Interventions to Help People Understand Community Immunity: A Systematic Review

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Abstract 296/300 words

Background: The dynamic relationships between individual- and community-level behaviors and outcomes are at the heart of public health. Herd immunity, or community immunity, offers an example of such a relationship. Community immunity occurs when susceptible people in a population are indirectly protected from infection thanks to the pervasiveness of immunity within the population. Knowledge of such relationship varies among the general public.

Methods: We searched PubMed, EMBASE, CINAHL, the Cochrane Central Register of Controlled Trials and Web of Science for peer-reviewed articles describing interventions with or without evaluations. We then conducted web searches with Google to identify interventions lacking associated publications. We extracted data about the target population of the interventions, the interventions themselves (e.g., did they describe what community immunity is, and how it works), any effects of evaluated interventions, and synthesized data narratively.

Results: We identified 32 interventions: 11 interventions described in peer-reviewed articles and 21 interventions without associated articles. Of the 32 interventions, 5 described what community immunity is, 6 described the mechanisms of how community immunity occurs and 21 described both. Fourteen of the 32 addressed infectious diseases in general while the other 13 addressed one or more specific diseases. Twelve of the 32 interventions used videos, 7 used interactive simulations and 6 used questionnaires. Ten of the 11 peer-reviewed articles described studies evaluating the effects of the interventions; of these 10, 4 reported increased knowledge about immunization, 3 reported shifts of attitudes in favour of vaccination, 1 reported an increase in intentions to vaccinate among participants who viewed an visual simulation.

Conclusions: A compelling benefit of vaccination exists at the population level in the form of community immunity. Identifying ways to do this may be important, because some evidence

suggests that effective communication about community immunity can increase vaccine intentions.

Highlights (3-5 bullet points, max 85 characters each including spaces)

- Little evidence is available about the effects of communicating about community immunity.
- Effective communication about community immunity may increase vaccine intentions.
- Future research should focus on how to communicate this concept effectively.

Keywords: Community Immunity, Herd Immunity, Vaccination, Vaccine Hesitancy

1. Introduction

Many vaccines protect against disease not only by preventing infection in those receiving the vaccine, but also by preventing the infection from being transmitted from one person to another [1,2]. The terms herd immunity and community immunity refer to the indirect protection of unvaccinated people obtained by elevating the pervasiveness of immunity within a population. Such an elevation breaks the chain of transmission and decreases one's probability of contact with an infectious agent [2]. In this paper we use the term *community immunity*.

Previous research has suggested that potential benefits and harms at the individual level are more influential than those at the community level on people's decisions to immunize or not [3].

However, it is not clear whether people understand what is community immunity but don't find it important, or whether they don't understand how it works. That is, are the relationships between individual-level vaccination behaviour and individual- and community-level benefits and harms made clear to people? This is a complex communication task, because whether or not a given population achieves community immunity depends on many variables, including vaccine effectiveness, vaccine coverage, distribution patterns of infection among populations, timing of vaccine administration and serotype replacement [4]. Given the underlying complexity of community immunity as a concept, it is plausible that its lack of observed influence on vaccination decisions [5,6] may stem at least partly from a lack of clarity about the concept by members of the public.

In this systematic review, we aimed to synthesize evidence about interventions intended to help members of the general public better understand the concept of community immunity. By interventions, we mean any method, strategy, or tool developed to help people understand the concept of community immunity. Because visualization is a powerful way to convey complex topics [7,8] and because visualizations have proved effective at helping members of the public understand other related mathematical concepts such as how population-based statistics apply to an individual [7,9], we were particularly interested in web-based visualizations as interventions. By visualization, we mean visual presentations of data or information. These presentations may be static or dynamic, and interactive or not. The objective of this systematic review was therefore to describe interventions, including web-based interventions, aimed at conveying the concept of community immunity and to describe any reported effects of such interventions.

2. Methods

2.1. Search strategy

To identify peer-reviewed literature describing interventions, we searched PubMed, EMBASE, CINAHL, the Cochrane Central Register of Controlled Trials and Web of Science on April 19, 2016, updated on January 25, 2018 to identify any newer articles. The full search strategy is available in Supplemental file 1. We did not apply any language or publication date restrictions. In addition, we retrieved further studies by searching the references of relevant review articles [10–19], by a hand search of articles cited by or cited in the included articles, and by consulting with 33 experts through professional networks of co-authors for suggestions of relevant published or unpublished literature or web-based interventions missed during our search.

