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REVIEW PAPER

# *Positive psychology mobile applications for increasing happiness and wellbeing – A systematic app store review. R U appy?*

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## Abstract

**Background:** The science of positive psychology has produced evidence for many interventions that increase happiness and wellbeing, and reduce anxiety and depression. Thousands of smartphone apps now also purport to do this, but little is known about how many publicly available apps use a positive psychology theoretical framework. For those that cite positive psychology, it is unknown how many have scientific evidence of efficacy.

**Objectives:** To estimate what proportion of publicly available apps that claim to offer a comprehensive therapeutic treatment for increasing happiness and/or wellbeing, or reducing anxiety and/or depression, use a positive psychology framework, and to determine what percentage of these have published evidence.

**Methods:** The two major app stores (Apple App Store and Google Play) were systematically searched by four different researchers. Inclusion criteria included: the app store description had to be in English; the description had to mention positive psychology as an influence; and the description had to demonstrate that the app used a comprehensive, therapeutic treatment approach towards increasing happiness and/or wellbeing, or reducing anxiety and/or depression.

**Results:** Approximately 14.72% (34/231) of apps that offer a comprehensive therapeutic treatment for increasing happiness and/or wellbeing, or reducing anxiety and/or depression, claim to use a positive psychology framework. Of these, 8.82% (3/34) have published evidence for their efficacy.

**Conclusions:** Future research must consider alternative methodologies for examining the efficacy and effectiveness of apps in order to bolster existing research, and this offers the positive psychology scientific community the opportunity to become a leader in developing these tools.

**Keywords:** apps; app store; happiness; wellbeing; smartphone; positive psychology.

## Abstrait

**Contexte:** La science de la psychologie positive a produit des preuves pour de nombreuses interventions qui augmentent le bonheur et le bien-être et réduisent l'anxiété et la dépression. Des milliers d'applications pour smartphone prétendent désormais le faire, mais on sait peu de choses sur le nombre d'applications accessibles au public utilisant un cadre théorique de psychologie positive. Pour ceux qui citent la psychologie positive, on ne sait pas combien ont des preuves scientifiques d'efficacité.

**Objectifs:** Estimer la proportion d'applications accessibles au public prétendant offrir un traitement thérapeutique complet pour augmenter le bonheur et / ou le bien-être, ou réduire l'anxiété et / ou la dépression, qui utilisent un cadre de psychologie positive et déterminer quel pourcentage d'entre elles ont publié des preuves.

**Méthodes:** Les deux principaux magasins d'applications (Apple App Store et Google Play) ont été systématiquement recherchés par quatre chercheurs différents. Les critères d'inclusion comprenaient: la description de l'App Store devait être en anglais; la description devait mentionner la psychologie positive comme influence; et la description devait démontrer que l'application utilisait une approche thérapeutique globale pour augmenter le bonheur et / ou le bien-être, ou réduire l'anxiété et / ou la dépression.

**Résultats:** Environ 14,72% (34/231) des applications qui offrent un traitement thérapeutique complet pour augmenter le bonheur et / ou le bien-être, ou réduire l'anxiété et / ou la dépression, affirment utiliser un cadre de psychologie positive. Parmi ceux-ci, 8,82% (3/34) ont publié des preuves de leur efficacité.

**Conclusions:** Les recherches futures doivent envisager des méthodologies alternatives pour examiner l'efficacité des applications afin de renforcer la recherche existante, ce qui offre à la communauté scientifique de la psychologie positive l'opportunité de devenir un leader dans le développement de ces outils.

**Mots-clés:** applications; magasin d'applications; bonheur; bien-être; téléphone intelligent; smartphone; psychologie positive.

