Board games for health:
A systematic literature review and meta-analysis

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Abstract

Non-digital board games are being used to engage players and impact outcomes in health and medicine across diverse populations and contexts. This systematic review and meta-analysis describes and summarizes their impact based on randomized and non-randomized controlled trials. An electronic search resulted in a review of n=21 eligible studies. Sample sizes ranged from n=17 to n=3110 (n = 6554 total participants). A majority of the board game interventions focused on education to increase health related knowledge and behaviours (76%, n=16). Outcomes evaluated included self-efficacy, attitudes/beliefs, biological health indicators, social functioning, anxiety, and executive functioning, in addition to knowledge and behaviours. Using the Cochrane Collaboration tool for assessing bias, most studies (52%, n=11) had an unclear risk of bias [33% (n=7) had a high risk and 14% (n=3) had a low risk]. Statistical tests of publication bias were not significant. A random-effects meta-analysis showed a large average effect of board games on health-related knowledge (d^*=0.82, 95% CI[0.15, 1.48]), a small to moderate effect on behaviours (d^*=0.33, 95% CI[0.16, 0.51]), and a small to moderate effect on biological health indicators (d^*=0.37, 95% CI[0.21, 0.52]). The findings contribute to the literature on games and gamified approaches in healthcare. Future research efforts should aim for more consistent high scientific standards in their evaluation protocols and reporting methodologies to provide a stronger evidence base.

Keywords: Board games, serious games, health, education, psychoeducation, meta-analysis

Introduction

The application of game design approaches and technologies has gained popularity in healthcare as a means of creating more engaging interventions which can improve knowledge, change real-world behaviours, and subsequently impact therapeutic outcomes. Successful examples exist in the areas of treatment adherence, pain management, physical rehabilitation, depression, schizophrenia, and phobias.[1–6] Games can support engagement in play and fantasy, which are described as important mechanisms facilitating greater attentional control, enhanced learning and providing patient insight towards impacting long-term behaviours.[7] From a theoretical perspective, it has been suggested that games stimulate or facilitate learning through immersion flow, and meeting individual's needs concerning mastery, fantasy, challenge and connectedness.[8–11]

Though digital games are popular, non-digital formats have also been addressed in the research literature.[12] Board games have a history of use in therapeutic contexts.[13–15] Aside from its engaging and entertaining characteristics, one of the great advantages of using a board game is its ability to facilitate face-to-face interactions with peers, tutors, family members or even a therapist. These social interactions are assumed to enhance learning opportunities.[16] However, only a very small proportion of board games described in the literature have been evaluated to determine their impact.[16] Reviews focussing on evaluating the use of board games in medical education, conclude that it would be premature to claim that board games have an impact on knowledge or other educational outcomes in medicine given the strength of the existing evidence reviewed.[17,18] More recently, evaluations of board games for health with patients and community members have demonstrated promising impacts on knowledge (e.g., knowledge of HIV and STIs),[19] health behaviours (e.g., improved food habits)[20] and objective indicators of health (e.g.,

HbA_{1c} improvements among patients with Type II Diabetes).[21] Results of these evaluations have not been synthesized or systematically assessed in the literature to date. Thus, there is a need to update previous reviews of board games in medical education and to expand the review including evaluations of board games in other health care contexts.

The aim of this systematic review and meta-analysis is to answer the following two questions: 1) What kinds of board games targeting medical and health-related outcomes have been evaluated in the literature?, and 2) What is the overall impact of these board games on health-related outcomes?

Method

This review follows the guidelines for the Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA).[22,23] In conformity with these guidelines, the Supplementary Materials document provides readers with additional detail regarding our method and results, while keeping the body of this paper a manageable length. The Supplementary Materials document includes detailed database search terms and strategies, elaborated descriptions of data collection and analysis methods, details of within-studies risk of bias analyses (e.g. bias matrices and interrater reliability results), effect sizes for each outcome comparison included in this study, and expanded results of publication bias analyses.