To identify interventions that may not have associated publications, we conducted an online Google search in two stages. We sought any web-based representations conveying the concept of herd immunity or community immunity. First, on April 24th 2017, we conducted a standard search using Google to find web-based representations which had herd immunity components or were about explaining community immunity. We used six search terms "Herd immunity", "Herd protection" , "Herd effect", "Community protection", "Indirect protection", "Community immunity" combining each with, "AND (simulation OR animation OR visualization)". We reviewed the first 30 results for each search, as it is rare for users to click past the third page of ten search results per page, and therefore, researchers analyzing medical content available on the web often use 30 as a threshold [20–23]. On June 9, 2017, we conducted the same searches in private browsing mode to ascertain whether our results had been affected by a "filter bubble"

[24]; that is, the way Google search results are adapted to one's previous browsing activity .

2.2. Study Selection and Screening Process

Two reviewers (HH, TP) independently identified and screened all studies and web-based interventions for their eligibility. Conflicts were resolved by a third reviewer (HW). We used PICO (Population, Intervention, Comparison, and Outcome) to structure study inclusion and exclusion criteria. Our population of interest was the general public or any subgroup thereof. We sought studies describing any strategies, tools or methods (including campaigns and educational tools) designed to help people understand more about the concept of community immunity. Our comparator was any control, including offering no education about community immunity or comparing participants before and after an intervention. Our outcomes of interest included common outcomes in vaccination acceptance studies: knowledge (comprehension, understanding), attitudes (attitudes toward or against vaccination), beliefs (risk perceptions, perceived benefits), and behavioural intentions (intentions to be vaccinated or not). We also sought to extract any data about emotions (e.g., fear, anxiety), as emotions are key drivers of decisions [25].

We excluded studies that did not have a component specifically about community immunity; for example, studies about policies, policy decision-making, vaccine provision programs, vaccine hesitancy, or anti-vaccine movements. For web-based tools, our inclusion and exclusion criteria used the same specifications regarding population and intervention. We did not apply comparison and outcome criteria to web-based tools because we did not expect these to report evaluation studies.We report this review according to PRISMA guidelines (see PRISMA

checklist in Supplemental file 2). This systematic review was registered in PROSPERO (CRD42017069206).

2.3. Data Extraction

Two people (HH, TP) independently extracted data from included articles and web-based interventions. Conflicts were resolved by a third reviewer (HW). From included articles and web-based interventions, we extracted information about: (1) the type of intervention (educational material for home use, live education session, etc.) (2) the medium of the intervention (paper, web, etc.), (3) the objective of the study or intervention, (4) whether the intervention was solely about community immunity or whether it was a broader intervention, (5) whether the intervention aimed to convey the importance or existence of community immunity (the "what" of community immunity; i.e., the existence of community-level protection to safeguard those who are not immune), how it works (the "how" of community immunity; i.e., community immunity is achieved by preventing the spread of infection from one person to another within the community), or both, and for evaluated interventions, (6) the characteristics of study participants and (7) outcomes observed. We extracted data about interventions' effects on knowledge, attitudes, beliefs (perceived benefits, perceived risks), and behaviours. We pre-selected these outcomes based on the Health Belief Model [26,27], a model widely used to predict health related-behaviours and to assess outcomes in studies of interventions about vaccination and immunization [10–13]. In the case of vaccination, people may rely on emotional, cultural, and social factors before making a decision [28,29]. Cultural and social factors are unlikely to be changed by interventions but emotions may be affected. Therefore, we also extracted data about emotions elicited by interventions based on the Affect Heuristic theoretical

framework, which describes the role and importance of emotions in judgment and decisions [25]. Because we sought to understand all possible effects, we did not prespecify any of these as a primary outcome.

2.4. Data Validation

When we were missing details or were uncertain about data, we contacted authors to review the data we had extracted about their studies. We contacted four authors via email. We received responses from three of these four, who reviewed the draft extractions we had sent as well as provided us with additional data not reported in their publication. After a reminder email with no response, we also followed up with the nonresponding author and their co-authors by email and phone, but were not able to reach any member of the authorship team.

2.5. Quality Assessment

We used the Mixed Methods Appraisal Tool (MMAT) by Pluye and colleagues [30] to assess the quality of all studies. Quality assessment was conducted independently by two reviewers (HH, TP) and disagreements were settled through discussion until consensus was reached. Remaining conflicts among them was resolved by a third reviewer (HW).