Mobile mental health applications (apps) are being developed rapidly on a worldwide scale. Governments are uncertain about how to regulate them (Armontrout, Torous, Cohen, McNeil, & Binder, 2018; Marshall, Dunstan, & Bartik, 2019; Wang, Varma, & Prosperi, 2018), clinicians are reluctant to recommend them (Hendrikoff et al., 2019; Neary & Schueller, 2018), and researchers struggle to implement large scale randomised controlled trials (RCTs) that provide evidence for their efficacy. Being a relatively new science, positive psychology has developed interventions in association with new digital technologies that are being utilised by mental health services. Evidence and commentary for the use of e-mental health programs using positive psychology frameworks to increase happiness and/or wellbeing, and reduce anxiety and/or depression, have been reported in the literature (Drozd, Mork, Nielsen, Raeder, & Bjorkli, 2014; Manicavasagar et al., 2014; Parks, 2014). However, little is known about how positive psychology frameworks are being used in mobile apps, and whether there is evidence that apps specifically using a positive psychology framework have proven efficacy or effectiveness. No previous review that focused solely on the availability of positive psychology apps could be located in the literature.

In two meta-analyses, Firth and colleagues found 22 mental health apps for reducing symptoms of anxiety and/or depression that had published evidence for their efficacy across 20 studies (Firth, Torous, Nicholas, Carney, Pratap, et al., 2017; Firth, Torous, Nicholas, Carney, Rosenbaum, et al., 2017). The 22 apps represent only 0.2% of the estimated 10,000 mental health apps currently available (Torous et al., 2018). These meta-analyses highlighted limitations of the research and the availability of apps with evidence, including: considerable heterogeneity amongst the limited available studies; lack of cohesion in methodologies; and, many of the researched apps were not publicly available. Four apps (18%) in these meta-analyses incorporated positive psychology interventions, with only two of these being publicly available. What is not known is the extent to which having a positive psychology theoretical framework influences the efficacy of an app, and what proportion of publicly available mental health apps use positive psychology-inspired interventions to underpin their claims. Furthermore, many apps have been developed that simply utilise a single positive psychology intervention, rather than offering a suite of interventions that constitute a comprehensive positive psychotherapeutic treatment (Rashid, 2015).

The present study systematically searched the major app stores to identify and examine apps that claimed to utilise a positive psychology framework to offer a therapeutic treatment for increasing happiness and/or wellbeing, or decreasing anxiety and/or depression. We sought explicit reference to the term *positive psychology* as evidence of the consideration of the science and evidence-base of positive psychology in the development of the app. We recognise that there may be apps that use a positive psychology approach and do not necessarily specify this in their app store description. To support our stance, only apps offering more than one positive psychology intervention were sought because there is evidence to suggest that people who pursue happiness tend to practice a variety of techniques simultaneously (Parks, Della Porta, Pierce, Zilca, & Lyubomirsky, 2012).

The research questions were:

*1. What proportion of publicly available apps for increasing happiness and/or wellbeing, or reducing anxiety and/or depression, use a positive psychology framework as part of a comprehensive therapeutic approach?*

*2. What proportion of these apps have evidence for their efficacy?*

## METHOD

This systematic review was shaped by the PRISMA protocol (Moher, Liberati, Tetzlaff, Altman, & The PRISMA Group, 2009) which has been produced expressly for literature searches. No such protocol for conducting app store searches and reviews could be located. We therefore adapted the PRISMA checklist into our own app store review protocol (*see Appendix 1, page 9*).

Four researchers, including the lead author, systematically searched the two biggest app stores, the Apple App Store and Google Play. The searches took place in Australia. Any discrepancies in shortlisted apps were discussed and resolved via consensus. The initial search was carried out in December 2018, and the lead researcher (JM) searched again in September 2019 to ensure recently developed apps were included for review, of which five were located. Searches in each marketplace were made with the terms: positive psychology, happiness, wellbeing, anxiety, depression. The rationale for the methodology is that the researchers wanted to mimic the way a consumer would locate a positive psychology app.

Apps that were available in both app stores were counted once. Apps that claimed to use more than one evidence-based technique, such as positive psychology *and* cognitive-behavioural therapy, were included. App store descriptions were used to create the shortlist. Inclusion criteria were:


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*1. The store description is in English;*
*2. The description specifies that positive psychology is used to inform its approach; and*
*3. The description offers a comprehensive therapeutic treatment for increasing happiness and/or wellbeing, or decreasing anxiety and/or depression, not just a single intervention or narrowly defined skill (such as hypnosis, or deep breathing etc.), or symptom recording, thought journal, or diagnostic tool (although apps could have any of these tools as part of offering a therapeutic treatment).*

## RESULTS

Using the key terms in five systematic searches of both app marketplaces, a list of 231 apps was produced. Of these, 34 (14.72%) apps claimed to offer positive psychology-informed interventions. Amongst the 34 shortlisted apps, the most popular positive psychology interventions used were: gratitude journal; acts of kindness; mindfulness; building resilience; and developing character strengths, social connections, and flow experiences.

