PR, Sesselberg TS, Cantrill JA. Health information-seeking behaviour in adolescence: the place of the internet. Soc Sci Med 2005; 60(7): 1467-1478.

[46] Kirby D. Sexuality and sex education at home and school. Adolesc Med 1999; 10: 195-209.

[47] Kirby D. Abstinence, sex, and STD/HIV education programs for teens: Their impact on sexual behavior, pregnancy, and sexually transmitted disease. Annu Rev Sex Res 2007;18(1), 143-177.

[48] Kirby D. Comprehensive sex education: strong public support and persuasive evidence of impact, but little funding. Arch Pediat Adol Med 2006; 160(11): 1182.

[49] Aspy CB, Vesely SK, Oman RF, Rodine S, Marshall L, McLeroy K. Parental communication and youth sexual behaviour. J Adolescence 2007; 30(3): 449-466.

[50] Eisenberg ME, Sieving RE, Bearinger LH, Swain C, Resnick MD. Parents' communication with adolescents about sexual behavior: A missed opportunity for prevention?. J Youth Adolescence 2006; 35(6): 893-902.

[51] Eisenberg ME, Bearinger LH, Sieving RE, Swain C, Resnick MD. Parents' beliefs about condoms and oral contraceptives: are they medically accurate?. Perspect Sex Reprod Health 2004; 36(2): 50-7.

[52] Ethier KA, Orr DP. Behavioral interventions for prevention and control of STDs among adolescents. In Behavioral Interventions for Prevention and Control of Sexually Transmitted Diseases. Springer US 2007;277-309.

[53] Bennett GG, Glasgow RE. The delivery of public health interventions via the Internet: actualizing their potential. Annu Rev Publ Health 2009; 30: 273-292.

[54] Doan AE, Williams JC. The politics of virginity: Abstinence in sex education. Soc Forces 2008; 89: 3.

[55] Santelli J, Ott MA, Lyon M, Roger J, Summers D, Schleifer R. (2006). Abstinence and abstinence-only education: a review of US policies and programs. J Adolesc Health 2006; 38(1): 72-81.

[56] Cohen DJ, Crabtree BF, Etz RS, *et al*. Fidelity versus flexibility: translating evidence-based research into practice. Am J Prev Med 2008; 35(5): S381-9.

[57] Fishbein M, Ajzen I. Belief, Attitude, Intention, and Behavior: An

Introduction to Theory and Research. MA: Addison-Wesley 1975.

[58] Ajzen I, Fishbein M. Understanding Attitudes and Predicting Social Behavior. Englewood Cliffs, NJ: Prentice-Hall 1980.

[59] Rosenstock IM. "Why people use health services", Milbank Memorial Fund Quarterly 1966; 44(3): 94–127.

[60] Janz NK, Becker MH. The Health Belief Model: A Decade Later. Health Educ Behav 1984; 11(1): 1–47.

[61] Glanz K, Bishop DB. The role of behavioral science theory in development and implementation of public health interventions. Annu Rev Publ Health 2010; 31: 399-418.

[62] Kim N, Stanton B, Li X, Dickersin K, Galbraith J. Effectiveness of the 40 adolescent AIDS risk reduction interventions: A quantitative review. J Adolesc Health 1997; 20: 204-15.

[63] Michie S, Abraham C. Interventions to change health behaviours: Evidence-based or evidence-inspired? Psychol Health 2004; 19: 29-49.

[64] Higgins DL, O'Reilly K, Tashima N, *et al*. Using formative research to lay the foundation for community level HIV prevention efforts: an example from the AIDS Community Demonstration Projects. Public Health Rep 1996; 111(Suppl 1): 28.

[65] Merzel C, D'afflitti J. Reconsidering community-based health promotion: promise, performance, and potential. Am J Public Health 2003;93(4): 557-574.

[66] Fischhoff B. Assessing adolescent decision-making competence. Dev Rev 2008; 28(1): 12-28.

[67] Fischhoff B, Bostrom A, Quadrel MJ. Risk perception and communication. Oxford Textbook of Public Health, 1105-23. London: Oxford University Press 2002.

[68] Goesling B, Colman S, Trenholm C, Terzian M, Moore K, Trends C. Programs to reduce teen pregnancy, sexually transmitted infections, and associated sexual risk behaviors: a systematic review. J Adolesc Health 2014; 54: 499-507.

