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Gamification for health promotion in smartphone apps: systematic review of behaviour change techniques

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Gamification for health promotion in smartphone apps: systematic review of behaviour change techniques

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ABSTRACT

OBJECTIVE: Smartphone games that aim to alter health behaviours are common, but there is uncertainty about how to achieve this. We systematically reviewed health apps containing gaming elements analysing their embedded behaviour change techniques.

METHODS: Two trained researchers independently coded apps for behaviour change techniques using a standard taxonomy. We explored associations with user ratings and price.

DATA SOURCES: We screened the NHS health apps library and all top-rated medical, health & wellness and health & fitness apps (defined by Apple and Google Play stores based on revenue and downloads). We included free and paid English language apps using 'gamification' (rewards, prizes, avatars, badges, leaderboards, competitions, levelling-up or health-related challenges). We excluded apps targeting health professionals.

RESULTS: 64 of 1,680 (3.8%) health apps included gamification and met inclusion criteria; only three of these were in the NHS library. Behaviour change categories used were: *feedback & monitoring* (n=60, 94% of apps); *reward & threat* (n=52, 81%); *goals & planning* (n=52, 81%). Individual techniques were: *self-monitoring of behaviour* (n=55, 86%); *non-specific reward* (n=49, 82%); *social support unspecified* (n=48, 75%); *non-specific incentive* (n=49, 82%); *focus on past success* (n=47, 73%). Median number of techniques per app was 14 (range 5-22). Common combinations were: *goal setting, self-monitoring, non-specific reward and non-specific incentive* (n=35, 55%); *goal setting, self-monitoring and focus on past success* (n=33, 52%). There was no correlation between number of techniques and user ratings ($p=0.07$; $r_s=0.23$) or price ($p=0.45$; $r_s=0.10$).

CONCLUSIONS: Few health apps currently employ gamification and there is wide variation in use of behaviour change techniques, which may limit potential to improve health outcomes. We found no correlation between user rating (a possible proxy for health benefits) and game content or price. Further research is required to evaluate effective behaviour change techniques and to assess clinical outcomes.

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Strengths and limitations of this study

- This is the first comprehensive systematic review examining the use of behaviour change techniques in smartphone games aimed at changing health-related behaviours.
- We rigorously evaluated behaviour change techniques and classified them using the most recently developed taxonomy.
- We identify individual behaviour change techniques and theoretically coherent combinations of techniques commonly used in smartphone games to facilitate development of more effective applications in future.
- We screened only 1680 top rated apps in the most popular app stores so whilst our sample may be representative of apps in common use we did not examine the full repertoire of apps offered by developers.
- We were not able to assess the clinical benefits or potential harms from using the apps since none have been rigorously evaluated.

INTRODUCTION

Smartphone use has increased rapidly in recent years both in developed and developing countries. There are over 2 billion smartphone users globally in 2016 and by 2018 one-third of the world's population will use smartphones[1]. China had 500 million smartphone users in 2014 and in 2016 India will exceed 200 million users overtaking the United States of America as the world's second-largest smartphone market[1].

Accompanying this rapid growth in smartphone use is a huge expansion in applications targeting health and health-related behaviours. Over 100,000 health applications (apps) are available worldwide for smartphones with exercise, diet and weight management apps being the most popular downloads[2-4]. Consumers are keen to access health information on their mobile devices and more than 500 million people globally currently use mobile health applications[5]. However, most health applications for smartphones have very simple functions and do little more than provide basic information[6]. There is little evidence that public health practitioners and users participate in the design of health apps and most apps do not contain theoretically consistent behaviour change techniques[7, 8]. Very few apps comply with regulatory processes or have had their effectiveness formally assessed[6, 8].

In parallel with the growth in health apps, there has been a remarkable increase in gaming on personal computers, dedicated game consoles and on smartphones. Games now form the largest market share of apps comprising 33% of all downloads[9]. It is estimated that 69% of people in the UK aged 8-74 are playing games on average 14 hours per week[10]. Of these players, 52% are female and the average age is 31 years. 'Gamification' harnesses a desire for competition, incorporating 'gaming elements' such as badges, leaderboards, competitions, rewards and avatars to engage and to motivate people[11]. Use of gamification is increasingly popular for training programmes in industry with a projected \$2.8 billion spend on gamification by businesses in 2016[12]. Higher education institutions have also integrated gaming techniques into their teaching programmes[13].

Whilst there are successful health applications of gamification on Super Nintendo, Nintendo Wii and personal computers, gamification in mobile health is, perhaps surprisingly, a relatively new concept[14-17]. Gamification can be effective in promoting and sustaining healthy behaviours, tapping into playful and goal-driven aspects of human nature. Gamification strategies such as goal setting, providing feedback on performance, reinforcement, comparing progress and social connectivity share key elements with established health behaviour change techniques[18].

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Here we provide the first comprehensive systematic review of behaviour change techniques in smartphone games classified using the taxonomy developed by Michie *et al.* comprising 16 behaviour change categories and 93 individual techniques. The purpose of this review is to identify appropriate behaviour change techniques and combinations of techniques for use in this setting to facilitate development of more effective smartphone games to promote health[19].

For peer review only

METHODS

We identified all English language health apps for all ages (both free and for purchase) that incorporated gamification. We defined gamification as use of at least one of the following techniques: rewards; prizes; avatars; badges; leader boards; competitions; health-related challenges. We searched the official Apple and Android app stores (<https://play.google.com/store>, <https://itunes.apple.com>) and selected 'top-rated' apps as defined by the store. The rating is derived from number of downloads and daily revenue generated[20]. We also searched the NHS Health apps library (<https://apps.nhs.uk>). The protocol for this review has been published and is available online:

http://www.crd.york.ac.uk/PROSPERO/display_record.asp?ID=CRD42015029841.

Prospero registration number: CRD42015029841.

Search Strategy:

The initial search was conducted by one review author (EE) from 1st April 2014 to 30th June 2015 examining all apps in the 'top-rated' categories in each app store. Data from apps meeting inclusion criteria were recorded in a pre-piloted, standardised, structured data collection form.

Inclusion/ Exclusion Criteria:

Inclusion criteria were broad, aiming to identify all 'top-rated' smartphone apps incorporating gaming elements, which were marketed to the general public (Table 1).

Table 1: Inclusion and exclusion criteria

Inclusion Criteria	Exclusion Criteria
English language smartphone apps	Apps designed for tablet computers
Apps available through Google play and iTunes or NHS app store	Non- English language apps
Apps included in the Medical, Health & Wellness or Health & Fitness section of Google play and iTunes and all NHS apps	Apps in other sections of the stores
Apps including gamification techniques: rewards, prizes, avatars, badges, leader boards, competitions, health-related challenges	Smartphone apps that do not contain gamification techniques
Smartphone apps targeted at users of any age	Smartphone apps designed for Health Care professionals
Free and paid Smartphone apps	Apps not targeting to change a physical health behaviour
Apps targeting to change a physical health behaviour	Apps that did not have customer ratings available

Coding the Apps for behaviour change techniques:

Apps meeting inclusion criteria were downloaded onto test devices. The same make and model of test device was used throughout the evaluation (LG Nexus 5 Android or iPhone 5c). Test devices were unmodified consumer-grade smartphones running up-to-date versions of their mobile operating system. The same version of each app was used throughout testing. Apps found in both the Apple store and Google Play store were not included twice and were recorded only in the Apple iPhone data.

Two researchers trained in behaviour change technique coding (EE, JL) coded apps independently. App content was assessed against criteria derived from a standard taxonomy of behaviour change techniques used in health behaviour change research[19]. Results were crosschecked for discrepancies, which were resolved by discussion with a third trained reviewer (LS), a health psychologist. Codes from each reviewer were recorded on a standardised, structured form. The number of individual behaviour change techniques included in each app was counted.

We recorded information on app version, date of first release, date of latest update,

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3 publisher, description, main function, target user, special features and number of
4 downloads where available. Missing data were requested from the author/publisher of the
5 app or from the Apple/Android stores.
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8 **Synthesis of results:**

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10 A qualitative and quantitative synthesis was conducted with calculation of basic
11 descriptive statistics. Behaviour change technique use including categories, individual
12 techniques, and combinations of techniques was analysed. Comparison was made
13 between the number of behaviour change techniques included, user rating and price.
14 Correlations were determined using Spearman's Rank correlation coefficient (r_s),
15 calculated with GraphPad Prism 6.
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RESULTS

We screened 1,680 Medical, Health & Wellness or Health & Fitness apps of which 64 (3.8 %) met inclusion criteria (Figure 1). Although the initial search was conducted by one review author (EE), the inclusion and exclusion criteria were defined *a priori* and agreed by three authors JL, LS and RW. Additional discussions occurred during this initial search period between EE and other review authors about inclusion of particular apps.

Apple displays 240 top-rated Medical and 240 Health & Wellness apps comprising both free and paid apps. Android displays free and paid apps separately, displaying their top 300 rated free Medical apps, 300 top rated paid Medical apps, 300 free top rated health & fitness and 300 paid top rated health & fitness apps. Thus, more Android than Apple apps were included.

In the apps meeting inclusion criteria, targeted behaviour changes included increasing/improving exercise (n=45, 70%), improving fitness (n=11, 17%), smoking cessation (n=4, 6%), encouraging oral hygiene (n=2, 3%), weight loss (n=1, 2%), blood glucose measurement adherence (n=1, 2%, Supplementary Table 1).

Median user rating was 4.5 (range 2.5 to 5). There was no correlation between the number of behaviour change techniques and customer ratings ($P = 0.07$; $r_s = 0.23$).

23 apps (35.9%) were available to purchase and the remainder were free. The median cost of the paid apps was £1.99 (range £0.62 to £3.10). There was no correlation between number of behaviour change techniques and price ($P = 0.45$ $r_s = 0.10$).

The median number of behaviour change techniques was 14 (range 5 to 22) with a negatively skewed distribution (Supplementary Figure 1). The most common behaviour change categories were: *feedback & monitoring* (n=60, 93.7% of apps); *comparison of behaviour* (n=52, 81.2% of apps); *reward & threat* (n=52, 81.2% apps). The most used individual techniques were: *self-monitoring of behaviour* (n=55, 85.9% apps); *non-specific reward* (n=49, 81.6% apps); *non-specific incentive* (n=49, 81.6% apps); *social support unspecified* (n=48, 75% apps); *focus on past success* (n=47, 73.4% of apps; Table 2; Figure 2).

Frequently used combinations of techniques were based on *self-monitoring* and *goal setting* with the addition of either *focus on past success* (n=33, 47.1%) or *non-specific rewards and incentives* (n=33, 47.1%; Table 3).

Only three apps were included in the NHS health apps library: *Change 4 Life fun generator* by NHS choices, *Zombies Run!* and *Zombies Run! 5k Training*.

Table 2: Behaviour change technique categories included in apps

BCT Taxonomy Category Groupings	Number of apps to use category	%
Feedback & Monitoring	60	93.7
Comparison of Behaviour	52	81.2
Reward & Threat	52	81.2
Self- belief	51	79.6
Repetition & Substitution	50	78.1
Social Support	48	75
Goals & Planning	46	71.8
Shaping Knowledge	25	39
Associations	20	31.2
Antecedents	18	28.1
Identity	12	18.7
Natural Consequences	9	14
Comparison of Outcomes	5	7.8
Regulation	1	1.5
Scheduled Consequences	3	4.6
Covert Learning	2	3.1

Table 3: Common combinations of behaviour change techniques

Technique combination	Number of apps to use combination N (%)
Goal setting, Self-monitoring, Non-specific reward, Non-specific incentive	35 (54.6)
Goal setting, Self-monitoring, Focus on past success	33 (51.5)
Goal setting, Self-monitoring, Non-specific reward, Non-specific incentive, Focus on past success	31 (48.4)
Goal setting, Self-monitoring, Feedback of behaviour, Social support unspecified, Focus of past success	27 (42.1)
Goal setting, Feedback of behaviour, Self-monitoring	28 (43.7)
Goal setting, Feedback of behaviour, Self-monitoring, Social support unspecified, Non-specific reward, Non-specific incentive, Focus past success	26 (40.6)
Goal setting, Feedback of behaviour, Self-monitoring, Feedback of outcome of behaviour, Social support unspecified, Non-specific reward, Non-specific incentive, Focus on past success	22 (34.3)

DISCUSSION

Main findings

Despite a rapid increase in use of gamification in the commercial and education sectors, smartphone applications using gamification for promoting health are currently limited. Our review highlights wide variation in use of behaviour change techniques; however, all apps reviewed included at least five recognised behaviour change techniques, most commonly *feedback and monitoring*, *comparison of behaviour* and *reward and threat*. It is encouraging also that app developers are using combinations of behaviour change techniques which are theoretically coherent such as *goal setting*, *self-monitoring* and *non-specific reward*.