2.6. Data Synthesis

We organized data in tables and synthesized it descriptively. We also calculated observed heterogeneity (Higgins I^2) to determine whether it would be possible to conduct meta-analyses of available randomized controlled trials [31,32] on common outcomes, namely, behavioural intentions, perceived risk of disease, and perceived risk of vaccination. We used package meta

version 4.4-0 [33] within R version 3.3.0 [34] for these calculations.

3. Results

3.1. Articles Identified, Scope of Literature

We identified a total of 16,012 records through database searches and 529 interventions through Google searches. After removing duplicates, we screened 9,380 database records and 285 Web-based representations. After our private browsing mode search, no change was detected that was different from our previous search. Through these methods, we identified 8 articles and 19 web-based representations. Hand-searching yielded three other articles and two additional web-based representations. Thus, our final data set included 11 peer-reviewed articles and 21 web-based representations, for a total of 32 interventions. Figure 1 shows our PRISMA diagram.

[Figure about here]

Out of 11 interventions described in peer-reviewed articles, 3 were solely about community immunity while the other 8 had a component about community immunity within a larger intervention (Table 1). Out of 21 web-based representations, 18 were solely about community immunity while the other 3 had a component about community immunity within a larger intervention (Table 2). Thus, out of 32 interventions in total (peer-reviewed and web-based representations together), 21 were solely about community immunity, and 11 had included community immunity as a component of a larger intervention. Five interventions aimed to convey the "what" of community immunity, meaning what it is, six addressed the "how" of community immunity, meaning how it works, and 21 interventions addressed both (Table 3). As shown in Table 3, web-based representations generally included elements of the "how" of

community immunity whereas this was not necessarily the case for interventions presented in the peer-reviewed literature. For example, 4 out of 11 (36%) interventions described in the peer-reviewed literature conveyed that community immunity works by preventing the spread of infection, whereas 17 out of 21 (81%) web-based representations did the same. Ten out of 11 peer-reviewed articles reported evaluating the intervention according to at least one of our outcomes of interest and described the demographic characteristics of participants (Table 4; Table 5).

[Table 1, Table 2, and Table 3 about here]

3.2. Quality Assessment

Table 4 provides Mixed Methods Assessment Tool scores of all evaluated peer-reviewed articles included in our review. Of the ten studies, four had high quality scores (75% or above), two were of medium quality (50%) and four were of low quality (25%) on this measure. Supplemental files 3 and 4 provides full details.

[Table 4 about here]

3.3. Effects of Evaluated Interventions

Ten studies evaluated at least one of our outcomes of interest. Four studies that assessed knowledge (2 high quality, 1 medium quality, 1 low quality) showed an increase in knowledge about immunization in general [35–38]. These studies were larger interventions that included information about community immunity as a component of the intervention. The community immunity component was not evaluated independently. Three studies out of five that assessed attitudes (1 high quality, 1 medium quality, 3 low quality) showed the intervention shifted

attitudes more in favour of vaccination [36–40]. One study (high-quality) of an intervention specifically about community immunity showed an increase in intentions to vaccinate when the intervention was interactive and the concept of community immunity was explained [32]. One study (low quality) showed that the intervention may increase interest in vaccination if the concept of community immunity was explained as one's vaccination protecting others in society [41]. Four studies (1 high quality, 1 medium quality, 2 low quality) did not show any significant influences on attitudes and intentions to vaccinate [34,42,43,45]. Out of the three studies that evaluated the effects of an intervention solely about community immunity, two resulted in an increase in intentions to vaccinate [32,41] while the other demonstrated no change[31] . No studies evaluated the effects of interventions on emotions. Summarized outcomes are shown in Table 5.

[Table 5 about here]

3.4. Meta-Analysis

Two randomized controlled trials [34,35] tested outcomes in common, specifically, the effects of communicating information about community immunity on behavioural intentions, perceived risk of disease, and perceived risk of vaccination. Mean I^2 estimates were 63% (see Supplemental file 5), confirming high heterogeneity between the two studies, meaning that reliable meta-analytic results were not possible.

4. Discussion

In this study, we aimed to describe interventions aimed at conveying the concept of community immunity and to describe any reported effects of such interventions. Our results lead us to four

principal findings.