Inclusion and exclusion criteria

In this paper, board games are defined as “a game of strategy […] played by moving pieces on a board”,[24] which does not include games played exclusively with cards (“card games”) or dice. Inclusion criteria were evaluations 1) of a health or medical-related non-digital board game intervention; 2) either as a standalone intervention or as part of a larger intervention program; 3) using random or other method of assignment to no treatment or active control group;

4) with participants from any sociodemographic background; 5) assessing medical and health-related outcomes; 6) of scholarly publications in a journal, thesis, research report or conference proceeding; 7) published in English. Exclusion criteria were evaluations 1) of digital board games (i.e. played on computers or smart phones); 2) of board games not implemented as an intervention (e.g. used as an assessment tool); and 3) of a board game's impact on processes rather than outcomes (e.g. usability, acceptability, credibility). Notably, digital board games were not included because they breach into the category of digital game-based learning and often involve more complex gaming and learning mechanics, which would increase the heterogeneity of the included studies, rendering conclusions about overall efficacy more difficult to summarize.[16]

Search method

An electronic search was performed on five databases: ProQuest (encompassing ERIC, IBSS, PsycINFO), Scopus, PubMed, JSTOR, and OVID (encompassing Medline, Embase). The search targeted board games specifically (term: "board game") in the area of health (terms: "health", "medical", "patient", "illness", "disease") (see Supplementary Materials for full search details). The searches were performed on February 8th, 2017 and include studies available up until this date. Hand-searching of the reference lists of articles that met final eligibility was also performed using the "snowball sampling" method.[25]

Study selection

Database search results were imported into RefWorks where duplicates and non-scholarly publications were removed. The remaining abstracts were screened to exclude articles if a non-digital medical or health-related board game was not mentioned. The full texts of the remaining articles were reviewed in detail to see if they met the inclusion/exclusion criteria. Reasons for excluding articles were documented. Three researchers independently evaluated the papers for eligibility for inclusion. A fourth rater performed a reliability check of a random-selection of 33% of the articles for eligibility. Inter-rater reliability was calculated using Cohen's kappa (κ) coefficient where a value greater than 0.7 would be deemed acceptable. The raters met to discuss and resolve any discrepancies until 100% agreement was achieved.

Data collection and data items

For each included paper, information such as the study design, participant characteristics, sample size, and means and standard deviations of measured outcomes at each recorded time-point (pre-intervention, post-intervention, delayed follow-up) were extracted (all data items are listed in the Supplementary Materials).

To identify what aspects of health and medicine have been impacted by board games in the literature, we performed a preliminary inductive coding of the measures and outcomes in each paper. Only outcomes that were measured for the board game group *and* one or more comparison groups were coded. Following the preliminary coding, the primary coder and another investigator held a meeting to refine the coding scheme until 100% agreement on codes was reached.

Data analyses

Summary measures.

General approach. Based on the extracted detailed data, the effect sizes (ES) and 95% confidence intervals were calculated using Cohen's *d*, based on a between groups mean difference for each continuous-data outcome at each time point (pre-intervention, post-intervention, delayed follow-up).[26] For dichotomous data, ES and standard errors were first calculated with a log odds ratio (using natural logarithm) then converted to Cohen's *d* by the method described in Borenstein et al. (pg. 47),[27] to establish comparability. Special considerations in the ES calculation were made for studies with a cluster randomized design, for studies with multiple comparison groups, and for studies with multiple outcome measures within the same outcome category (see Supplementary Materials).[28]

Since most outcome measurements extracted from the included studies did not report variance metrics for pre- to post-intervention change/improvement (only 7.4% of outcomes included this data), our analysis focused on ES comparing post-intervention scores between experimental groups and, when reported, delayed follow-up scores. The ES of pre-intervention scores were taken into account when evaluating the risk of bias for each comparison. Where negative ES represented a preferred outcome (e.g. zBMI as related to obesity, or reduction in positive attitudes toward cigarette smoking), these results were multiplied by -1 to be reflect a positive result in the meta-analysis.

Synthesis of data.