Results in the context of other studies

We found that self-regulatory behaviour change techniques were most commonly used (*feedback & monitoring* including *self-monitoring of behaviour*). The effectiveness of these techniques in achieving behaviour change has been supported by findings from a wide range of studies[21-26]. Frequently used behaviour change categories were *comparison of behaviour* and *reward and threat*. Common individual behaviour change techniques were *social support unspecified*, *non-specific reward*, *non-specific incentive* and *focus on past success*. We suggest that the use of some of these techniques may be driven by ease of implementation on a smartphone platform with an Internet connection. Sharing activity on social media is a common feature of mobile apps and is easy to integrate into app design.

One previous meta-analysis examined combinations of health behaviour change techniques using classification and regression trees and suggested that *provide information about behaviour* and *prompt intention formation* was one of the most effective combinations[27]. However, comparison with our findings is problematic because the study used the earlier 26 category taxonomy[28] which does not easily translate into the more recent 96 category taxonomy[19].

A second meta-analysis of internet-based interventions suggested that number of techniques included in the intervention and the resulting behaviour change outcomes were directly related[29]. This review also suggested benefit from linking techniques to behaviour change theory. We were not able to examine effects on outcomes because of lack of data, although we saw no relation between behaviour change technique content and user rating which may be a proxy for outcome. Several studies in other clinical settings find no relation between number of behaviour change techniques and health outcome, for example in obesity, healthy eating and physical activity[22-24], although

these studies did not specifically examine effects using a technology-based delivery method.

We found a high number of behaviour change techniques in each app (median 14, range 5 to 22). This figure is higher than previous reviews of non-app interventions to promote healthy eating (mean 6, range 1 to 13)[28] and physical activity (mean 6, range 1 to 13)[28] (mean 6, SD 3.1)[24]. This may be related to the overlap between gamification methodology and health behaviour change techniques which might also account for the skewed distribution that we observed compared to the normal distribution seen in conventional interventions.

Whilst there was no overall relationship between user rating and behaviour change technique content, one particular app deserves mention. 'Diabetes Companion' by mySugr has a 5/5* customer rating in the app store and used 18 behaviour change techniques. The Diabetes Companion is a charming, sometimes outspoken, diabetes monster that aims to make diabetes monitoring and data collection useful and fun in everyday life. The app is approved as a medical device by the Food and Drug Administration in the USA and has a Conformité Européene (CE) mark. Elements of gamification in the app and immediate feedback help to keep players motivated and involved in self-management. Whilst there is no evaluation against health outcomes this app may nevertheless provide a model for employing gamification and health behaviour techniques in smartphone apps[30, 31].

We found that the price of an app was unrelated to number of behaviour change techniques reinforcing a similar finding from a content analysis of exercise apps[32]. However, other earlier studies showed a positive relationship between price and behaviour change technique content[33, 34]. The disparity between findings could be explained by the recent rise in Freemium apps, which are free to download, but then apply charges for additional features[35].

Strengths and weaknesses

This is the first comprehensive review of the use of behaviour change techniques in smartphone games using the most recent behaviour change taxonomy[19]. One previous review found limited use of behaviour change theory in health apps[4]. The review focused only on free physical activity and diet apps in the Apple store and used 13 core health behaviour constructs rather than a standard taxonomy of behaviour change techniques.

A limitation of our review is that we were unable to explore associations between use of behaviour change techniques and change in health behaviour or other health-related

outcomes. This is because none of the apps have been systematically evaluated and highlights the need for well-designed studies to determine the effectiveness of health and fitness apps against a range of process and health-related outcomes.

A further limitation is that we only reviewed top rated apps in the two most popular app stores and did not sample the entire range of apps available. Thus, the range of health behaviours targeted will reflect the preferences of the consumers rather than covering the entire repertoire of apps offered by developers. It is possible that in general apps with a high behaviour change content are less popular with users and we were not able to test this. Nevertheless, we were able to study the use of behaviour change techniques in apps in common use, which was the objective of our study.

Implications for clinicians and policymakers

Smartphone games could provide a potentially cost-effective platform for health promotion and thus, could have a substantial public health impact. An efficient mechanism will be needed to promote those apps that are most likely to bring health benefits. Only three apps in our review were approved by the NHS Health Apps Library, which is intended to provide this function for consumers in the United Kingdom. Whilst this may be because other apps were reviewed and not approved it is possible that the Library in its current form does not present the full range of apps available to the public. The NHS library is currently updating review processes aiming to provide an accredited set of apps, which have been endorsed and given a service quality certification mark by The British Standards Institution (Kitemark) through NHS Choices[36].

The majority of apps that we identified focussed on exercise and fitness. There were very few gamified apps targeting health behaviours more directly relevant to clinical outcomes, highlighting a potential gap in the market and possible untapped resource for health promotion. It is possible that the task of encouraging exercise and fitness lends itself more easily to gamification and that application of gamification to other aspects of health promotion will be more challenging. However, another explanation may be that health and fitness apps are simply more popular since we searched only the top rated apps in the most popular stores. In the latter case, the challenge will be to make apps and smartphone games that are as appealing to users as those promoting exercise and fitness.

Unanswered questions and future research

This review provides evidence to inform further research in the growing field of gamification in healthcare apps and to determine optimum use of behaviour change constructs in smartphone games. The relationship between the behaviour change

technique content of an intervention and the resulting health behaviour change is not simple[22-24]. More techniques are not necessarily better and further work is needed on the specific combinations of techniques likely to be effective in smartphone games.

There may be potential for more effective apps to be developed drawing from the full repertoire of techniques and combinations of techniques, which are appropriate to this platform. This development will require multidisciplinary collaboration between game developers, behaviour change experts and public health specialists.

Further research and clinical evaluation is urgently needed for health care apps to assess their effectiveness in modifying health behaviour and the clinical consequences of these behaviour changes. None of the apps in our review has been evaluated in randomised controlled trials to quantify potential benefit and harms that may arise from use of this technology. There is a need for regulation of health care apps and strengthened approval mechanisms to ensure patients have access to effective and safe interventions. The British Standards Institution has formulated and published a code of practice for health and wellness apps, providing app developers with quality criteria to consider during the development process[37]. We suggest that this code should be widely adopted and could lead to better quality and more effective products.

The economics of production and scale of delivery could potentially give smartphone apps an advantage over other health promotion interventions. Similar methods of assessing cost effectiveness could be used as for other health technologies (<https://www.nice.org.uk/about/what-we-do/our-programmes/nice-guidance/nice-medical-technologies-guidance>).

CONCLUSIONS

We provide an overview of the use of behaviour change techniques in the rapidly developing area of smartphone games, aiming to provide insights to inform more effective development of applications to change health-related behaviours. We suggest that strengthening collaboration between app developers, behavioural scientists and public health practitioners is necessary to realise the full health benefits of this new technology, which could be substantial. The benefits and harms arising should be evaluated using standard methods to enable consumers to make appropriate choices and allow health systems to make decisions about reimbursement.

CONTRIBUTORSHIP

EAE, JL, CR, LS, ST, RTW were involved in conception and design of the review. EAE searched app databases and EAE and JL extracted data and coded behaviour change techniques. EAE, JL, CR, LAE, AT and RS analysed data. EAE, JL, CR, LS, RS, ST, RTW and HC were involved in interpretation of the results. EAE and RTW drafted the manuscript, and CR, LS, ST, CG, MRM and HC revised it critically for intellectual content. All authors approved the final version of the article. All authors had access to all study data and take responsibility for data integrity and accuracy of the analysis. RTW is the guarantor.

COMPETING INTERESTS

HC is a smartphone game developer and director of Healthy Games.

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DATA SHARING

Additional data for this article has been provided as supplementary. There is no additional unpublished data.

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Table 1: Inclusion and exclusion criteria

Inclusion and exclusion criteria that were established for the initial search of the official Apple, Android app stores and NHS Health apps library aiming to identify all ‘top-rated’ smartphone apps incorporating gaming elements, which were marketed to the general public.

Table 2: Behaviour change technique categories included in apps

Number and percentage of apps to use the 16 Behaviour change techniques as derived from a standard taxonomy of behaviour change techniques used in health behaviour change research[19].

Table 3: Common combinations of behaviour change techniques

Number and percentage of apps to use commonly identified combinations of behaviour change techniques.

Figure 1: Flowchart of the app selection process

Flowchart of the app selection process including total number of apps screened, number of apps that met inclusion criteria, number of apps that were included in the review and total number of apps that were excluded.

Figure 2: Number of apps with individual behaviour change technique

Number of apps to use the individual 93 Behaviour change techniques as derived from a standard taxonomy of behaviour change techniques used in health behaviour change research[19].

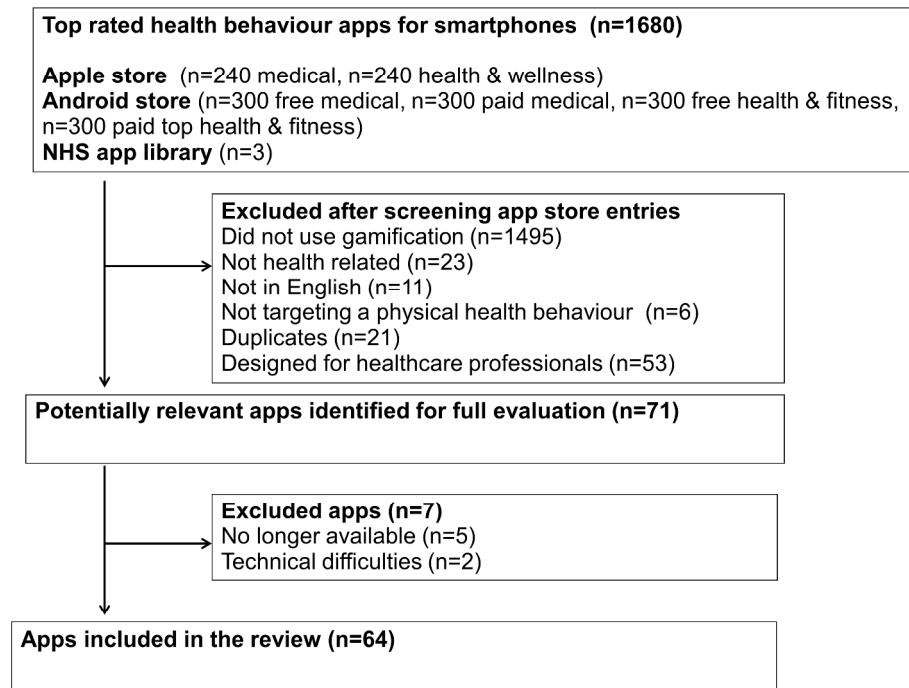


Figure 1: Flowchart of the app selection process

Flowchart of the app selection process including total number of apps screened, number of apps that met inclusion criteria, number of apps that were included in the review and total number of apps that were excluded.