[69] Aral SO. Utility and delivery of behavioural interventions to prevent sexually transmitted infections. Sex Transm Infect 2011; 87(Suppl 2): ii31-ii33.

[70] Aral SO, Blanchard J, Lipshutz J. STD/HIV prevention intervention: efficacy, effectiveness and population impact. Sex Transm Infect 2008; 84(Suppl 2): ii1-ii3.

[71] Dusenbury L, Brannigan R, Falco M, Hansen WB. A review of research on fidelity of implementation: implications for drug abuse prevention in school settings. Health Education Research 2003; 18(2): 237-256.

[72] Durlak JA, DuPre EP. Implementation matters: A review of research on the influence of implementation on program outcomes and the factors affecting implementation. Am J Commun Psychol 2008; 41(3-4): 327-350.

[73] Carroll C, Patterson M, Wood S, Booth A, Rick J, Balain S. A conceptual framework for implementation fidelity. Implement Sci 2007; 2(40): 1-9.

[74] Valdiserri. Accomplishments in HIV prevention science: Implications for stemming the epidemic. Nat Med 2003; 9: 881-6.

[75] Delgado HM, Austin SB. Can media promote responsible sexual

behaviors among adolescents and young adults? Current Opinion in Pediatrics 2007; 19(4): 405-410.

[76] Noar SM. Computer technology-based interventions in HIV prevention: state of the evidence and future directions for research. AIDS Care 2011; 23(5): 525-533.

[77] Bailey JV, Murray E, Rait G, *et al*. Computer-based interventions for sexual Health promotion: systematic review and meta-analyses. Int J STD AIDS 2012; 23(6): 408-413.

[78] Noar SM, Black HG, Pierce LB. Efficacy of computer technology based HIV prevention interventions: a meta-analysis. AIDS 2009; 23(1): 107-115.

[79] Healton CG, Messeri P. The effect of video interventions on improving knowledge and treatment compliance in the sexually tranmsitted disease clinic setting. Sex Transm Dis 1993; 20: 70-76.

[80] Kalichman SC. HIV-AIDS prevention videotapes: A review of empirical findings. J Prim Prev 1996; 17(2): 259-279.

[81] Tuong W, Larsen ER, Armstrong AW. Videos to influence: a systematic review of effectiveness of video-based education in modifying health behaviors. J Behav Med 2012: 1-16.

[82] Zimmers E, Privette G, Lowe RH, Chappa F. Increasing use of the female condom through video instruction. Percept Motor Skills 1999; 88: 1071-77.

[83] O'Donnell LN, Doval AS, Duran R, O'Donnell C. Video-based sexually transmitted disease patient education: Its impact on condom

acquisition. Am J Public Healt 1995; 85: 817-822.

[84] Solomon MZ, DeJong W. Preventing AIDS and other STDs through condom promotion: A patient education intervention. Am J Public Healt 1989; 79: 453-8.

[85] Kalichman SC, Cherry C, Browne-Sperling F. Effectiveness of a video-based motivational skills-building HIV risk-reduction intervention for inner city African American men. J Consult Clin Psychol 1999; 67: 959-966.

[86] Sanderson CA, Yopyk DJ. Improving condom use intentions and behavior by changing perceived partner norms: an evaluation of condom promotion videos for college students. Health Psychol 2007; 26(4): 481.

[87] Wingood GM, Card JJ, Er D, *et al*. Preliminary efficacy of a computer-based HIV intervention for African-American women. Psychol Health 2011; 26(2): 223 234.

[88] O'Donnell CR, O'Donnell L, San Doval A, Duran R, Labes K. Reductions in STD infections subsequent to an STD clinic visit using video-based patient education to supplement provider interactions. Sex Transm Dis 1998; 25: 161-168.

[89] Neumann MS, O'Donnell L, San Doval A, *et al*. Effectiveness of the VOICES/VOCES sexually transmitted disease/Human Immunodeficiency Virus prevention intervention when administered by health department staff: Does it work in the “real world”? Sex Transm Dis 2011; 38(2): 133-9.

[90] Card JJ, Kuhn T, Solomon J, Benner TA, Wingood GM, DiClemente RJ. Translating an effective group-based HIV prevention program to a program

delivered primarily by a computer: methods and outcomes. AIDS Educ Prev 2011; 23(2):159-174.

[91] Reyna VF, Farley F. Risk and rationality in adolescent decision making implications for theory, practice, and public policy. Psychol Sci Public Interest 2006; 7(1): 1-44.