It has been argued that combining heterogeneous studies may be appropriate if the purpose of the analysis is to come to higher-order generalizations about the topic in question.[29,30] As such, this review combines heterogeneous studies investigating an array of board games and populations to answer our research questions. A summary of inconsistency across studies for each outcome is given by the value I^2 under each table summarizing the meta-analysis.[28] For each outcome measure category (e.g. knowledge, behaviour, self-efficacy, etc.)—and separately for both post-intervention and delayed follow-up time points—the following random-effects meta-analyses are produced when two or more data points were available:

1. An overall analysis that synthesizes all comparisons where an ES could be calculated (see Summary Measures)

2. A sensitivity analysis using only outcome comparisons at a low risk of bias.

Risk of bias

Risk of bias in individual studies.

For each extracted outcome measure, its risk of bias was assessed using the Cochrane Collaboration tool for assessing risk of bias,[28] where six categories of bias (selection bias, performance bias, detection bias, attrition bias, reporting bias, and other bias) were evaluated. These categories were judged as either ‘low risk’, if the bias was unlikely to affect the study’s results; ‘unclear risk’, if the information was not included or was insufficient; or ‘high risk’, if the bias would seriously affect confidence in the results. Two raters assessed risk in each study and inter-rater reliability for each category of bias was calculated using Cohen’s kappa coefficient where a value greater than 0.7 was deemed acceptable. Discrepancies between the two assessors were identified, discussed, and resolved with 100% agreement.

Risk of bias across studies.

The inverse standard error and the weighted variance for each study’s combined *d* statistic was calculated to investigate the risk of publication bias across studies visually with a funnel plot. Egger’s regression test was used to assess the 1) overall publication bias in the literature (i.e. across outcomes) at post-intervention and delayed follow-up separately, and 2) for each outcome category individually, at the post-intervention time point. For the analysis across all outcomes, to avoid a unit-of-analysis error, all results from each study were combined into a single ES (see Supplementary Material: Summary Measures).

Results

Study selection

Our electronic database search resulted in a total of n=1043 articles from ProQuest (n=578), Scopus (n=185), PubMed (n=55), JSTOR (n=18), and OVID (n=207), while another three (n=3) other references were identified as potential candidates based on a "snowball" search of the reference lists of eligible articles. Figure 1 documents the study selection process. A total of 22 articles met our inclusion/exclusion criteria; however, n=2 articles reported the same outcomes and intervention.[31,32] The data from these two articles were extracted, summarized and considered as one article, resulting in 21 total selected studies. Additionally, two of the articles evaluated the same board game reported on different outcomes in two distinctly different studies.[20,33] They are thus considered separate studies of one board game in this report. Inter-rater reliability on the study selection process was high, with κ=0.86 and a 97.92% agreement rate.

Study characteristics

Table 1 summarises study characteristics across the 21 research studies, including study designs, sample/cluster sizes, populations/locations, and play duration, while the details of each board game intervention (i.e. purpose, general intervention structure, and mechanics employed) are presented in Table 2.

Study design.

Studies consisted of n=11 randomized controlled trials; n=4 cluster randomized controlled trials; and n=6 quasi-experimental or non-randomized trials, one of which was a case-controlled trial. Most of the studies (n=16) included a "no intervention" or a standard of care/learning comparison group. Two studies compared the board game with other educational media,[34,35] and four compared the board game with an educational lecture.[19,31,32,36,37] Finally, two studies included a specialized training intervention as control that mirrored the content/experiences targeted in the board game.[38,39]

Sample sizes.

Studies varied in sample size, from small (n=17)[40] to large (n=3110 across 20 clusters),[20] with n=6554 total participants across all 21 studies. Of these, n=3055 received a board game-based intervention and n=3499 were in a comparison/control group.

Populations.

The samples used to evaluate the board games included a wide range of age groups, from children as young as 8 years old[35] to older adults.[40] Most (57%, n=12) of the studies' participants were students enrolled in school. Participants in the remaining n=9/21 studies (who were not students enrolled in schools) were patients in n=6 studies and people recruited from specific communities in the remaining n=3 studies.

Duration of play.

Interventions varied in total play-time reported ranging from 5 minutes[38] to 30 hours,[40] and in overall duration of intervention, from a single session to 24 weeks.[33]

Description of the board game interventions.