First, there is relatively little evidence about the effects of communicating about community immunity. Although a number of interventions described in the literature included a component about community immunity, few studies isolated the effects of such a component. This makes it difficult to interpret and report the effectiveness of interventions about community immunity, as any effects of these larger interventions may be due to their other components. However, within the limited sample of interventions specifically about community immunity, we observed that two out of three such interventions resulted in increases in intentions to vaccinate [32,41]. This suggests that communicating population-level benefits of vaccination may encourage vaccine uptake.

Second, we identified a number of interventions available online for which we were unable to find associated evaluation studies. These web-based representations often showed people not only what community immunity is, but also how it is achieved. This may be easier to do using dynamic methods such as visualization. It is unknown, however, whether such demonstrations make a difference, meaning that although communicating about community immunity may encourage vaccination, there remains little evidence about how to do this most effectively. Future research could compare different ways of communicating about community immunity to assess their influence on people's views about their role in protecting their community from infectious disease.

Third, studies in this review offered few results regarding variables that shape vaccination

intentions, such as knowledge or emotion. Although several studies reported effects on knowledge about immunization, few reported knowledge specifically about community immunity and none assessed emotions as outcomes. Emotions are critical to human decision-making [42] and influence decisions through their effects on risk perception [47], attitudes, and behavioural intentions [43–45]. Future research about the effects of communication interventions might therefore be improved by evaluating interventions' effects on emotions in addition to knowledge, attitudes, beliefs, and behavioural intentions.

Fourth and finally, our review documented that most included interventions were designed for high-income, Western countries. Moreover, evaluation studies measured the effects of their intervention mostly on sub-populations of school, college or university students. These population selection factors raise questions about the potential differential effects of interventions among members of the general population with varied age groups or education levels. One intervention that was designed to be used across cultures was more effective in encouraging vaccination intentions in Western countries than it was in Eastern countries. The authors noted that this was possibly because baseline vaccine uptake was already high in Eastern countries and there was therefore less room for change [32]. Cultural differences and differences between countries in terms of vaccination programs may be important to consider when analyzing public responses to interventions.

To the best of our knowledge, there are no previous systematic reviews synthesizing interventions to convey the concept of community immunity. Previous work has been mostly focused on improving knowledge, attitudes, beliefs, and behavioural intentions in order to

improve immunization or vaccination coverage, with limited research on how and whether the concept of community immunity might be conveyed.

Our systematic review had two main limitations. First, we may be missing relevant data. Although we aimed to be meticulous in our search strategy, it is possible that we missed some relevant studies or interventions. Even among included studies, when publications lacked details, some authors responded to our queries while others were not reachable. In addition, although we did not apply any language restriction when searching databases, our web searches used English keywords, and therefore, we may have missed interventions in other languages. Second, most of our evaluation data came from studies of interventions that included information about community immunity as a component of an overall intervention. This means that, in most cases, we were unable to isolate the effects of community immunity components.

5. Conclusions

This systematic review demonstrates that despite the existence of a number of interventions available for conveying the concept of community immunity, little is known about how to make this mathematically complex concept comprehensible to members of the general population. Identifying ways to do this may be important, because some evidence suggests that effective communication about community immunity can increase vaccine intentions. Future research should focus on how to communicate this concept effectively and should evaluate interventions' effects on vaccine intentions and uptake as well as their precursors, such as knowledge, attitudes, beliefs and emotions.

Conflict of interest

None

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Authors' Contributions

HH, HW contributed to the design of the study. HH, TP and HW contributed to data collection. HH and HW conducted data analysis and interpretation. HH and HW drafted the first version of the article with early revision by HH, TP and HW. HH, TP, CTC, ED, TG, AMCG, NMI, SMD, JSP, KW, DR, HW critically revised the article and approved the final version for submission for publication. HH, TP and HW had full access to all the data in the study and had final responsibility for the decision to submit for publication.

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Supplemental files

Supplemental file 1. Search Strategy

Supplemental file 2. PRISMA Checklist

Supplemental file 3. MMAT Score

Supplemental file 4. Risk of Bias

Supplemental file 5. Meta-Analysis

Tables

Figure

Abbreviations

MMAT= Mixed method assessment tool

SD = Sample standard deviation

MMR= Measles Mumps and Rubella

IB= Individual Benefits

SB= Social Benefits

Ctl= Control

References

[1] Metcalf CJE, Ferrari M, Graham AL, Grenfell BT. Understanding Herd Immunity. Trends Immunol 2015;36:753–5.