[92] Morgan MG, Fischhoff B, Bostrom A, Atman C. Risk Communication: The Mental Models Approach. New York: Cambridge University Press 2001.

[93] Fischhoff B, Kadvany J. Risk: A Very Short Introduction. Oxford: Oxford University Press 2011.

[94] Gentner D, Stevens AL. Mental Models. Hillsdale, NJ: Erlbaum 1983.

[95] Johnson-Laird PN. Mental Models. Cambridge, MA: Harvard University Press 1983.

[96] Newell A, Simon HA. Human Problem Solving. Englewood Cliffs, NJ: Prentice-Hall 1972.

[97] Rouse WB, Morris NM. On looking into the black box: Prospects and limits in the search for mental models. Psychol Bull 1986; 100: 349-363.

[98] Bruine de Bruin W, Downs JS, Fischhoff B. Adolescents' thinking about the risks and benefits of sexual behavior. In: Lovett, M. & Shah, P. (Eds.) Thinking With Data. Mahwah, NJ: Erlbaum 2007.

[99] Downs JS, Bruine de Bruin W, Fischhoff B. Parents' vaccination comprehension and decisions. Vaccine 2008; 26: 1595-1607.

[100] Silverman E, Woloshin S, Schwartz LM, Byram SJ, Welch HG, Fischhoff B. Women's views of breast cancer risk and screening mammography:

A qualitative interview study. Med Decis Making 2001; 21: 231-240.

[101] Riley DM, Fischhoff B, Small M, Fischbeck P. Evaluating the effectiveness of risk-reduction strategies for consumer chemical products. Risk Anal 2001; 21: 357-369.

[102] Downs JS, Bruine de Bruin W, Fischhoff B, Hesse B, Maibach E. How people think about cancer: A mental models approach. In O'Hair D (Ed.) Handbook of Risk and Crisis Communication, Mahwah, NJ: Erlbaum 2008.

[103] Casman E, Fischhof B, Palmgren C, Small M, Wu F. Integrated risk model of a drinking waterborne Cryptosporidiosis outbreak. Risk Anal 2000; 20: 493-509.

[104] Fischhoff B, Downs JS. Communicating foodborne disease risk. Emerg Infect Dis 1998;3: 489-495.

[105] Downs JS, Fischhoff B. Qualitative Risk. In B. Fischhoff, N. Brewer, & J. S. Downs (Eds.) Communicating Risks and Benefits: An Evidence-Based User's Guide, Silver Spring, MD: US Department of Health and Human Services, Food and Drug Administration 2011; pp. 65-76.

[106] Burns WJ, Clemen RT. Covariance structure models and influence diagrams. Manage Sci 1993; 39: 816

[107] Howard RA. Knowledge Maps. Manage Sci 1989; 35: 903-922.

[108] Morgan MG, Henrion M. Uncertainty: A Guide to Dealing with Uncertainty in Quantitative Risk and Policy Analysis.New York: Cambridge University Press 1990.

[109] Bruine de Bruin W, Bostrom A. Assessing what to address in science

communication. Proceedings of the National Academy of Sciences 2013; 110(Supplement 3): 14062-14068.

[110] Guest G, Bunce A, Johnson L. How many interviews are enough? An experiment with data saturation and variability. Field Methods 2006; 18(1): 59-82.

[111] Fischhoff B. Giving advice: Decision theory perspectives on sexual assault. Am Psychol 1992; 47: 577-588.

[112] Fischhoff B, Downs JS, Bruine de Bruin W. Adolescent vulnerability: A framework for behavioral interventions. Appl Prev Psychol 1998; 7(2): 77-94.

[113] Sternberg RJ. Cognitive Psychology. Belmont, CA: Wadsworth 2012.

[114] Bandura A. Self-efficacy: Toward a unifying theory of behavior change. Psychol Rev 1977; 84: 191-215

[115] Bandura A. Self-efficacy: The Exercise of Control. New York: Freeman 1997.

[116] Scott-Sheldon LA, Johnson BT. Eroticizing creates safer sex: a research synthesis. J Prim Prev 2006; 27(6): 619-640.

[117] Fortenberry JD, Tu W, Harezlak J, Katz BP, Orr DP. Condom use as a function of time in new and established adolescent sexual relationships. Am J Public Health 2002; 92(2).