Figure 1
279x209mm (300 x 300 DPI)

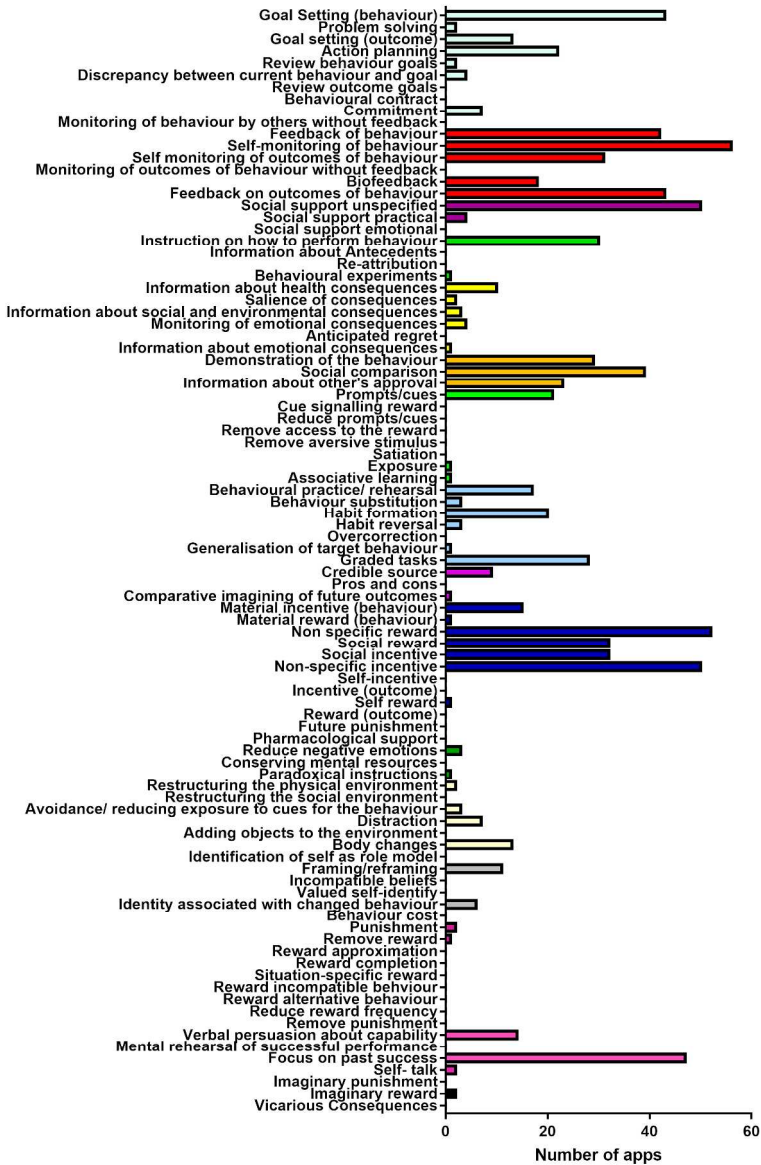
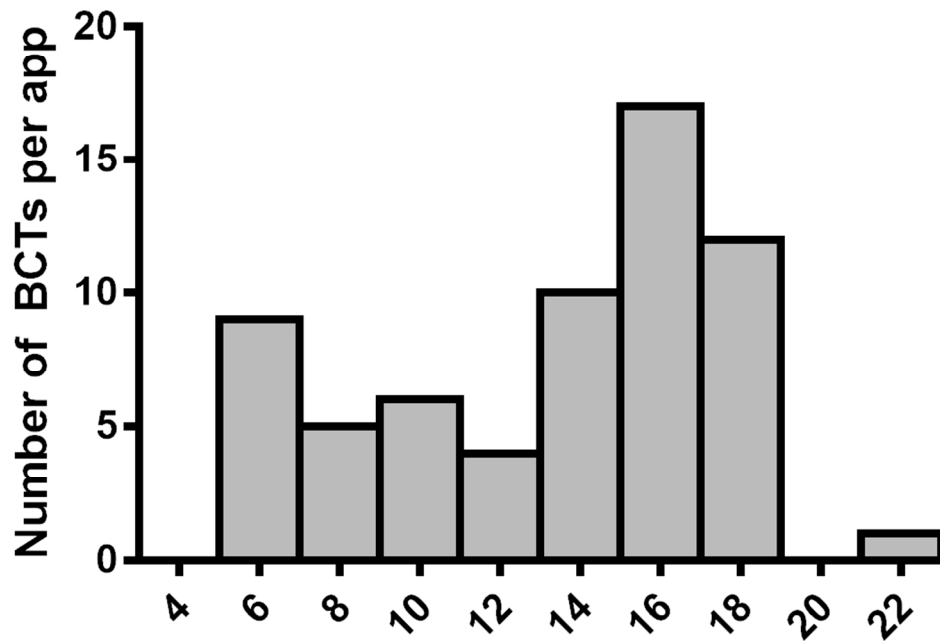


Figure 2: Number of apps with individual behaviour change technique
Number of apps to use the individual 93 Behaviour change techniques as derived from a standard taxonomy of behaviour change techniques used in health behaviour change research[19].

Figure 2
197x298mm (300 x 300 DPI)



Supplementary Figure 1: Number of behaviour change techniques per app
Histogram of the number of behaviour change techniques included per app.

Supplementary Figure 1
95x70mm (300 x 300 DPI)

Supplementary Table 1: Characteristics of included apps

Name of App	Category	Source	Targeted behaviour	Cost	User ratings	Number of BCTs
My Diet Coach – Pro	Health & Wellness	Android	Weight loss	£1.99	4.5	22
Nike+ Running	Health & Fitness	Apple iPhone	Exercise	£0.0	4	18
Speedo Fit	Health & Fitness	Apple iPhone	Exercise	£0.0	3.5	18
Runtastic Sit Ups Trainer PRO	Health & Fitness	Apple iPhone	Exercise	£1.49	4.5	18
Runtastic Squats Trainer	Health & Fitness	Apple iPhone	Exercise	£0.0	4.5	18
Diabetes Companion by mySugr	Medical	Apple iPhone	Blood sugar monitoring adherence	£0.0	5	18
Runtastic Squats PRO	Health & Wellness	Android	Exercise	£1.91	4.7	18
Runtastic Pull-Ups PRO	Health & Wellness	Android	Exercise	£1.73	4.5	18
Runtastic Sit-Ups	Health & Wellness	Android	Exercise	£0.0	4.4	18
Runtastic Push-Ups	Health & Wellness	Android	Exercise	£0.0	4.5	18
Fitocracy	Health & Fitness	Apple iPhone	Fitness	£0.0	5	17
UP	Health & Fitness	Apple iPhone	Fitness	£0.0	2.5	17
RunKeeper - GPS Track Run Walk	Health & Wellness	Android	Exercise	£0.0	4.4	17
Run with Map My Run	Health & Fitness	Apple iPhone	Exercise	£0.0	5	16
Map My Ride+ GPS Cycling Riding	Health & Fitness	Apple iPhone	Exercise	£1.99	4.5	16
Map My Ride - GPS Cycling, Riding, Mountain Biking, and Workout Tracking	Health & Fitness	Apple iPhone	Exercise	£0.0	4.5	16
Map My Fitness	Health & Fitness	Apple iPhone	Fitness	£0.0	4.5	16
Adrian James 6 Pack Abs Workout Lite	Health & Fitness	Apple iPhone	Exercise	£0.0	5	16
Run with Map My Run+	Health & Fitness	Apple iPhone	Exercise	£1.99	4.5	16
Zombies, Run!	Health & Fitness	Apple iPhone	Exercise	£2.49	4.5	16
Map My Walk+ GPS Pedometer	Health & Wellness	Android	Exercise	£1.91	4.4	16
Map My Run+ GPS Running	Health & Wellness	Android	Exercise	£1.99	4.5	16
Map My Fitness+ Workout Trainer	Health & Wellness	Android	Exercise	£0.69	4.4	16

Map My Hike+ GPS Hiking	Health & Wellness	Android	Exercise	£0.77	4.4	16
Quit-Smoking Coach	Health & Wellness	Android	Smoking Cessation	£2.90	4.4	16
STOP Cigarettes PRO Quit Smoking	Health & Wellness	Android	Smoking Cessation	£1.86	4.8	16
Map My Walk GPS Walking	Health & Wellness	Android	Exercise	£0.0	4.4	16
Map My Run GPS Running	Health & Wellness	Android	Exercise	£0.0	4.5	16
Endomondo Sports Tracker	Health & Fitness	Apple iPhone	Exercise	£0.0	3	15
Nike+ FuelBand	Health & Fitness	Apple iPhone	Exercise	£0.0	4	15
Strava Cycling	Health & Fitness	Apple iPhone	Exercise	£0.0	5	14
5K runner free	Health & Fitness	Apple iPhone	Exercise	£0.0	4.5	14
Strava Run	Health & Fitness	Apple iPhone	Exercise	£0.0	5	14
5K Runner paid	Health & Fitness	Apple iPhone	Exercise	£1.99	5	14
Zombies, Run! 5k Training Zombies	Health & Fitness	Apple iPhone	Exercise	£1.49	4.5	14
Freeletics	Health & Wellness	Android	Fitness	£1.99	4	14
Fitbit	Health & Fitness	Apple iPhone	Fitness	£0.0	4	13
JEFIT Pro - Workout & Fitness	Health & Wellness	Android	Exercise	£2.99	4.6	13
Virtuagym Fitness Home & Gym	Health & Wellness	Android	Exercise	£0.0	4.2	13
100% Army Fit	Health & Wellness	Android	Fitness	£0.0	4.4	13
Karrimor Elite	Health & Wellness	Android	Exercise	£0.0	4.4	12
7 Minute Workout "Seven" with High Intensity Interval Training Challenge	Health & Fitness	Apple iPhone	Exercise	£0.0	4.5	11
Change For Life- Smart Restart	Health & Fitness	Apple iPhone	Fitness	£0.0	4.5	11
Total Fitness - Gym & Workouts	Health & Wellness	Android	Exercise	£0.0	4.4	11
Aquafresh Brush Time	Health & Fitness	Apple iPhone	Tooth brushing	£0.0	3.5	10
Adidas Snapshot	Health & Fitness	Apple iPhone	Exercise	£0.0	4.5	10
Stop Smoking Pro	Health & Wellness	Android	Smoking cessation	£1.99	4.3	10
RunTroll	Health & Wellness	Android	Exercise	£0.0	4.9	10
Steps Mania Pro	Health & Wellness	Android	Exercise	£0.62	4.2	9

Stop Smoking	Health & Wellness	Android	Smoking cessation	£0.0	4.1	9
MyFit Fitness	Health & Fitness	Apple iPhone	Fitness	£0.0	3.5	8
The Spartan 300 Workout	Health & Wellness	Android	Exercise	£3.10	4.3	8
Disney Magic Timer by Oral-B	Health & Wellness	Android	Tooth brushing	£0.0	3	7
Runtastic Road Bike	Health & Wellness	Android	Exercise	£0.0	4.6	7
Plank Challenge	Health & Wellness	Android	Exercise	£0.0	4	7
Runmeter GPS Pedometer	Health & Fitness	Apple iPhone	Exercise	£0.0	5	6
Cyclemeter GPS	Health & Fitness	Apple iPhone	Exercise	£0.0	5	6
Walkmeter GPS Pedometer	Health & Fitness	Apple iPhone	Exercise	£0.0	4.5	6
Gorilla Workout: Strength Plan	Health & Wellness	Android	Exercise	£0.62	4.3	6
Fitness Flow	Health & Wellness	Android	Fitness	£2.75	4.5	6
AllSport GPS PRO	Health & Wellness	Android	Exercise	£3.10	4.1	6
Fitness Flow FREE	Health & Wellness	Android	Adult Fitness	£0.0	4	6
Change4Life fun generator	Health & Fitness	Apple iPhone	Fitness	£0.0	3	5
Runtastic Pedometer	Health & Wellness	Android	Exercise	£0.0	4.3	5

Supplementary Table 1: Characteristics of included apps

Characteristics of apps meeting the inclusion criteria including: name of app, given category in the app store, source of app identified as either being from the Apple or Android store, targeted behaviour, cost of the app in sterling, user ratings as defined by either Apple or Android stores and number of individual behaviour change techniques included.

Supplementary Figure 1: Number of behaviour change techniques per app

Histogram of the number of behaviour change techniques included per app.

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‘Gamification’ for health behaviour change in smartphone apps: systematic review of behaviour change techniques

Elizabeth Edwards, Jim Lumsden, Carol Rivas, Liz Steed, Lindsey Edwards, Arun Rajan, Ratna Sohanpal, Hope Caton, Steph Taylor, Robert Walton

Citation

Elizabeth Edwards, Jim Lumsden, Carol Rivas, Liz Steed, Lindsey Edwards, Arun Rajan, Ratna Sohanpal, Hope Caton, Steph Taylor, Robert Walton. ‘Gamification’ for health behaviour change in smartphone apps: systematic review of behaviour change techniques. PROSPERO 2015:CRD42015029841 Available from http://www.crd.york.ac.uk/PROSPERO_REBRANDING/display_record.asp?ID=CRD42015029841

Review question(s)

What proportion of Health Care apps on the official Apple and Android stores use gamification to modify health behaviour?

What behaviour change techniques and combinations of techniques are used?

Is there an association between behaviour change techniques and combinations of techniques with NHS library ratings, user ratings and price?

Searches

We aim to identify all English language health apps using gamification and available on the official Apple and Android app stores that are ‘top rated’, defined by Apple and Google Play stores (<https://play.google.com/store>)(<https://itunes.apple.com>).

The following search terms will be used: rewards, prizes, avatar use, badges, leaderboards, competitions, health-related challenges. All apps meeting the inclusion criteria will be recorded in a standardized structured form.

Types of study to be included

Not applicable

Condition or domain being studied

We plan to review all apps that aim to modify any health behaviour.

Participants/ population

Inclusion criteria:

English language apps

Apps that use the following gamification techniques: rewards, prizes, avatar use, badges, leader boards, competitions, health-related challenges

Apps available through google play and I Tunes

Smart phone app

Apps in the Medical, Health & Wellness or Health & Fitness section

Apps targeted at users of any age

Free and paid apps

Exclusion criteria:

Apps designed for tablets

Non- English language apps

Non-health related apps

Apps that do not contain gamification techniques

Apps designed for Health Care professionals

Intervention(s), exposure(s)

The identified apps will be screened independently by two review authors (EE, JL) trained in coding behaviour change techniques. Coding will be carried out independently by the two reviewers who will then cross-check for discrepancies. Responses from each review author will be recorded independently in a standardized structured form.