[2] Rashid H, Khandaker G, Booy R. Vaccination and herd immunity: what more do we know? Curr Opin Infect Dis 2012;25:243–9.

[3] Quadri-Sheriff M, Hendrix KS, Downs SM, Sturm LA, Zimet GD, Finnell SME. The role of herd immunity in parents' decision to vaccinate children: a systematic review. Pediatrics 2012;130:522–30.

[4] Scarbrough Lefebvre CD, Terlinden A, Standaert B. Dissecting the indirect effects caused by vaccines into the basic elements. Hum Vaccin Immunother 2015;11:2142–57.

[5] Fefferman NH, Naumova EN. Dangers of vaccine refusal near the herd immunity threshold: a modelling study. Lancet Infect Dis 2015;15:922–6.

[6] Betsch C. Innovations in communication: the Internet and the psychology of vaccination decisions. Euro Surveill 2011;16.

[7] Hawley ST, Zikmund-Fisher B, Ubel P, Jancovic A, Lucas T, Fagerlin A. The impact of the format of graphical presentation on health-related knowledge and treatment choices. Patient Educ Couns 2008;73:448–55.

[8] Okan Y, Garcia-Retamero R, Cokely ET, Maldonado A. Improving risk understanding across ability levels: Encouraging active processing with dynamic icon arrays. J Exp Psychol Appl 2015;21:178–94.

[9] Garcia-Retamero R, Cokely ET. Effective communication of risks to young adults: using message framing and visual aids to increase condom use and STD screening. J Exp Psychol Appl 2011;17:270.

[10] Dubé E, Gagnon D, MacDonald NE. Strategies intended to address vaccine hesitancy: Review of published reviews. Vaccine 2015;33:4191–203.

[11] Kaufman J, Synnot A, Ryan R, Hill S, Horey D, Willis N, et al. Face to face interventions for informing or educating parents about early childhood vaccination. The Cochrane Library 2013.

[12] Cairns G, MacDonald L, Angus K, Walker L, Cairns-Haylor T, Bowdler T. Systematic literature review of the evidence for effective national immunisation schedule promotional communications. European Centre for Disease Prevention and Control (ECDC); 2012.

[13] Saeterdal I, Lewin S, Austvoll□Dahlgren A, Glenton C, Munabi□Babigumira S. Interventions aimed at communities to inform and/or educate about early childhood vaccination. The Cochrane Library 2014.

[14] Odone A, Ferrari A, Spagnoli F, Visciarelli S, Shefer A, Pasquarella C, et al. Effectiveness of interventions that apply new media to improve vaccine uptake and vaccine coverage: A systematic review. Hum Vaccin Immunother 2015;11:72–82.

[15] Jarrett C, Wilson R, O'Leary M, Eckersberger E, Larson HJ. Strategies for addressing vaccine hesitancy–a systematic review. Vaccine 2015;33:4180–90.

[16] Sadaf A, Richards JL, Glanz J, Salmon DA, Omer SB. A systematic review of interventions for reducing parental vaccine refusal and vaccine hesitancy. Vaccine 2013;31:4293–304.

[17] Lorini C, Santomauro F, Donzellini M, Capecchi L, Bechini A, Boccalini S, et al. Health literacy and vaccination: A systematic review. Hum Vaccin Immunother 2018;14:478–88.