Purpose/aims of the board game interventions. Most of the board game interventions focused on education to increase knowledge and/or skills (n=17/21 studies representing 16 board games). The remaining board games evaluated in n=4/21 studies aimed to directly impact a neurological skill (i.e. cognitive functioning for community seniors),[40] physical rehabilitation skills (i.e. hand pinch strength),[38] increase interest in Global Health issues,[41] or change in motivations among community members to increase their intentions to seek local pharmacy advice.[42]

General intervention structure. Most of the included studies (n=15 studies, representing n=14 board games) evaluated a board game in itself as an intervention, while n=6 studies investigated the effect of a board game as part of a multi-component intervention program.

Game design and mechanics. The mechanics for only n=15/20 board games could be interpreted (Table 2). Notably, most games (n=12) were competitive in nature. The most popular learning mechanic implemented in the board game was a question-and-answer (self-testing) strategy, with n=9 interventions employing this mechanic as their primary method of learning. In all cases, progressing in the game required questions to be answered correctly. In contrast, n=4 board games implemented an action-and-consequence style of learning mechanic that involved a more reflective learning. For example, to affect diet and lifestyle behaviour in children, *Kalèdo* employs nutrition and activity cards that the children must balance to optimize calorie-intake and energy expenditure; furthermore, the player faces consequences (e.g. loss or gain of points) throughout the game for real-life dietary/exercise decisions made during the day, thereby enhancing their understanding of healthy and unhealthy behaviour and encouraging real-world transfer.[20,33]

Outcomes assessed.

Coding of the outcome measures resulted in eight categories of health-related outcomes across the studies: 1) health-related behaviour (including self-reported behaviour, self-reported behavioural intentions, and measured behaviours), 2) knowledge (of a health concept or skill), 3) self-efficacy (perceived confidence in one's abilities to carry out a health-related behaviour), 4) attitudes and beliefs about a health concept, 5) biological health indicators, 6) social functioning, 7) anxiety and 8) executive functioning. The distribution of studies, measures, and between-groups comparisons across outcome categories are presented in Table 3. Hereafter, we use the term "outcome" to refer to the construct that was measured; the "measure" to refer to the method or means used to quantify the outcome; and "comparison" to refer to a between-groups analysis of two or more comparisons between groups for a single measure (e.g. game vs. no intervention, game vs. lecture).

Risk of bias within studies

Overall, n=3 studies were considered to have an overall low risk of bias;[19,20,43] n=7 were considered to have an overall high risk of bias;[31,32,35,41,42,44–46] and n=11 were considered to have an unclear risk of bias.[21,33,49,34,36–40,47,48] Risk of bias matrices for each outcome category and interrater reliability statistics are reported in the Supplementary Materials. Table 3 also presents the number of low risk of bias and other comparisons suitable for inclusion in the data synthesis.

Results by type of outcome

Below, we present the syntheses of between-groups mean difference ES (Cohen's *d*) for each study categorized by the type of outcome measurement, at both the post-intervention and delayed follow-up (if applicable) time points (visualized in Figure 2). Overall synthetic analyses (using comparisons at all levels of risk of bias) and sensitivity analyses (using only comparisons at a low risk of bias) are presented. An ES given as "*d**" denotes a synthesized effect across two or more studies, whereas "*d*" denotes an effect within a single study. A summary of the risk of bias across studies in each category is included in each subsection.

Health-related behaviour.

Health-related behaviours are made up of the subcategories of self-reported behaviour, behavioural intentions, and measured behaviours. Taken together, health behaviours showed a small to moderate effect in favour of board games compared to control group(s) at immediate post-intervention assessment (*d**=0.33, 95% CI [0.16, 0.51], Q=18.90, *df*=7, C=373.59, Tau=0.03, I^2=62.97%, Z=3.83, p<.001) and a small effect in favour of board games at delayed follow-up (d*=0.24, 95% CI [0.02, 0.45], Q=1.86, df=1, C=70.45, Tau=0.01, I^2=46.24%, Z=2.18, p=.029). Each sub-category of health-related behaviour is discussed individually in more detail below.