App content will be assessed against criteria derived from a behaviour change taxonomy used in health behaviour change intervention established by Michie et.al [1]. The taxonomy consists of 16 categories and 93 individual techniques. The number of individual techniques included in each app will be counted (range 0-93). The use of behaviour change categories, individual techniques and combinations of techniques will be examined. Associations with NHS library ratings, user ratings and price will also be explored.

References:

1. Michie, S., et al., The behavior change technique taxonomy (v1) of 93 hierarchically clustered techniques: building an international consensus for the reporting of behavior change interventions. Ann Behav Med, 2013. 46(1): p. 81-95.

Comparator(s)/ control

Not applicable

Outcome(s)

Primary outcomes

The number of Health Care apps to incorporate gamification:

We will assess the proportion of apps in the official Apple and Google Play stores and NHS health apps library to incorporate gamification in order to modify health behaviour. A systematic search of the top rated free and paid Medical, Health & Wellness, Health & Fitness apps will be conducted.

The use of behaviour change techniques and combination of Behaviour change technique:

The number of individual techniques included in each app will be counted (range 0-93). The mean number, median value and the range will also be calculated. We will investigate what behaviour change categories, individual techniques and combinations of techniques are used.

The association of behavior change technique use with downloads, user ratings, price and NHS library ratings:

We will explore associations between number of individual behaviour change technique and combination of behaviour change techniques with downloads, user ratings, price and NHS library ratings. Customer ratings will be obtained from the Apple store and Google Play. The total rating for all versions of the app will be used. The price will be recorded as free or paid. The exact price of each app will also be recorded.

As above, under each Primary outcome

Secondary outcomes

Not applicable

Data extraction, (selection and coding)

The initial systematic review of top rated Medical, Health & Wellness, Health & Fitness apps on the official Apple and Google Play stores and NHS health apps library will be conducted by one review author (EE). Assessments against eligibility criteria will be recorded on a standardized structured form.

Medical, Health & Wellness or Health & Fitness apps meeting inclusion criteria will be downloaded on to a test device. The same test device will be used throughout the evaluation. Test devices will be unmodified consumer-grade smartphones running up-to-date versions of their mobile operating system. The same version of each app will be used throughout testing.

The identified apps will then be screened independently by two review authors (EE, JL) trained in BCT coding. Any discrepancies will be discussed with a third review author (LS). Responses from each review author will be recorded independently in a second standardized structured form.

Extracted information will include: version, date of first release, date of latest update, publisher, description of the app, main function of the app, target user, special features incorporated, number of downloads in the Android store, number in the chart in the Apple store. Missing data will be requested from the author/publisher or the app or Apple/Android store.

Risk of bias (quality) assessment

Not Applicable

Strategy for data synthesis

A quantitative synthesis of the number of apps to contain gamification will be conducted including all apps that meet the inclusion criteria and that are identified in the review. Basic descriptive statistics will be calculated. Apps found in both the Apple store and Google Play store will not be included twice and will be recorded only in the Apple iPhone data. The number of Behaviour change technique and combination of Behaviour change technique will be compared to user ratings, price and NHS library ratings. Apps that do not have customer ratings available will not be included in this analysis. Statistical significance of the association between the number of behaviour change techniques and the combination of behaviour change techniques with user ratings, price and NHS library ratings will be determined by linear regression or Spearman's Rank Correlation Coefficient as appropriate. This will be calculated using GraphPad Prism 6.

Analysis of subgroups or subsets

None Planned

Dissemination plans

The results of this research will be disseminated in a number of ways to all stakeholders. Professional groups both in the Academic/Clinical setting and Technologists will be informed through presentation at local, National and International conferences/meetings. Results of the review will be published in highly cited and open access peer reviewed journals. Relevant public health, NHS and other healthcare organisations including policy and decision makers will be informed of the results of the research. This will be at both local and national meetings.

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<http://blizard.qmul.ac.uk/centres/centre-for-primary-care-and-public-health.html>

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Anticipated or actual start date

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Conflicts of interest

None known

Language

English

Country

England

Subject index terms status

Subject indexing assigned by CRD

Subject index terms

Behavior Therapy; Health Behavior; Humans; Smartphone

Stage of review

Ongoing

Date of registration in PROSPERO

02 December 2015

Date of publication of this revision

02 December 2015

Stage of review at time of this submission

Started

Completed

Preliminary searches

No

Yes

Piloting of the study selection process

No

Yes

Formal screening of search results against eligibility criteria

No

Yes

Data extraction

No

No

Risk of bias (quality) assessment

No

No

Data analysis

No

No

PROSPERO

International prospective register of systematic reviews

The information in this record has been provided by the named contact for this review. CRD has accepted this information in good faith and registered the review in PROSPERO. CRD bears no responsibility or liability for the content of this registration record, any associated files or external websites.



PRISMA 2009 Checklist

Section/topic	#	Checklist item	Reported on page #
TITLE			
Title	1	Identify the report as a systematic review, meta-analysis, or both.	1
ABSTRACT			
Structured summary	2	Provide a structured summary including, as applicable: background; objectives; data sources; study eligibility criteria, participants, and interventions; study appraisal and synthesis methods; results; limitations; conclusions and implications of key findings; systematic review registration number.	2
INTRODUCTION			
Rationale	3	Describe the rationale for the review in the context of what is already known.	4-5
Objectives	4	Provide an explicit statement of questions being addressed with reference to participants, interventions, comparisons, outcomes, and study design (PICOS).	5
METHODS			
Protocol and registration	5	Indicate if a review protocol exists, if and where it can be accessed (e.g., Web address), and, if available, provide registration information including registration number.	6
Eligibility criteria	6	Specify study characteristics (e.g., PICOS, length of follow-up) and report characteristics (e.g., years considered, language, publication status) used as criteria for eligibility, giving rationale.	6-7
Information sources	7	Describe all information sources (e.g., databases with dates of coverage, contact with study authors to identify additional studies) in the search and date last searched.	6
Search	8	Present full electronic search strategy for at least one database, including any limits used, such that it could be repeated.	6
Study selection	9	State the process for selecting studies (i.e., screening, eligibility, included in systematic review, and, if applicable, included in the meta-analysis).	6
Data collection process	10	Describe method of data extraction from reports (e.g., piloted forms, independently, in duplicate) and any processes for obtaining and confirming data from investigators.	6-7
Data items	11	List and define all variables for which data were sought (e.g., PICOS, funding sources) and any assumptions and simplifications made.	6-7
Risk of bias in individual studies	12	Describe methods used for assessing risk of bias of individual studies (including specification of whether this was done at the study or outcome level), and how this information is to be used in any data synthesis.	N/A
Summary measures	13	State the principal summary measures (e.g., risk ratio, difference in means).	8
Synthesis of results	14	Describe the methods of handling data and combining results of studies, if done, including measures of consistency (e.g., I^2 for each meta-analysis).	N/A

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PRISMA 2009 Checklist

Page 1 of 2

Section/topic	#	Checklist item	Reported on page #
Risk of bias across studies	15	Specify any assessment of risk of bias that may affect the cumulative evidence (e.g., publication bias, selective reporting within studies).	N/A
Additional analyses	16	Describe methods of additional analyses (e.g., sensitivity or subgroup analyses, meta-regression), if done, indicating which were pre-specified.	N/A
RESULTS			
Study selection	17	Give numbers of studies screened, assessed for eligibility, and included in the review, with reasons for exclusions at each stage, ideally with a flow diagram.	9
Study characteristics	18	For each study, present characteristics for which data were extracted (e.g., study size, PICOS, follow-up period) and provide the citations.	Supplementary table 1
Risk of bias within studies	19	Present data on risk of bias of each study and, if available, any outcome level assessment (see item 12).	N/A
Results of individual studies	20	For all outcomes considered (benefits or harms), present, for each study: (a) simple summary data for each intervention group (b) effect estimates and confidence intervals, ideally with a forest plot.	9-11
Synthesis of results	21	Present results of each meta-analysis done, including confidence intervals and measures of consistency.	N/A
Risk of bias across studies	22	Present results of any assessment of risk of bias across studies (see Item 15).	N/A
Additional analysis	23	Give results of additional analyses, if done (e.g., sensitivity or subgroup analyses, meta-regression [see Item 16]).	N/A
DISCUSSION			
Summary of evidence	24	Summarize the main findings including the strength of evidence for each main outcome; consider their relevance to key groups (e.g., healthcare providers, users, and policy makers).	12-15
Limitations	25	Discuss limitations at study and outcome level (e.g., risk of bias), and at review-level (e.g., incomplete retrieval of identified research, reporting bias).	13-14
Conclusions	26	Provide a general interpretation of the results in the context of other evidence, and implications for future research.	15
FUNDING			
Funding	27	Describe sources of funding for the systematic review and other support (e.g., supply of data); role of funders for the systematic review.	16

BMJ Open

Gamification for health promotion: systematic review of behaviour change techniques in smartphone apps

Journal:	<i>BMJ Open</i>
Manuscript ID	bmjopen-2016-012447.R1
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Primary Subject Heading:	Health informatics
Secondary Subject Heading:	Public health
Keywords:	Health informatics < BIOTECHNOLOGY & BIOINFORMATICS, Telemedicine < BIOTECHNOLOGY & BIOINFORMATICS, Information technology < BIOTECHNOLOGY & BIOINFORMATICS, PUBLIC HEALTH

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Manuscripts

Gamification for health promotion: systematic review of behaviour change techniques in smartphone apps

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ABSTRACT

OBJECTIVE: Smartphone games that aim to alter health behaviours are common, but there is uncertainty about how to achieve this. We systematically reviewed health apps containing gaming elements analysing their embedded behaviour change techniques.

METHODS: Two trained researchers independently coded apps for behaviour change techniques using a standard taxonomy. We explored associations with user ratings and price.

DATA SOURCES: We screened the NHS health apps library and all top-rated medical, health & wellness and health & fitness apps (defined by Apple and Google Play stores based on revenue and downloads). We included free and paid English language apps using 'gamification' (rewards, prizes, avatars, badges, leaderboards, competitions, levelling-up or health-related challenges). We excluded apps targeting health professionals.

RESULTS: 64 of 1,680 (4%) health apps included gamification and met inclusion criteria; only three of these were in the NHS library. Behaviour change categories used were: *feedback & monitoring* (n=60, 94% of apps); *reward & threat* (n=52, 81%); *goals & planning* (n=52, 81%). Individual techniques were: *self-monitoring of behaviour* (n=55, 86%); *non-specific reward* (n=49, 82%); *social support unspecified* (n=48, 75%); *non-specific incentive* (n=49, 82%); *focus on past success* (n=47, 73%). Median number of techniques per app was 14 (range 5-22). Common combinations were: *goal setting, self-monitoring, non-specific reward and non-specific incentive* (n=35, 55%); *goal setting, self-monitoring and focus on past success* (n=33, 52%). There was no correlation between number of techniques and user ratings ($p=0.07$; $r_s=0.23$) or price ($p=0.45$; $r_s=0.10$).

CONCLUSIONS: Few health apps currently employ gamification and there is wide variation in use of behaviour change techniques, which may limit potential to improve health outcomes. We found no correlation between user rating (a possible proxy for health benefits) and game content or price. Further research is required to evaluate effective behaviour change techniques and to assess clinical outcomes.

Prospero Registration number: CRD42015029841

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Strengths and limitations of this study

- This is the first comprehensive systematic review examining the use of behaviour change techniques in smartphone games aimed at changing health-related behaviours.
- We rigorously evaluated behaviour change techniques and classified them using the Behaviour Change Technique Taxonomy v1.
- We identify individual behaviour change techniques and combinations of techniques commonly used in smartphone games to facilitate development of more effective applications in future.
- We screened only 1680 top rated apps in the most popular app stores so whilst our sample may be representative of apps in common use we did not examine the full repertoire of apps offered by developers.
- We were not able to assess the clinical benefits or potential harms from using the apps since none have been rigorously evaluated.

INTRODUCTION

Smartphone use has increased rapidly in recent years both in developed and developing countries. There are over 2 billion smartphone users globally in 2016 and by 2018 one-third of the world's population will use smartphones[1]. China had 500 million smartphone users in 2014 and in 2016 India will exceed 200 million users overtaking the United States of America as the world's second-largest smartphone market[1].