Of the 34 positive psychology apps, three (8.82%) had published peer-reviewed evidence for their efficacy: *MoodHacker*, *Happify*, and *SuperBetter*. These are available on both Android and iOS platforms and all three have a positive, as opposed to negative, focus in their treatment approaches. *MoodHacker* is only available to registered users through participating health plans and corporations. *Happify* is free to download a basic version, but requires a subscription in order to access the full version. *SuperBetter* is free to download, but has different versions that require a fee.

The three studies were RCTs and contained a total of 623 participants in the intervention conditions, and 747 participants in the control conditions. See Tables 1 and 2 for a summary of research characteristics. It was decided that a meta-analysis would not produce meaningful data due to only three articles being located. Of the remaining 31 apps, 28 had a positive, as opposed to a negative, focus (90.3%), and only one (*Strong Minds*) was aimed specifically at children (see Table 3 for more details on the 34 shortlisted apps).

## DISCUSSION

This study located 231 apps claiming to offer a therapeutic treatment for increasing happiness and/or wellbeing, or reducing symptoms of anxiety and/or depression. Positive psychology was mentioned in the description of 34 (14.72%) of these apps. Given the rise in applying positive psychology interventions in clinical practice (Rashid, 2009) and the increased teaching of positive psychology in academia (PositivePsychology.com, 2019), together with its current popularity in mainstream media and society (Donaldson, 2011), this appears to be a low percentage. Only three (8.82%) of these 34 apps had published evidence. This is surprising given that positive psychology has grounded itself in, and placed great emphasis on, the importance of scientific research (Kim, Doiron, Warren, & Donaldson, 2018).

The three peer-reviewed RCTs providing evidence of efficacy were scrutinised for quality. No long-term follow-up was reported in any study. Intervention periods differed from six to ten weeks, and no single measure was used across all three studies. All studies were scientifically sound, but heterogeneity and the small number prevented meaningful meta-analysis. Most of the 34 positive psychology apps mentioned "evidence-based" or "clinically proven" techniques. It is desirable that mental health apps employ evidence-based techniques, but a lack of knowledge about the mechanism of action of mental health apps prohibits the conclusion that face-to-face interventions with efficacy will also be efficacious if delivered digitally.

There are some limitations to this study. Firstly, by using a consumer experience approach, the search capabilities of the app stores are restricted by narrow search options that are inferior to the sophisticated search options of journal databases. Search results are determined by each store's internally developed algorithms, which remain corporate intellectual property, and this leads to results that can also differ from country to country. Secondly, as a literature search was not carried out, there may be other positive psychology apps with research evidence that were not found in the app store search. As noted previously, there are many mental health apps that have been developed and researched by academic institutions, but are not publicly available (Torous, Levin, Ahern, & Oser, 2017). Finally, the shortlist of 34 apps was determined by the contents of each app's description, not by using the app itself. There may be other available apps that are unknowingly using positive psychology interventions, or making a deliberate decision not to use the term "positive psychology". Such apps would not have been captured by this review because of the requirement to explicitly reference "positive psychology".