Self-reported behaviour. In the subcategory of self-reported health behaviours (Table 4), we observe a significant small to moderate effect in favour of board games (d*=0.38, 95% CI[0.07, 0.69]) over other control conditions immediately after the intervention takes place. Additionally, we see a small effect at delayed follow-up (d*=0.24, 95% CI[0.02, 0.45]). Overall, the risk of bias associated with self-reported behaviour outcomes was deemed to be 'unclear', with ~56% of the weight at a low risk of bias, ~31% at an unclear risk of bias, and 13.3% at a high risk of bias. However, sensitivity analyses—that include only comparisons at a low risk of bias—show similar effects at both the post-intervention (d*=0.38, 95% CI[0.08, 0.83]) and delayed follow-up (d*=0.24, 95% CI[0.01, 0.46]).

Behavioural intentions. Behavioural intentions as a subcategory are considered distinct from self-reported behaviours because they measure intent to engage in behaviours in the future, as opposed to self-reported behaviours that occurred in the past. A small effect of board games over control groups is observed for behavioural intentions post-intervention (d*=0.28, 95% CI[0.06, 0.50], Table 5). No study measured behavioural intentions at delayed follow-up. The risk of bias associated with comparisons measuring behavioural intentions is high overall, with 44.3% weighted as 'unclear' risk of bias, and 55.6% at high risk of bias. No study provided low risk of bias comparisons, so sensitivity analyses were not performed.

Measured behaviour. Finally, Moyer and Nelson assessed the subcategory of health-related behaviour directly, with hand pinch strength (pressure) and pinch repetitions in individuals attending rehabilitation sessions.[38] Combining multiple comparisons in this study, no effect of board game over the control group was observed (*d*=0.33, 95% CI[-0.22, 0.88], Z=1.18, *p*=.239). This comparison has an overall unclear risk of bias.

Knowledge.

A large and significant post-intervention effect of health/disease-related knowledge in favour of board games was observed at immediate follow-up (*d**=0.82, 95% CI[0.15, 1.48]). The effect was small and not significant at the delayed follow-up (*d**=0.25, 95% CI[-0.53, 1.03]). Heterogeneity of the post-intervention ES was very high (I^2=94.50%) and included studies measuring very different types of knowledge. The synthesis of ES for health-related knowledge outcomes have only 28.7% of the weight associated with low risk of bias, 27.6% with high risk of bias, and 43.8% with an unclear risk of bias. Using only low risk of bias ES, the large post-intervention ES remains (*d**=1.05, 95% CI[0.82, 1.28]), and the one study[20] that did a delayed follow-up assessment of knowledge shows a marginally significant small to moderate effect (*d*=0.34, 95% CI[-0.03, 0.72], *p*=.063). Refer to Table 6 for details.

Self-efficacy.

Self-efficacy refers to an individual's self-perceived abilities to engage in behaviours despite challenges.[50] The mean ES for self-efficacy showed no evidence of an effect at immediate (*d**=0.09, 95% CI[-0.03, 0.22]) or at delayed follow-up (*d**=0.18, 95% CI[-0.36, 0.71]), Table 7. The comparisons for self-efficacy are at an overall low risk of bias, with ~69% of weighted data at low risk and ~31% at an unclear risk. Results are consistent with the overall synthesis (above) when analysing only comparisons with a low risk of bias at the post-test (*d**=0.12, 95% CI[-0.02, 0.25]) and delayed follow-up (*d**=0.18, 95% CI[-0.39, 0.75]).

Attitudes and beliefs.

Participants' attitudes and beliefs about a health topic showed a small but significant effect in favour of board games post-intervention (*d**=0.15, 95% CI[0.05, 0.25]), but not at delayed follow-up (*d**=0.06, 95% CI[-0.05, 0.18]), Table 8. The comparisons associated with health-related attitudes and beliefs are largely at a low risk of bias, with ~72% weighted at low risk of bias, ~17% at an unclear risk of bias, and ~11% at a high risk of bias. Sensitivity analyses using only low-risk of bias comparisons confirm a small effect of board games over other control comparators at the post-test (*d**=0.23, 95% CI[0.11, 0.36]) and a very small and trending effect upon delayed follow-up (*d**=0.12, 95% CI[-0.01, 0.24]).