Accompanying this rapid growth in smartphone use is a huge expansion in applications targeting health and health-related behaviours. Over 100,000 health applications (apps) are available worldwide for smartphones with exercise, diet and weight management apps being the most popular downloads[2-4]. Consumers are keen to access health information on their mobile devices and more than 500 million people globally currently use mobile health applications[5]. However, most health applications for smartphones have very simple functions and do little more than provide basic information[6]. There is little evidence that public health practitioners and users participate in the design of health apps and most apps do not contain theoretically consistent behaviour change techniques[7-18]. Very few apps comply with regulatory processes or have had their effectiveness formally assessed[6, 8, 16, 19], leading to concerns about lack of benefit or even potentially harmful apps[19].

Whilst there is guidance from both Apple and Android stores on criteria that must be met for app inclusion[20, 21], this focuses on ensuring that app content is not of a violent, illegal or sexual nature, that it functions reliably and that intellectual property is secured. The NHS Health Apps Library uses a more rigorous approach with a clinical assurance team to ensure apps comply with trusted sources of information and to identify apps which may potentially cause harm[22]. However, currently, there is no requirement to demonstrate effectiveness in modifying either behavioural or clinical outcomes or that the app complies with regulatory frameworks

(<http://www.fda.gov/MedicalDevices/DigitalHealth/MobileMedicalApplications/default.htm>, <https://www.gov.uk/government/publications/medical-devices-software-applications-apps>).

In parallel with the growth in health apps, there has been a remarkable increase in gaming on personal computers, dedicated game consoles and on smartphones. Games now form the largest market share of apps comprising 33% of all

downloads[23]. It is estimated that 69% of people in the UK aged 8-74 are playing games on average 14 hours per week[24]. Of these players, 52% are female and the average age is 31 years. 'Gamification' harnesses a desire for competition, incorporating 'gaming elements' such as badges, leaderboards, competitions, rewards and avatars to engage and to motivate people[25]. Use of gamification is increasingly popular for training programmes in industry with a projected \$2.8 billion spend on gamification by businesses in 2016[26]. Higher education institutions have also integrated gaming techniques into their teaching programmes[27].

Whilst there are successful health applications of gamification on Super Nintendo, Nintendo Wii and personal computers, gamification in mobile health is, perhaps surprisingly, a relatively new concept[28-31]. Gamification can be effective in promoting and sustaining healthy behaviours, tapping into playful and goal-driven aspects of human nature. Gamification strategies such as goal setting, providing feedback on performance, reinforcement, comparing progress and social connectivity share key elements with established health behaviour change techniques[32].

A behaviour change technique is "an observable, replicable and irreducible component of an intervention designed to alter or redirect causal processes that regulate behaviour; that is, a technique is proposed to be an 'active ingredient' (e.g., *feedback, self-monitoring, reinforcement*)"[7]. These techniques have been clearly defined, linked with theories of behaviour change and classified into an internationally recognised taxonomy, comprising 93 individual techniques, grouped into 16 behaviour change categories [7].

This taxonomy builds on previous work to identify the active components of complex interventions [8, 23, 24, 33-35]. For example, Dombrowski *et al.*, coded behaviour change techniques for obese adults with obesity-related comorbidities in behavioural interventions applying a 26-category taxonomy developed by Abraham and Michie *et al.*, [34, 36].

Although apps have proliferated, work aiming to characterise the use of behaviour change techniques in smartphone apps and smartphone games is relatively novel. Two reviews include Direito *et al.*, who used a 26-category taxonomy developed by Abraham and Michie *et al.*, [36, 37] and Conroy *et al.*, who used the Coventry, Aberdeen and London- Revised (CALO-RE) developed also by Michie *et al.*, and found limited use of behaviour change techniques in diet and physical activity apps[8,

38]. Crane *et al.*, examined use of behaviour change techniques in alcohol reduction apps using the BCT Taxonomy v1[7]. Findings again found limited use of behaviour change techniques.

Here we provide the first comprehensive systematic review of behaviour change techniques in smartphone games classified using the BCT taxonomy (v1) developed by Michie *et al.* comprising 16 behaviour change categories and 93 individual techniques. The purpose of this review is to identify appropriate behaviour change techniques and combinations of techniques for use in this setting to facilitate development of more effective smartphone games to promote health[7].

METHODS

We identified all English language health apps for all ages (both free and for purchase) that incorporated gamification. We defined gamification as use of at least one of the following techniques: rewards; prizes; avatars; badges; leader boards; competitions; health-related challenges. We searched the official Apple and Android app stores (<https://play.google.com/store>, <https://itunes.apple.com>) and selected 'top-rated' apps as defined by the store. The rating is derived from number of downloads and daily revenue generated[39]. We also searched the NHS Health apps library (<https://apps.nhs.uk>). The protocol for this review has been published and is available online and as a supplementary file (Supplementary Prospero File):

http://www.crd.york.ac.uk/PROSPERO/display_record.asp?ID=CRD42015029841.

Prospero registration number: CRD42015029841.

Search Strategy:

The initial search was conducted by one review author (EE) from 1st April 2014 to 30th June 2015 examining all apps in the 'top-rated' categories in each app store. Data from apps meeting inclusion criteria were recorded in a pre-piloted, standardised, structured data collection form.

Inclusion/ Exclusion Criteria:

Inclusion criteria were broad, aiming to identify all 'top-rated' smartphone apps incorporating gaming elements, which were marketed to the general public (Table 1).

Table 1: Inclusion and exclusion criteria

Inclusion Criteria	Exclusion Criteria
English language smartphone apps	Apps designed for tablet computers
Apps available through Google play and iTunes or NHS app store	Non- English language apps
Apps included in the Medical, Health & Wellness or Health & Fitness section of Google play and iTunes and all NHS apps	Apps in other sections of the stores
Apps including gamification techniques: rewards, prizes, avatars, badges, leader boards, competitions, health-related challenges	Smartphone apps that do not contain gamification techniques
Smartphone apps targeted at users of any age	Smartphone apps designed for Health Care professionals
Free and paid Smartphone apps	Apps not targeting to change a physical health behaviour
Apps targeting to change a physical health behaviour	Apps that did not have customer ratings available

Coding the Apps for behaviour change techniques:

All apps meeting inclusion criteria were downloaded onto test devices. The same make and model of test device was used throughout the evaluation (LG Nexus 5 Android or iPhone 5c). Test devices were unmodified consumer-grade smartphones running up-to-date versions of their mobile operating system. The same version of each app was used throughout testing. The entire app content was coded for behaviour change techniques including text, images, video and other multimedia content. Apps found in both the Apple store and Google Play store were not included twice and were recorded only in the Apple iPhone data.

Two researchers trained in behaviour change technique coding (EE, JL) coded apps independently. App content was coded using the BCT taxonomy (v1)[7]. Techniques were classified as either present or absent. An example of the coding process and application of behaviour change techniques to app content is provided (Supplementary Figure 1). The number of individual behaviour change techniques included in each app was counted. There was no count of the frequency in which techniques were used in each individual app.

We used Cohen's kappa to assess inter-rater reliability of BCT coding at the initial stage of review. There was substantial agreement between the two reviewers ($\kappa = .79$, 95% CI, .76 to .81). All discrepancies in reviewer coding were then resolved through discussion with a third trained reviewer (LS), a health psychologist.

Codes from each reviewer were recorded on a standardised, structured form. We recorded information on app version, date of first release, date of latest update, publisher, description, main function, target user, special features and number of downloads where available. Missing data were requested from the author/publisher of the app or from the Apple/Android stores.

Synthesis of results:

A qualitative and quantitative synthesis was conducted with calculation of basic descriptive statistics. Behaviour change technique use including categories, individual techniques, and combinations of techniques was analysed. Comparison was made between the number of behaviour change techniques included, user rating and price. Correlations were determined using Spearman's Rank correlation coefficient (r_s), calculated with GraphPad Prism 6.

RESULTS

We screened 1,680 Medical, Health & Wellness or Health & Fitness apps of which 64 (4 %) met inclusion criteria (Figure 1). Although the initial search was conducted by one review author (EE), the inclusion and exclusion criteria were defined *a priori* and agreed by three authors JL, LS and RW. Additional discussions occurred during this initial search period between EE and other review authors about inclusion of particular apps.

Apple displays 240 top-rated Medical and 240 Health & Wellness apps comprising both free and paid apps. Android displays free and paid apps separately, displaying their top 300 rated free Medical apps, 300 top rated paid Medical apps, 300 free top rated health & fitness and 300 paid top rated health & fitness apps. Thus, more Android than Apple apps were included.

In the apps meeting inclusion criteria, targeted behaviour changes included increasing/improving exercise (n=45, 70%), improving fitness (n=11, 17%), smoking cessation (n=4, 6%), encouraging oral hygiene (n=2, 3%), weight loss (n=1, 2%), blood glucose measurement adherence (n=1, 2%, Supplementary Table 1).

The median number of behaviour change techniques was 14 (range 5 to 22) with a negatively skewed distribution (Supplementary Figure 2). The most common behaviour change categories were: *feedback & monitoring* (n=60, 94% of apps); *comparison of behaviour* (n=52, 81% of apps); *reward & threat* (n=52, 81% apps). The most used individual techniques were: *self-monitoring of behaviour* (n=55, 86% apps); *non-specific reward* (n=49, 82% apps); *non-specific incentive* (n=49, 82% apps); *social support unspecified* (n=48, 75% apps); *focus on past success* (n=47, 73% of apps; Table 2; Figure 2).

42 of 93 (45%) behaviour change techniques in the taxonomy were not used in any app.

Frequently used combinations of techniques were based on *self-monitoring* and *goal setting* with the addition of either *focus on past success* (n=33, 47%) or *non-specific rewards and incentives* (n=33, 47%; Table 3).

Median user rating was 4.5 (range 2.5 to 5). There was no correlation between the number of behaviour change techniques and customer ratings ($P = 0.07$; $r_s = 0.23$). 23 apps (36%) were available to purchase and the remainder were free. The median cost of the paid apps was £1.99 (range £0.62 to £3.10). There was no correlation between number of behaviour change techniques and price ($P = 0.45$ $r_s = 0.10$). Only three apps were included in the NHS health apps library: *Change 4 Life fun generator* by NHS choices, *Zombies Run!* and *Zombies Run! 5k Training*.

Table 2: Behaviour change technique categories included in apps

BCT Taxonomy Category Groupings	Number of apps to use category	%
Feedback & Monitoring	60	94
Comparison of Behaviour	52	81
Reward & Threat	52	81
Self- belief	51	80
Repetition & Substitution	50	78
Social Support	48	75
Goals & Planning	46	72
Shaping Knowledge	25	39
Associations	20	31
Antecedents	18	28
Identity	12	19
Natural Consequences	9	14
Comparison of Outcomes	5	8
Regulation	1	2
Scheduled Consequences	3	5
Covert Learning	2	3

Table 3: Common combinations of behaviour change techniques

Technique combination	Number of apps to use combination N (%)
Goal setting, Self-monitoring, Non-specific reward, Non-specific incentive	35 (55)
Goal setting, Self-monitoring, Focus on past success	33 (51)
Goal setting, Self-monitoring, Non-specific reward, Non-specific incentive, Focus on past success	31 (48)
Goal setting, Self-monitoring, Feedback of behaviour, Social support unspecified, Focus of past success	27 (42)
Goal setting, Feedback of behaviour, Self-monitoring	28 (44)
Goal setting, Feedback of behaviour, Self-monitoring, Social support unspecified, Non-specific reward, Non-specific incentive, Focus past success	26 (41)
Goal setting, Feedback of behaviour, Self-monitoring, Feedback of outcome of behaviour, Social support unspecified, Non-specific reward, Non-specific incentive, Focus on past success	22 (34)

DISCUSSION

Main findings

Despite a rapid increase in use of gamification in the commercial and education sectors, smartphone applications using gamification for promoting health are currently limited. Our review highlights wide variation in use of behaviour change techniques; however, all apps reviewed included at least five recognised behaviour change techniques, most commonly *feedback and monitoring*, *comparison of behaviour* and *reward and threat*. It is encouraging also that app developers are using combinations of behaviour change techniques which are theoretically consistent such as *goal setting*, *self-monitoring* and *non-specific reward*.

Results in the context of other studies

We found that self-regulatory behaviour change techniques were most commonly used (*feedback & monitoring* including *self-monitoring of behaviour*). These techniques are also commonly used in non-gamified apps targeting physical activity, healthy eating and alcohol reduction[37, 38, 40]. The effectiveness of these techniques in achieving behaviour change is supported by findings from a wide range of studies[8, 23, 24, 33-35] and linked to control theory[24]. Control theory suggests that setting goals, monitoring of behaviour, receiving feedback and reviewing relevant goals in the light of feedback may be effective in changing behaviour[41] and is one of a broader group of theories involving feedback loops and self-regulation[42].