[18] Crocker-Buque T, Mindra G, Duncan R, Mounier-Jack S. Immunization, urbanization and slums - a systematic review of factors and interventions. BMC Public Health 2017;17:556.
[19] Jordan R, Connock M, Albon E, Fry-Smith A, Olowokure B, Hawker J, et al. Universal vaccination of children against influenza: are there indirect benefits to the community? A systematic review of the evidence. Vaccine 2006;24:1047–62.
[20] Hargrave DR, Hargrave UA, Bouffet E. Quality of health information on the Internet in pediatric neuro-oncology. Neuro Oncol 2006;8:175–82.
[21] Petrescu P. Google organic click-through rates in 2014. MOZ Blog (October 1st)-Http://moz Com/blog/google-Organic-Click-through-Rates-in-2014 [2016 05 30] 2014.
[22] iProspect Search Engine User Behavior Study n.d.
[23] van der Marel S, Duijvestein M, Hardwick JC, van den Brink GR, Veenendaal R, Hommes DW, et al. Quality of web-based information on inflammatory bowel diseases. Inflamm Bowel Dis 2009;15:1891–6.
[24] Resnick P, Garrett RK, Kriplean T, Munson SA, Stroud NJ. Bursting Your (Filter) Bubble: Strategies for Promoting Diverse Exposure. Proceedings of the 2013 Conference on Computer Supported Cooperative Work Companion, New York, NY, USA: ACM; 2013, p. 95–100.
[25] Slovic P, Finucane ML, Peters E, MacGregor DG. The affect heuristic. Eur J Oper Res 2007;177:1333–52.
[26] Janz NK, Becker MH. The Health Belief Model: a decade later. Health Educ Q 1984;11:1–47.
[27] Rosenstock IM. Historical origins of the health belief model. Health Educ Monogr 1974;2:328–35.
[28] Dubé E, Laberge C, Guay M, Bramadat P, Roy R, Bettinger J. Vaccine hesitancy: an overview. Hum Vaccin Immunother 2013;9:1763–73.
[29] Hobson-West P. Understanding vaccination resistance: moving beyond risk. Health Risk Soc 2003;5:273–83.
[30] Pluye P, Gagnon M-P, Griffiths F, Johnson-Lafleur J. A scoring system for appraising mixed methods research, and concomitantly appraising qualitative, quantitative and mixed methods primary studies in Mixed Studies Reviews. Int J Nurs Stud 2009;46:529–46.
[31] Betsch C, Böhm R, Korn L. Inviting free-riders or appealing to prosocial behavior? game-theoretical reflections on communicating herd immunity in vaccine advocacy. Health Psychol 2013;32:978.
[32] Betsch C, Böhm R, Korn L, Holtmann C. On the benefits of explaining herd immunity in vaccine advocacy. Nature Human Behaviour 2017;1:s41562–017 – 0056.
[33] Tran A. Meta Box 4.4.0 Released - Meta Box. Meta Box 2014. https://metabox.io/version-4-4-0/ (accessed November 15, 2017).
[34] R Development Core Team. R: A language and environment for statistical computing. Vienna, Austria: R Foundation for Statistical Computing; 2017.
[35] Awadh AI, Hassali MA, Al-Lela OQ, Bux SH, Elkalmi RM, Hadi H. Does an educational intervention improve parents' knowledge about immunization? Experience from Malaysia. BMC Pediatr 2014;14:254.
[36] Gargano LM, Herbert NL, Painter JE, Sales JM, Vogt TM, Morfaw C, et al. Development, Theoretical Framework, and Evaluation of a Parent and Teacher–Delivered Intervention on Adolescent Vaccination. Health Promot Pract 2014:1524839913518222.

[37] Glik D, Macpherson F, Todd W, Stone K, Ang A, Connell Jones M. Impact of an immunization education program on middle school adolescents. Am J Health Behav 2004;28:487–97.
[38] Schoeppe J, Cheadle A, Melton M, Faubion T, Miller C, Matthys J, et al. The Immunity Community: A Community Engagement Strategy for Reducing Vaccine Hesitancy. Health Promot Pract 2017;18:654–61.
[39] Carolan K, Verran J, Crossley M, Redfern J, Whitton N, Amos M. Impact of educational interventions on adolescent attitudes and knowledge regarding vaccination: A pilot study. PLoS One 2018;13:e0190984.
[40] Kennedy A, Glasser J, Covello V, Gust D. Development of vaccine risk communication messages using risk comparisons and mathematical modeling. J Health Commun 2008;13:793–807.
[41] Vietri JT, Li M, Galvani AP, Chapman GB. Vaccinating to help ourselves and others. Med Decis Making 2012;32:447–58.
[42] Lerner JS, Li Y, Valdesolo P, Kassam KS. Emotion and Decision Making 2015. doi:10.1146/annurev-psych-010213-115043.
[43] Kahneman D, Ritov I. Determinants of stated willingness to pay for public goods: A study in the headline method. J Risk Uncertain 1994;9:5–37.
[44] Kahneman D, Schkade D, Sunstein C. Shared Outrage and Erratic Awards: The Psychology of Punitive Damages. J Risk Uncertain 1998;16:49–86.
[45] Fazio - Attitude strength: Antecedents and consequences RH, 1995. Attitudes as object-evaluation associations: Determinants, consequences, and correlates of attitude accessibility. Books.google.com 1995.