Biological health indicators.

There was a small to moderate effect of board games on biological health indicators (e.g. zBMI, diabetes indicators) measured immediately after the intervention (*d**=0.37, 95% CI[0.21, 0.52], Table 9). Only Viggiano et al.[20] performed a delayed follow-up measurement, which showed a moderate effect of lower zBMI scores in favour of the game group over a no-intervention group. The comparisons in this category's synthesis showed 45.5% weight at low risk and the remaining 54.6% at an unclear risk. Only the comparisons by Viggiano et al.[20] are at a low risk of bias, so sensitivity analyses were not performed.

Social functioning.

A single study targeted social functioning in patients with schizophrenia with seven subscales.[39] Though the authors report significant outcomes on a few subscales (e.g. recreational activities), there was no significant effect of the board game on social functioning (*d*=0.19, 95% CI[-0.11, 0.48], Z=1.22, *p*=.221). The risk of bias associated with the comparisons in this combined ES was unclear.

Anxiety.

The effect of a board game intervention on anxiety was assessed in one study by Fernandes et al. in preoperative children and their parents.[35] The authors did not provide information about variance for the data, which prevented us from calculating ES for anxiety. These comparisons were at an overall high risk of bias.

Executive functioning.

Finally, executive functioning was assessed by Fissler and colleagues among elderly retirement home patients at risk of dementia.[40] An overall large but non-significant effect of the game intervention program was observed at immediate follow-up (d=0.88, 95% CI[-0.19, 1.95], Z=1.82, p=.068). This comparison was associated with an unclear risk of bias.

Risk of bias across studies

The risk of publication bias across studies was assessed visually with a funnel plot (Figure 3). Though there is a noticeable lack of studies to support other interventions over board games (dots left of zero), Egger's test was not significant for post-intervention comparisons (β_0=-0.09, 90% CI [-3.84, 3.64], df_{total}=16, t=-0.05, p=.964). Publication bias was also not observed in the majority of the individual outcome categories (see Supplementary Materials). Lastly, Egger's test was not significant for delayed follow-up comparisons (β_0=-0.91, 90% CI [-6.05, 4.24], df_{total}=2, t=-1.11, p=.466).

Discussion

This systematic review and meta-analysis is the first to provide a synthesis on and analysis of non-digital board games for health impacts for users in academic, patient/hospital and community settings together. It extends Bochennek and colleague's review of board games for medical education by also including games for patients and laypeople from a community context.[16] The findings further contribute to theories about how games can facilitate learning and behaviour change.[8–11] The overall quality of the studies investigated was not high; risk of bias assessments revealed that 85.7% of the studies had a high or unclear risk of bias associated with their methodological designs. Keeping these biases in mind, we have been able to draw some general insights about the impact of board games on health-related outcomes and about potential future directions for research.

Main findings

The designs of board games evaluated, and the types of measures used to evaluate outcomes across studies were heterogeneous; a finding that is consistent with previous reviews of board games for medical education that also found the topics addressed and game approaches difficult to place in broad categories due to the diversity of examples in the literature.[16,18] The diversity of approaches and topics addressed in board games was also found in reviews of digital game based learning and serious games.[2,51]

Whilst the majority of games in this review are applied to behavioural challenges consistent with major healthcare priorities (e.g. reduction in rates of obesity), they typically aim to affect change by conveying knowledge. For instance, Viggiano et al.[20] targeted lifestyle changes in children by conveying knowledge about healthy diet and exercise. Our meta-analysis showed that board games resulted in significantly more knowledge attainment than other non-game conditions, consistent with findings of meta-analyses in the realm of digital game-based learning.[52–55] This—along with the null or very small effects measured in self-efficacy and attitudes/beliefs—suggests that the primary value of board games thus far is shown when applied to behavioural problems arising through lack of knowledge or difficulty in communicating health-related concepts, rather than those characterised by the persistence of negative behaviour in the presence of knowledge. Even Khazaal et al.,[43] who did not measure knowledge directly, aimed to change smoking behaviour through the conveyance of facts about smoking (e.g. costs associated with addiction, biological effects of smoking). However, it should be noted that the lack of analyses of board games applied to situations wherein negative behaviour persists in the face of knowledge precludes conclusions regarding their suitability in these contexts.