Frequently used behaviour change categories were *comparison of behaviour* and *reward and threat*. Common individual behaviour change techniques were *social support unspecified*, *non-specific reward*, *non-specific incentive* and *focus on past success*. We suggest that the use of some of these techniques may be driven by ease of implementation in smartphone games with an Internet connection. Sharing activity on social media is a common feature of mobile apps and is easy to integrate into app design. Social support as a behaviour change technique is also common in physical activity apps[38].

Other reviews have found that the behaviour change technique *providing instruction on how to perform behaviour* has featured highly amongst physical activity apps (n=33, 83% of apps)[37] (n=111, 66% of apps)[38], however, this technique was found in relatively few apps in our review (n=25, 39% of apps). It is possible that this

technique may be more suited to physical activity apps since it was not found in apps to reduce alcohol consumption[40]. Alcohol reduction apps also featured a range of techniques not found in smartphone games: *facilitate self-recording; provide information on consequences; give options for additional and later support; offer/direct towards appropriate written materials*[40]. Whilst, these techniques may be more suited to alcohol reduction apps it is also possible that they do not lend themselves to use on the gaming platform.

One previous meta-analysis examined combinations of health behaviour change techniques using classification and regression trees and suggested that *provide information about behaviour* and *prompt intention formation* was one of the most effective combinations[43], however, comparison with our findings is problematic because the study used the earlier 26 category taxonomy[36] which does not easily translate into the more recent 93 category taxonomy (v1)[7].

A second meta-analysis of internet-based interventions suggested that number of techniques included in the intervention and the resulting behaviour change outcomes were directly related[44]. This review also suggested benefit from linking techniques to behaviour change theory. We were not able to examine effects on outcomes because of lack of outcome data, although we saw no relation between behaviour change technique content and user rating which may be a proxy for outcome. Several studies in other clinical settings find no relation between number of behaviour change techniques and health outcome, for example in obesity, healthy eating and physical activity[24, 34, 35], although these studies did not specifically examine effects using a technology-based delivery method. One study examining technology-based delivery found that popularity and user ratings were only weakly associated with behaviour change technique content[40].

We found a high number of behaviour change techniques in each smartphone game (median 14, range 5 to 22). This figure is higher than previous reviews of non-app interventions to promote healthy eating (mean 6, range 1 to 13)[36] and physical activity (mean 6, range 1 to 13)[36] (mean 6, SD 3.1)[24] (mean 8, range 2-18)[37]. Two other reviews of behaviour change techniques in physical activity and non-gamified alcohol reduction apps found a slightly lower number (mean 4.2, range 1-13)[38](mean 3.6, range 0-13)[40]. This may be related to the overlap between gamification methodology and health behaviour change techniques.

Whilst there was no overall relationship between user rating and behaviour change technique content, one particular app deserves mention. 'Diabetes Companion' by mySugr has a 5/5* customer rating in the app store and used 18 behaviour change techniques. The Diabetes Companion is a charming, sometimes outspoken, diabetes monster that aims to make diabetes monitoring and data collection useful and fun in everyday life. The app is approved as a medical device by the Food and Drug Administration in the USA and has a Conformité Européene (CE) mark. Elements of gamification in the app and immediate feedback help to keep players motivated and involved in self-management. Whilst there is no evaluation against health outcomes this app may nevertheless provide a model for employing gamification and health behaviour techniques in smartphone apps[45, 46].

We found that the price of an app was unrelated to number of behaviour change techniques reinforcing a similar finding from a content analysis of exercise apps[47]. However, other earlier studies showed a positive relationship between price and behaviour change technique content[14, 37, 48]. The disparity between findings could be explained by the recent rise in Freemium apps, which are free to download, but then apply charges for additional features[49].

Strengths and weaknesses

This is the first comprehensive review of the use of behaviour change techniques in smartphone games using the most recent behaviour change taxonomy[7]. One previous review found limited use of behaviour change theory in gamified health apps[3]. The review focused only on free physical activity and diet apps in the Apple store and used 13 core health behaviour constructs rather than a standard taxonomy of behaviour change techniques. Another review used the BCT taxonomy (v1), however, considered only non-gamified alcohol reduction apps[40].

A further strength of this review is that we considered combinations of behaviour change techniques that were used in the apps. Many of the existing reviews report individual behaviour change techniques rather than combinations. However, our aim was only to identify the combinations of techniques that smartphone game developers are currently using. We had insufficient power to examine effects of theoretically consistent groups of techniques on proxy outcomes such as user rating or price. This is an interesting area of work requiring further research in larger databases, which would ideally include behavioural and clinical outcomes[50].

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Whilst there may be a degree of subjectivity when coding behaviour change techniques using taxonomies[51], this would have been reduced by independent coding by two trained researchers[51]. In addition we demonstrated substantial agreement between the two reviewers.

A limitation of our review is that we were unable to explore associations between use of behaviour change techniques and change in health behaviour or other health-related outcomes. This is because none of the apps have been systematically evaluated and highlights the need for well-designed studies to determine the effectiveness of health and wellness apps against a range of process and health-related outcomes.

A further limitation is that we only reviewed top rated apps in the two most popular app stores and did not sample the entire range of apps available. Thus, the range of health behaviours targeted will reflect the preferences of the consumers rather than covering the entire repertoire of apps offered by developers. It is possible that apps with certain characteristics, for example high behaviour change content, are less popular with users and we were not able to test this hypothesis. Nevertheless, we were able to study the use of behaviour change techniques in apps in common use, which was the objective of our study.

In this review, we focussed on commonly used behaviour change techniques. It would be interesting to examine behaviour change techniques that were not used or had a low frequency of use, to determine how these aligned with relevant behavioural and cognitive theories and hence identify any potential opportunities for app developers. Similarly, we did not examine the frequency with which behaviour change techniques were used in each individual app and the mode of delivery of each behaviour change technique. Future work in larger data sets might usefully make these more detailed observations and could also examine the effects of pre-specified, theoretically consistent groups of behaviour change techniques against relevant outcomes.

Implications for clinicians and policymakers

Smartphone games could provide a potentially cost-effective platform for health promotion and thus, could have a substantial public health impact. An efficient mechanism will be needed to promote those apps that are most likely to bring health benefits. Only three apps in our review were approved by the NHS Health Apps Library, which is intended to provide this function for consumers in the United Kingdom. Whilst this may be because other apps were reviewed and not approved it is possible that the Library in its current form does not present the full range of apps available to the public. The NHS library is currently updating review processes aiming to provide an accredited set of apps, which have been endorsed and given a service quality certification mark by The British Standards Institution (Kitemark) through NHS Choices[52].

The majority of apps that we identified focussed on exercise and fitness. There were very few gamified apps targeting health behaviours more directly relevant to clinical outcomes, highlighting a potential gap in the market and possible untapped resource for health promotion. It is possible that the task of encouraging exercise and fitness lends itself more easily to gamification and that application of gamification to other aspects of health promotion will be more challenging. However, another explanation may be that health and fitness apps are simply more popular since we searched only the top rated apps in the most popular stores. In the latter case, the challenge will be to make apps and smartphone games that are as appealing to users as those promoting exercise and fitness.

Unanswered questions and future research

This review provides evidence to inform further research in the growing field of gamification in healthcare apps and to determine optimum use of behaviour change constructs in smartphone games. The relationship between the behaviour change technique content of an intervention and the resulting health behaviour change is not simple[24, 34, 35]. More techniques are not necessarily better and further work is needed on the specific combinations of techniques likely to be effective in smartphone games.

There may be potential for more effective apps to be developed drawing from the full repertoire of techniques and combinations of techniques, which are appropriate to this platform. This development will require multidisciplinary collaboration between game developers, behaviour change experts and public health specialists.

Further research and clinical evaluation is urgently needed for health care apps to assess their effectiveness in modifying health behaviour and the clinical consequences of these behaviour changes. None of the apps in our review has been evaluated in randomised controlled trials to quantify potential benefit and harms that may arise from use of this technology. There is a need for regulation of health care apps and strengthened approval mechanisms to ensure patients have access to effective and safe interventions. The British Standards Institution has formulated and published a code of practice for health and wellness apps, providing app developers with quality criteria to consider during the development process[53]. We suggest that this code should be widely adopted and could lead to better quality and more effective products.

The economics of production and scale of delivery could potentially give smartphone apps an advantage over other health promotion interventions. Similar methods of assessing cost effectiveness could be used as for other health technologies (<https://www.nice.org.uk/about/what-we-do/our-programmes/nice-guidance/nice-medical-technologies-guidance>).

CONCLUSIONS

We provide an overview of the use of behaviour change techniques in the rapidly developing area of smartphone games, aiming to provide insights to inform more effective development of applications to change health-related behaviours. We suggest that strengthening collaboration between app developers, behavioural scientists and public health practitioners is necessary to realise the full health benefits of this new technology, which could be substantial. The benefits and harms arising should be evaluated using standard methods to enable consumers to make appropriate choices and allow health systems to make decisions about reimbursement.

CONTRIBUTORSHIP STATEMENT

EAE, JL, CR, LS, ST, RTW were involved in conception and design of the review. EAE searched app databases and EAE and JL extracted data and coded behaviour change techniques. EAE, JL, CR, LAE, AT and RS analysed data. EAE, JL, CR, LS, RS, ST, RTW and HC were involved in interpretation of the results. EAE and RTW drafted the manuscript, and CR, LS, ST, CG, MRM and HC revised it critically for intellectual content. All authors approved the final version of the article. All authors had access to all study data and take responsibility for data integrity and accuracy of the analysis. RTW is the guarantor.

COMPETING INTERESTS

HC is a smartphone game developer and director of Healthy Games.

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DATA SHARING STATEMENT

Additional data for this article has been provided as supplementary. There is no additional unpublished data.

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Table 1: Inclusion and exclusion criteria

Inclusion and exclusion criteria that were established for the initial search of the official Apple, Android app stores and NHS Health apps library aiming to identify all 'top-rated' smartphone apps incorporating gaming elements, which were marketed to the general public.

Table 2: Behaviour change technique categories included in apps

Number and percentage of apps to use the 16 Behaviour change techniques as derived from a standard taxonomy of behaviour change techniques used in health behaviour change research[19].

Table 3: Common combinations of behaviour change techniques

Number and percentage of apps to use commonly identified combinations of behaviour change techniques.

Figure 1: Flowchart of the app selection process

Flowchart of the app selection process including total number of apps screened, number of apps that met inclusion criteria, number of apps that were included in the review and total number of apps that were excluded.

Figure 2: Number of apps with individual behaviour change technique

Number of apps to use the individual 93 Behaviour change techniques as derived from a standard taxonomy of behaviour change techniques used in health behaviour change research[7].

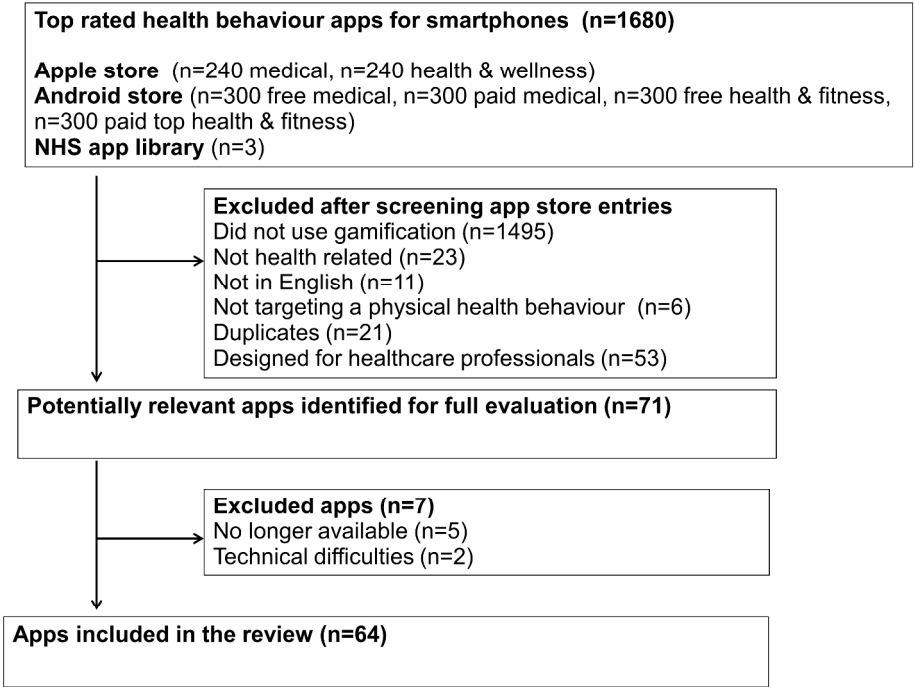


Figure 1: Flowchart of the app selection process
Flowchart of the app selection process including total number of apps screened, number of apps that met inclusion criteria, number of apps that were included in the review and total number of apps that were excluded.

Figure 1
279x209mm (300 x 300 DPI)

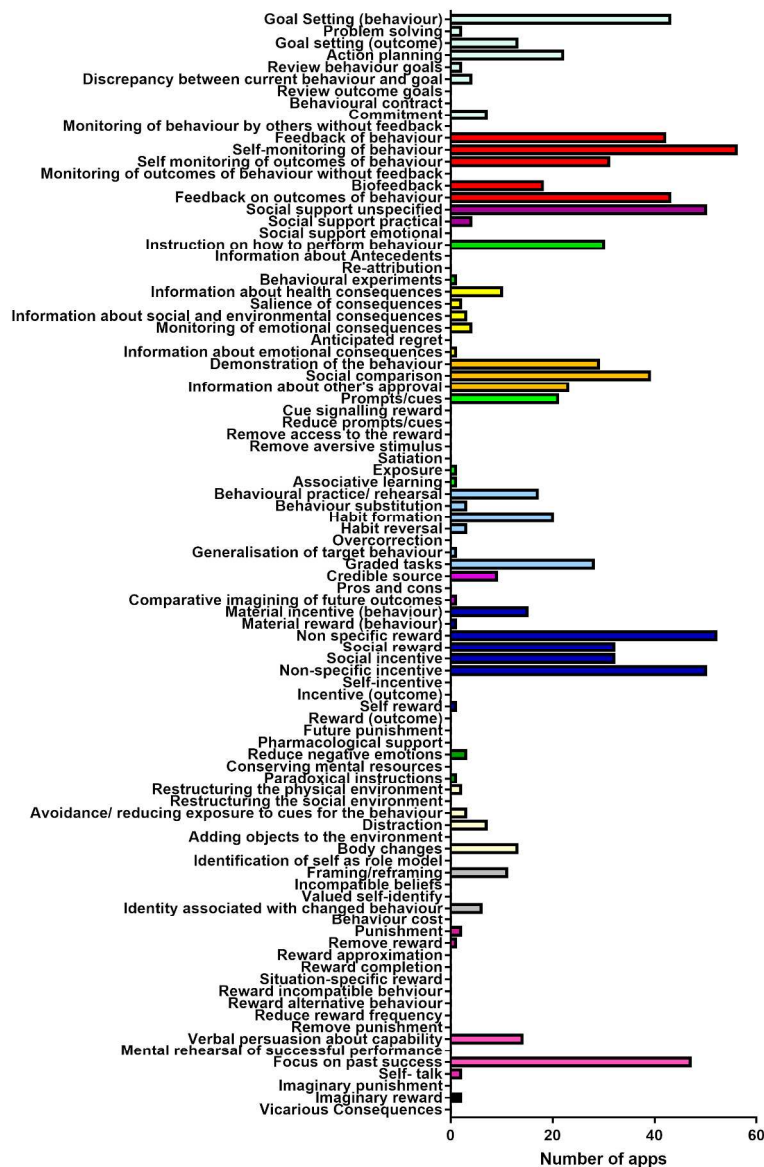
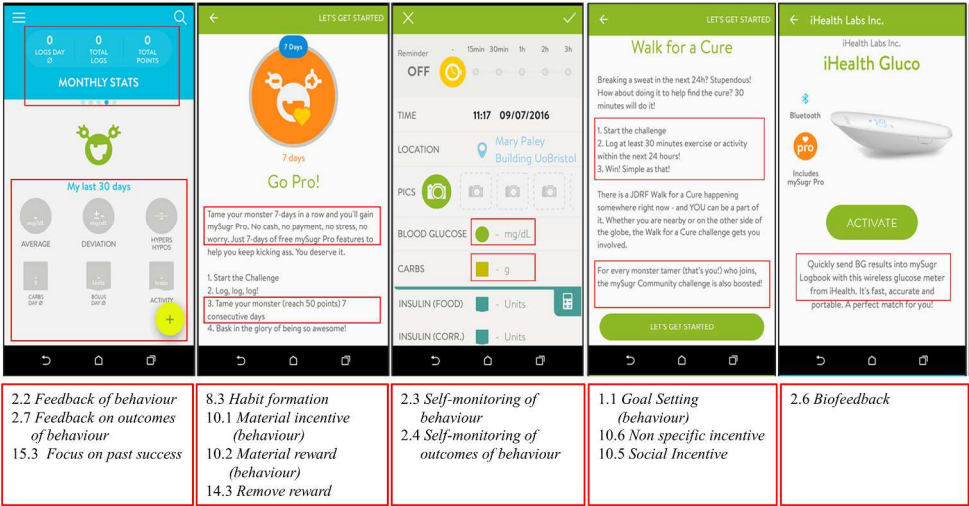


Figure 2: Number of apps with individual behaviour change technique

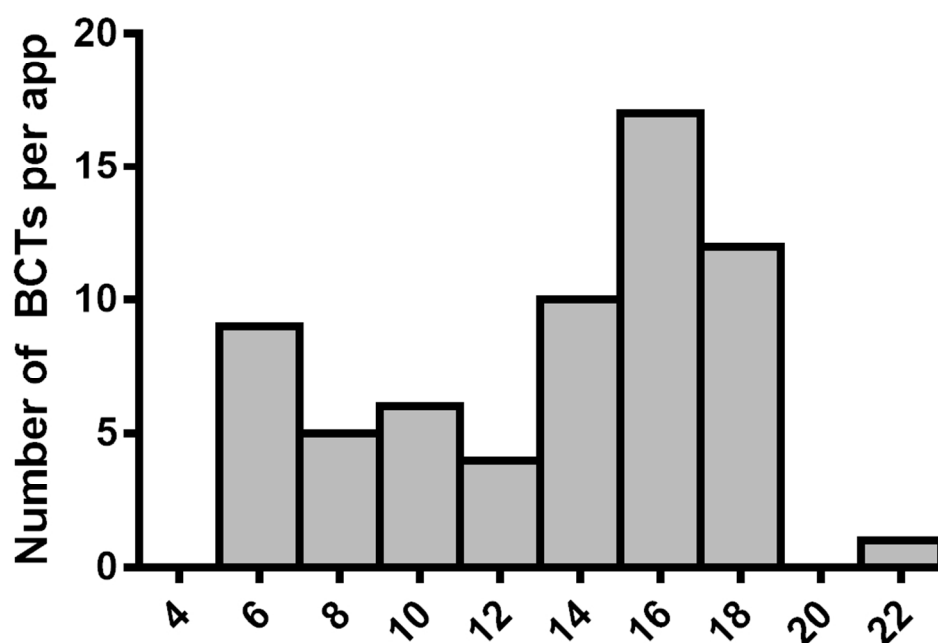
Number of apps to use the individual 93 Behaviour change techniques as derived from a standard taxonomy of behaviour change techniques used in health behaviour change research[19].

Figure 2
197x298mm (300 x 300 DPI)



Supplementary Figure 1: Example of app content coding with individual behaviour change techniques An example of behaviour change technique coding using the standard 93 category taxonomy[7]. Screen-shots of the 'Diabetes Companion' by mySugr[52] are shown with examples of behaviour change techniques highlighted. Of note, some screen shots may have multiple behaviour change techniques, which have not been highlighted but would have been coded accordingly.

Supplementary Figure 1
275x190mm (300 x 300 DPI)



Supplementary Figure 2: Number of behaviour change techniques per app Histogram of the number of behaviour change techniques included per app.

Supplementary Figure 2
95x70mm (300 x 300 DPI)

Supplementary Table 1: Characteristics of included apps

Name of App	Category	Source	Targeted behaviour	Cost	User ratings	Number of BCTs
My Diet Coach – Pro	Health & Wellness	Android	Weight loss	£1.99	4	22
Nike+ Running	Health & Fitness	Apple iPhone	Exercise	£0.0	4	18
Speedo Fit	Health & Fitness	Apple iPhone	Exercise	£0.0	3	18
Runtastic Sit Ups Trainer PRO	Health & Fitness	Apple iPhone	Exercise	£1.49	4	18
Runtastic Squats Trainer	Health & Fitness	Apple iPhone	Exercise	£0.0	4	18
Diabetes Companion by mySugr	Medical	Apple iPhone	Blood sugar monitoring adherence	£0.0	5	18
Runtastic Squats PRO	Health & Wellness	Android	Exercise	£1.91	4	18
Runtastic Pull-Ups PRO	Health & Wellness	Android	Exercise	£1.73	4	18
Runtastic Sit-Ups	Health & Wellness	Android	Exercise	£0.0	4	18
Runtastic Push-Ups	Health & Wellness	Android	Exercise	£0.0	4	18
Fitocracy	Health & Fitness	Apple iPhone	Fitness	£0.0	5	17
UP	Health & Fitness	Apple iPhone	Fitness	£0.0	2	17
RunKeeper - GPS Track Run Walk	Health & Wellness	Android	Exercise	£0.0	4	17
Run with Map My Run	Health & Fitness	Apple iPhone	Exercise	£0.0	5	16
Map My Ride+ GPS Cycling Riding	Health & Fitness	Apple iPhone	Exercise	£1.99	4	16
Map My Ride - GPS Cycling, Riding, Mountain Biking, and Workout Tracking	Health & Fitness	Apple iPhone	Exercise	£0.0	4	16
Map My Fitness	Health & Fitness	Apple iPhone	Fitness	£0.0	4	16
Adrian James 6 Pack Abs Workout Lite	Health & Fitness	Apple iPhone	Exercise	£0.0	5	16
Run with Map My Run+	Health & Fitness	Apple iPhone	Exercise	£1.99	4	16
Zombies, Run!	Health & Fitness	Apple iPhone	Exercise	£2.49	4	16
Map My Walk+ GPS Pedometer	Health & Wellness	Android	Exercise	£1.91	4	16
Map My Run+ GPS Running	Health & Wellness	Android	Exercise	£1.99	4	16
Map My Fitness+ Workout Trainer	Health & Wellness	Android	Exercise	£0.69	4	16

Map My Hike+ GPS Hiking	Health & Wellness	Android	Exercise	£0.77	4	16
Quit-Smoking Coach	Health & Wellness	Android	Smoking Cessation	£2.90	4	16
STOP Cigarettes PRO Quit Smoking	Health & Wellness	Android	Smoking Cessation	£1.86	4	16
Map My Walk GPS Walking	Health & Wellness	Android	Exercise	£0.0	4	16
Map My Run GPS Running	Health & Wellness	Android	Exercise	£0.0	4	16
Endomondo Sports Tracker	Health & Fitness	Apple iPhone	Exercise	£0.0	3	15
Nike+ FuelBand	Health & Fitness	Apple iPhone	Exercise	£0.0	4	15
Strava Cycling	Health & Fitness	Apple iPhone	Exercise	£0.0	5	14
5K runner free	Health & Fitness	Apple iPhone	Exercise	£0.0	4	14
Strava Run	Health & Fitness	Apple iPhone	Exercise	£0.0	5	14
5K Runner paid	Health & Fitness	Apple iPhone	Exercise	£1.99	5	14
Zombies, Run! 5k Training Zombies	Health & Fitness	Apple iPhone	Exercise	£1.49	4	14
Freeletics	Health & Wellness	Android	Fitness	£1.99	4	14
Fitbit	Health & Fitness	Apple iPhone	Fitness	£0.0	4	13
JEFIT Pro - Workout & Fitness	Health & Wellness	Android	Exercise	£2.99	4	13
Virtuagym Fitness Home & Gym	Health & Wellness	Android	Exercise	£0.0	4	13
100% Army Fit	Health & Wellness	Android	Fitness	£0.0	4	13
Karrimor Elite	Health & Wellness	Android	Exercise	£0.0	4	12
7 Minute Workout "Seven" with High Intensity Interval Training Challenge	Health & Fitness	Apple iPhone	Exercise	£0.0	4	11
Change For Life- Smart Restart	Health & Fitness	Apple iPhone	Fitness	£0.0	4	11
Total Fitness - Gym & Workouts	Health & Wellness	Android	Exercise	£0.0	4	11
Aquafresh Brush Time	Health & Fitness	Apple iPhone	Tooth brushing	£0.0	3	10
Adidas Snapshot	Health & Fitness	Apple iPhone	Exercise	£0.0	4	10
Stop Smoking Pro	Health & Wellness	Android	Smoking cessation	£1.99	4	10
RunTroll	Health & Wellness	Android	Exercise	£0.0	4	10
Steps Mania Pro	Health & Wellness	Android	Exercise	£0.62	4	9

Stop Smoking	Health & Wellness	Android	Smoking cessation	£0.0	4	9
MyFit Fitness	Health & Fitness	Apple iPhone	Fitness	£0.0	3	8
The Spartan 300 Workout	Health & Wellness	Android	Exercise	£3.10	4	8
Disney Magic Timer by Oral-B	Health & Wellness	Android	Tooth brushing	£0.0	3	7
Runtastic Road Bike	Health & Wellness	Android	Exercise	£0.0	4	7
Plank Challenge	Health & Wellness	Android	Exercise	£0.0	4	7
Runmeter GPS Pedometer	Health & Fitness	Apple iPhone	Exercise	£0.0	5	6
Cyclemeter GPS	Health & Fitness	Apple iPhone	Exercise	£0.0	5	6
Walkmeter GPS Pedometer	Health & Fitness	Apple iPhone	Exercise	£0.0	4	6
Gorilla Workout: Strength Plan	Health & Wellness	Android	Exercise	£0.62	4	6
Fitness Flow	Health & Wellness	Android	Fitness	£2.75	4	6
AllSport GPS PRO	Health & Wellness	Android	Exercise	£3.10	4	6
Fitness Flow FREE	Health & Wellness	Android	Adult Fitness	£0.0	4	6
Change4Life fun generator	Health & Fitness	Apple iPhone	Fitness	£0.0	3	5
Runtastic Pedometer	Health & Wellness	Android	Exercise	£0.0	4	5

Supplementary Table 1: Characteristics of included apps

Characteristics of apps meeting the inclusion criteria including: name of app, given category in the app store, source of app identified as either being from the Apple or Android store, targeted behaviour, cost of the app in sterling, user ratings as defined by either Apple or Android stores and number of individual behaviour change techniques included.