Overall, and in many cases as a result of increased knowledge through gameplay,[20,33,34,41–43,46] health-related behavioural outcomes (e.g. smoking cessation, diet and lifestyle changes) showed a small to moderate post-intervention effect in favour of board games, particularly in the self-reported behaviour category. This is consistent with studies of video games targeting health behaviour-change that generally show positive effects.[2,56] However, self-reported measures of behaviour are particularly vulnerable for bias because they can be associated with social stigmas (e.g. around diet and exercise).[57,58] Unfortunately, only a single study in our review included an objective measure of behaviour.[38] Ultimately, downstream biological health/patient outcomes, such as reduced zBMI scores, are the desired objectives of behaviour-targeting games and indicate real-world behaviour change; our synthesis of biological health outcomes demonstrated small to moderate effects in this category, highlighting the potential of board games to facilitate real-world change, though only three studies included such outcomes. A meta-analysis investigating the synthesized effects of active video games on health outcomes also showed small to large effects.[59]

While our analyses suggest that board games can be effective at increasing knowledge, changing behaviour and, in turn, affecting biological outcomes, the evidence for improvement of self-efficacy was not significant; this is inconsistent with a meta-analysis of active video games that showed moderate effects on self-efficacy,[59] perhaps because players of active video games experience the behaviour first-hand, instead of receiving knowledge about the behaviour to apply at a later time, like in the reviewed board games. Furthermore, we can fairly confidently conclude (due to the low risk of bias and significant synthesized effects) that board games affect attitudes and/or beliefs very little, which contrasts stronger findings in the digital game-based learning literature.[60] Lastly, there is insufficient evidence to conclude whether board games may impact other outcomes in health and medicine, such as anxiety, social functioning, and executive functioning, with only single studies covering these themes. However, game-based studies of other "non-board" games not included in this review (e.g. Mahjong) have shown some promise in the realm of executive functioning.[61–63]

Limitations

This meta-analysis is limited by heterogeneity of outcomes used to evaluate the board games, poor methodological design of many of the studies, and the small sample size/inadequate power of most of the included studies. Synthesizing highly heterogeneous studies (note the high I^2 values for our various syntheses), is a clear weakness in this meta-analysis. However, heterogeneous outcomes are often examined in order to come to higher-order generalizations about a topic in question.[29,30] In this case, we were interested in examining whether board games could be used as a tool to impact outcomes in the domain of health. Therefore, the results should be used as a general summary of the effect across the educational board game literature in different outcomes. Furthermore, because of the limited number of comparisons within each outcome category, we were unable to perform moderator analyses to investigate possible confounding effects of, for example, total play-time, primary game mechanic (e.g. question-and-answer vs. action-and-consequence), or target audience (e.g. adults or children), It should finally be noted that, since studies with larger samples (and therefore less variance) tended to contribute more toward synthesized effects (e.g. Viggiano et al.[20] accounted for ~40% of the weight in self-reported behaviour; Khazaal et al. accounted for 54% of the weight in attitudes and beliefs), our reported effects may be more representative of the types of board games or play contexts found in these more robust studies.

Another limitation of the data synthesis is that, while we examined outcomes from studies with control/comparison groups, some of these included research designs that did not randomize participants to treatment and control groups. The randomized trial is considered the Gold Standard for determining causality in evaluating the impact of interventions on outcomes.[4] Until results from larger and higher quality randomised controlled trials of board game interventions in healthcare are available, the research results presented in this review represent the best strategy for appraising the evidence, while considering the inherent bias in the studies evaluated.

A further limitation is that the findings reported do not consider pre-intervention results because 1) some studies did not include baseline measurements and 2) most studies did not report variance for pre- to post-intervention change, thus excluding pre-post improvement information from ES calculations; this precluded our ability to evaluate whether or not differences between treatment and control groups observed at the post-intervention may have been related to pre-existing differences at baseline. However, it should be noted that effects with baseline imbalances (or no reported baseline measurements at all) were excluded from sensitivity analyses as they fell into the high or unclear risk of bias categories. Finally, the findings from this study are also limited due to missing data from studies; there was missing data from 11/88 post-intervention comparisons where the authors did not include enough information for ES to be calculated (all these studies are at an unclear to high risk of bias).