Supplementary Figure 1: Example of app content coding with individual behaviour change techniques

An example of behaviour change technique coding using the standard 93 category taxonomy[7]. Screen-shots of the 'Diabetes Companion' by mySugr[52] are shown with examples of behaviour change techniques highlighted. Of note, some screen shots may have multiple behaviour change techniques, which have not been highlighted but would have been coded accordingly.

Supplementary Figure 2: Number of behaviour change techniques per app

Histogram of the number of behaviour change techniques included per app.

PROSPERO International prospective register of systematic reviews

‘Gamification’ for health behaviour change in smartphone apps: systematic review of behaviour change techniques

Elizabeth Edwards, Jim Lumsden, Carol Rivas, Liz Steed, Lindsey Edwards, Arun Rajan, Ratna Sohanpal, Hope Caton, Steph Taylor, Robert Walton

Citation

Elizabeth Edwards, Jim Lumsden, Carol Rivas, Liz Steed, Lindsey Edwards, Arun Rajan, Ratna Sohanpal, Hope Caton, Steph Taylor, Robert Walton. ‘Gamification’ for health behaviour change in smartphone apps: systematic review of behaviour change techniques. PROSPERO 2015:CRD42015029841 Available from http://www.crd.york.ac.uk/PROSPERO_REBRANDING/display_record.asp?ID=CRD42015029841

Review question(s)

What proportion of Health Care apps on the official Apple and Android stores use gamification to modify health behaviour?

What behaviour change techniques and combinations of techniques are used?

Is there an association between behaviour change techniques and combinations of techniques with NHS library ratings, user ratings and price?

Searches

We aim to identify all English language health apps using gamification and available on the official Apple and Android app stores that are ‘top rated’, defined by Apple and Google Play stores (<https://play.google.com/store>)(<https://itunes.apple.com>).

The following search terms will be used: rewards, prizes, avatar use, badges, leaderboards, competitions, health-related challenges. All apps meeting the inclusion criteria will be recorded in a standardized structured form.

Types of study to be included

Not applicable

Condition or domain being studied

We plan to review all apps that aim to modify any health behaviour.

Participants/ population

Inclusion criteria:

English language apps

Apps that use the following gamification techniques: rewards, prizes, avatar use, badges, leader boards, competitions, health-related challenges

Apps available through google play and I Tunes

Smart phone app

Apps in the Medical, Health & Wellness or Health & Fitness section

Apps targeted at users of any age

Free and paid apps

Exclusion criteria:

Apps designed for tablets

Non- English language apps

Non-health related apps

Apps that do not contain gamification techniques

Apps designed for Health Care professionals

Intervention(s), exposure(s)

The identified apps will be screened independently by two review authors (EE, JL) trained in coding behaviour change techniques. Coding will be carried out independently by the two reviewers who will then cross-check for discrepancies. Responses from each review author will be recorded independently in a standardized structured form.

App content will be assessed against criteria derived from a behaviour change taxonomy used in health behaviour change intervention established by Michie et.al [1]. The taxonomy consists of 16 categories and 93 individual techniques. The number of individual techniques included in each app will be counted (range 0-93). The use of behaviour change categories, individual techniques and combinations of techniques will be examined. Associations with NHS library ratings, user ratings and price will also be explored.

References:

1. Michie, S., et al., The behavior change technique taxonomy (v1) of 93 hierarchically clustered techniques: building an international consensus for the reporting of behavior change interventions. *Ann Behav Med*, 2013. 46(1): p. 81-95.

Comparator(s)/ control

Not applicable

Outcome(s)

Primary outcomes

The number of Health Care apps to incorporate gamification:

We will assess the proportion of apps in the official Apple and Google Play stores and NHS health apps library to incorporate gamification in order to modify health behaviour. A systematic search of the top rated free and paid Medical, Health & Wellness, Health & Fitness apps will be conducted.

The use of behaviour change techniques and combination of Behaviour change technique:

The number of individual techniques included in each app will be counted (range 0-93). The mean number, median value and the range will also be calculated. We will investigate what behaviour change categories, individual techniques and combinations of techniques are used.

The association of behavior change technique use with downloads, user ratings, price and NHS library ratings:

We will explore associations between number of individual behaviour change technique and combination of behaviour change techniques with downloads, user ratings, price and NHS library ratings. Customer ratings will be obtained from the Apple store and Google Play. The total rating for all versions of the app will be used. The price will be recorded as free or paid. The exact price of each app will also be recorded.

As above, under each Primary outcome

Secondary outcomes

Not applicable

Data extraction, (selection and coding)

The initial systematic review of top rated Medical, Health & Wellness, Health & Fitness apps on the official Apple and Google Play stores and NHS health apps library will be conducted by one review author (EE). Assessments against eligibility criteria will be recorded on a standardized structured form.

Medical, Health & Wellness or Health & Fitness apps meeting inclusion criteria will be downloaded on to a test device. The same test device will be used throughout the evaluation. Test devices will be unmodified consumer-grade smartphones running up-to-date versions of their mobile operating system. The same version of each app will be used throughout testing.

The identified apps will then be screened independently by two review authors (EE, JL) trained in BCT coding. Any discrepancies will be discussed with a third review author (LS). Responses from each review author will be recorded independently in a second standardized structured form.

Extracted information will include: version, date of first release, date of latest update, publisher, description of the app, main function of the app, target user, special features incorporated, number of downloads in the Android store, number in the chart in the Apple store. Missing data will be requested from the author/publisher or the app or Apple/Android store.

Risk of bias (quality) assessment

Not Applicable

Strategy for data synthesis

A quantitative synthesis of the number of apps to contain gamification will be conducted including all apps that meet the inclusion criteria and that are identified in the review. Basic descriptive statistics will be calculated. Apps found in both the Apple store and Google Play store will not be included twice and will be recorded only in the Apple iPhone data. The number of Behaviour change technique and combination of Behaviour change technique will be compared to user ratings, price and NHS library ratings. Apps that do not have customer ratings available will not be included in this analysis. Statistical significance of the association between the number of behaviour change techniques and the combination of behaviour change techniques with user ratings, price and NHS library ratings will be determined by linear regression or Spearman's Rank Correlation Coefficient as appropriate. This will be calculated using GraphPad Prism 6.

Analysis of subgroups or subsets

None Planned

Dissemination plans

The results of this research will be disseminated in a number of ways to all stakeholders. Professional groups both in the Academic/Clinical setting and Technologists will be informed through presentation at local, National and International conferences/meetings. Results of the review will be published in highly cited and open access peer reviewed journals. Relevant public health, NHS and other healthcare organisations including policy and decision makers will be informed of the results of the research. This will be at both local and national meetings.

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Anticipated or actual start date

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Anticipated completion date

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Conflicts of interest

None known

Language

English

Country

England

Subject index terms status

Subject indexing assigned by CRD

Subject index terms

Behavior Therapy; Health Behavior; Humans; Smartphone

Stage of review

Ongoing

Date of registration in PROSPERO

02 December 2015

Date of publication of this revision

02 December 2015

Stage of review at time of this submission

Started

Completed

Preliminary searches

No

Yes

Piloting of the study selection process

No

Yes

Formal screening of search results against eligibility criteria

No

Yes

Data extraction

No

No

Risk of bias (quality) assessment

No

No

Data analysis

No

No

PROSPERO

International prospective register of systematic reviews

The information in this record has been provided by the named contact for this review. CRD has accepted this information in good faith and registered the review in PROSPERO. CRD bears no responsibility or liability for the content of this registration record, any associated files or external websites.



PRISMA 2009 Checklist

Section/topic	#	Checklist item	Reported on page #
TITLE			
Title	1	Identify the report as a systematic review, meta-analysis, or both.	1
ABSTRACT			
Structured summary	2	Provide a structured summary including, as applicable: background; objectives; data sources; study eligibility criteria, participants, and interventions; study appraisal and synthesis methods; results; limitations; conclusions and implications of key findings; systematic review registration number.	2
INTRODUCTION			
Rationale	3	Describe the rationale for the review in the context of what is already known.	4-5
Objectives	4	Provide an explicit statement of questions being addressed with reference to participants, interventions, comparisons, outcomes, and study design (PICOS).	5-6
METHODS			
Protocol and registration	5	Indicate if a review protocol exists, if and where it can be accessed (e.g., Web address), and, if available, provide registration information including registration number.	6
Eligibility criteria	6	Specify study characteristics (e.g., PICOS, length of follow-up) and report characteristics (e.g., years considered, language, publication status) used as criteria for eligibility, giving rationale.	6-7
Information sources	7	Describe all information sources (e.g., databases with dates of coverage, contact with study authors to identify additional studies) in the search and date last searched.	6
Search	8	Present full electronic search strategy for at least one database, including any limits used, such that it could be repeated.	6
Study selection	9	State the process for selecting studies (i.e., screening, eligibility, included in systematic review, and, if applicable, included in the meta-analysis).	6
Data collection process	10	Describe method of data extraction from reports (e.g., piloted forms, independently, in duplicate) and any processes for obtaining and confirming data from investigators.	6-7
Data items	11	List and define all variables for which data were sought (e.g., PICOS, funding sources) and any assumptions and simplifications made.	6-7
Risk of bias in individual studies	12	Describe methods used for assessing risk of bias of individual studies (including specification of whether this was done at the study or outcome level), and how this information is to be used in any data synthesis.	N/A
Summary measures	13	State the principal summary measures (e.g., risk ratio, difference in means).	8
Synthesis of results	14	Describe the methods of handling data and combining results of studies, if done, including measures of consistency (e.g., I^2 for each meta-analysis).	N/A

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PRISMA 2009 Checklist

Page 1 of 2

Section/topic	#	Checklist item	Reported on page #
Risk of bias across studies	15	Specify any assessment of risk of bias that may affect the cumulative evidence (e.g., publication bias, selective reporting within studies).	N/A
Additional analyses	16	Describe methods of additional analyses (e.g., sensitivity or subgroup analyses, meta-regression), if done, indicating which were pre-specified.	N/A
RESULTS			
Study selection	17	Give numbers of studies screened, assessed for eligibility, and included in the review, with reasons for exclusions at each stage, ideally with a flow diagram.	9
Study characteristics	18	For each study, present characteristics for which data were extracted (e.g., study size, PICOS, follow-up period) and provide the citations.	Supplementary table 1
Risk of bias within studies	19	Present data on risk of bias of each study and, if available, any outcome level assessment (see item 12).	N/A
Results of individual studies	20	For all outcomes considered (benefits or harms), present, for each study: (a) simple summary data for each intervention group (b) effect estimates and confidence intervals, ideally with a forest plot.	9-11
Synthesis of results	21	Present results of each meta-analysis done, including confidence intervals and measures of consistency.	N/A
Risk of bias across studies	22	Present results of any assessment of risk of bias across studies (see Item 15).	N/A
Additional analysis	23	Give results of additional analyses, if done (e.g., sensitivity or subgroup analyses, meta-regression [see Item 16]).	N/A
DISCUSSION			
Summary of evidence	24	Summarize the main findings including the strength of evidence for each main outcome; consider their relevance to key groups (e.g., healthcare providers, users, and policy makers).	12-17
Limitations	25	Discuss limitations at study and outcome level (e.g., risk of bias), and ators)bi□□:□t (e.e□□-□i□7□-□i□7□c□J□v□□□□on□□□IT□□e7□J	