Despite these limitations, it should be noted that an overall strength of this review is that it synthesizes data across diverse populations to estimate the impact that board games have had on various health-related outcomes, which has not previously been done in the literature.

Future directions

Our suggestions based on our critical review of the studies are consistent with previous games for health guidelines that call for the use of randomised controlled trials with adequate sample sizes to clarify the causal role of the intervention's impact on outcomes.[56,64] Studies should also aim to measure behaviour through direct means or consecutively logged activity to prevent biases associated with self-reports and, when possible, include more objective biological outcomes (e.g. zBMI) to corroborate behaviour findings in a standard way across studies.

Furthermore, as discussed above, a main finding of this review was that the majority of board games targeting health-related behaviours did so through conveying *new* knowledge. Future research might investigate whether a board game might be effective in changing persistent, negative behaviours in the presence of knowledge.

Finally, a qualitative interpretation of the included studies would suggest that board games integrating a question-and-answer mechanic (i.e. trivia genre; a popular gaming pattern implemented by most of the included studies)[19,31,32,36,42–45,47,49] have potential to lead to significant gains in knowledge; this is consistent with other research regarding the impact of self-testing strategies on knowledge consolidation in non-gaming contexts.[65,66] However, there appears to be a lack of board games that incorporate learning and gaming mechanics in more complex ways (e.g. through action-and-consequence),[20,33,34,43] which limits our understanding of the different ways board games can be designed to support learning. Future games as educational tools should attempt to integrate more complex design strategies and explore whether or not existing digital game design frameworks (e.g. Learning Mechanics-Game Mechanics model, or the Activity Theory Model of Serious Games)[67,68] can be applied to justify design decisions and advance our understanding in this area. Moreover, game efficacy should be examined through studies designed to clarify whether mechanisms of the board game itself (e.g., cooperative or competitive) or the context of its delivery (e.g., in a clinic, in a school setting) is responsible for the impacts observed in carefully designed studies; while such investigations are inherently more difficult to perform, the importance of asking more design-oriented questions is well recognized.[53,69]

Conclusion

In sum, this systematic review updates and extends previous reviews of board games for health. Although the findings of this meta-analysis are limited given the current state of evaluations of board games for health in the literature, they do show preliminary evidence for the use of board games to improve knowledge in health outcomes. Future efforts to develop board games should focus on directly targeting behaviours related to downstream biological health outcomes, exploring alternative game design strategies to the trivia-genre, and evaluating board game interventions using rigorous scientific methods. Once knowledge about the overall efficacy of board games is better established, health care professionals, patients, students and community members can benefit from this engaging approach to promote health and medical outcomes.

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Table captions

Table 1 Study design characteristics including sample size, age range, location of study, description of participants, types of comparison group(s), and the duration of the intervention (i.e. how long did the participants play the game).

Table 2 Board game intervention titles, content description, and identifiable learning mechanics for each study.

Table 3 The number of studies, measures, and game-control comparisons extracted from the literature in each outcome category.

Table 4 Effect size details for studies measuring **Self-Reported Health-Related Behaviour.**

Table 5 Effect sizes for studies measuring health-related **Behavioural Intentions**.

Table 6 Effect sizes for studies measuring health-related **Knowledge**.

Table 7 Effect sizes for studies measuring health-related **Self-efficacy**.

Table 8 Effect size details for studies measuring **Attitudes and/or beliefs**.

Table 9 Effect size details for studies measuring health-related **Biological Health Indicators**.

Figure captions

Figure 1 Flow diagram of study selection process.

Figure 2 Forest plots of effect sizes at the post-intervention and delayed post-intervention time points, displaying results at all levels of risk of bias (diamonds). Refer to Table 4 through Table 9 for details.

Figure 3 Funnel plot of effect sizes from post-intervention and delayed follow-up comparisons against the inverse of the standard error of the effect, across all outcome categories.