There are many potential future directions in research on positive psychology apps. Firstly, the present review was a snapshot of the scientific influence of positive psychology on


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**Table 1: Journal articles reporting research evidence for the effectiveness of positive psychology apps**

| Article | App name | Type of study | Participants – Intervention group at completion (at start) | Participants – Control group at completion (at start) | Type of control group | Measures used | Intervention period |
|---|---|---|---|---|---|---|---|
| Birney, Gunn, Russell, and Ary (2016) | MoodHacker | RCT | 140 (150) | 145 (150) | Links to depression websites | PHQ-9; BADS; ATQ-R. | 10 weeks |
| Parks et al. (2018) | Happify | RCT | 472 (2275) | 579 (2210) | Psycho-education | PHQ-9; GAD-7; PSS; HS-E; LOT-R. | 8 weeks |
| Roepke et al. (2015) | SuperBetter | RCT | 11 (93) | 23 (93) | Waitlist | CES-D; GAD-7; SWLS; NGSE. | 6 weeks |

Note: PHQ-9 = Patient Health Questionnaire; BADS = Behavioral Activation for Depression Scale; ATQ-R = Automatic Thoughts Questionnaire – Revised; GAD-7 = Generalized Anxiety Disorder Scale; PSS = Perceived Stress Scale; HS-E = Happify Scale – Emotion subscale; LOT-R = Life Orientation Test – Revised; CES-D = Center for Epidemiological Studies - Depression Scale; SWLS = Satisfaction With Life Scale; NGSE = New General Self-Efficacy Scale.

**Table 2 : Statistical summary of journal articles reporting research evidence for the effectiveness of positive psychology apps**

| Article | Outcome variable | Statistic | *p* | Effect size |
|---|---|---|---|---|
| Birney et al. (2016) | Depression for MoodHacker vs control | $f = 6.39$ | .01 | $\eta_p^2 = .021$ |
| Parks et al. (2018) | Depression for Happify recommended usage vs control recommended usage | $t = 3.41$ | < .001 | Cohen's d = 0.50 (Happify recommended dosage); 0.23 (control recommended usage) |
| | Anxiety for Happify recommended usage vs control recommended usage | $t = 2.67$ | .008 | Cohen's d = 0.50 (Happify recommended usage); 0.27 (control recommended usage) |
| | Resilience for Happify recommended usage vs control recommended usage | $t = 3.30$ | < .001 | Cohen's d = 0.54 (Happify recommended usage); 0.32 (control recommended usage) |
| Roepke et al. (2015) | Depression for SuperBetter full version vs control | $t = -2.80$ | .01 | Cohen's d = 0.43 |
| | Anxiety for SuperBetter full version vs control | $t = -2.48$ | .01 | Not provided |
| | Life satisfaction for SuperBetter full version vs control | $t = 3.55$ | < .001 | Not provided |
| | Self-efficacy for SuperBetter full version vs control | $t = 3.59$ | < .001 | Not provided |



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**Table 3: Shortlisted apps referencing positive psychology in their app store descriptions**

| App name | App website | App focus (based on content of website or app store description) | Summary of other attributes (based on content of website or app store description) |
|---|---|---|---|
| Alive | None found | Increase happiness, resilience, success | Activities and tools, including mood tracker |
| Be Intent | https://www.beintent.com/ | Increase resilience, mindfulness, productivity | Gamification, activities and tools |
| Bliss | https://bliss31.com/ | Increase happiness, success, meaning at work | Activities |
| Clear To Thrive | http://www.claritypsych.com/free-mobile-application-app.html | Increase positive emotions, create meaningful relationships and character strengths | Meditations, progressive muscle relaxation exercises, writing exercises |
| Feely | http://feely.se/ | Increase happiness, improve mental health | Mood tracker, activities, psychoeducation |
| Free Happiness | None found | Increase happiness | Activities, mood tracker, journaling |
| Happify | https://www.happify.com/ | Decrease negative thoughts and stress, improve mental health and happiness | Activities, mood tracker |
| HappiMe | http://www.happi-me.org/ | Increase resilience, confidence, and self-esteem, decrease anxiety | Activities, psychoeducation |
| Happy Habits: Choose Happiness | None found | Increase happiness | Activities, assessments, psychoeducation |
| InnerHour Self-Care Therapy* | https://www.theinnerhour.com/ | Decrease anxiety, depression, stress | Activities, mood tracker, goal-setting |
| Live Happy | https://www.livehappy.com/ | Increase happiness, meaning | Interviews with experts, accompanying notes with a wide selection of activities |
| meQuilibrium | https://www.mequilibrium.com/ | Business / corporate, increase productivity, engagement, wellbeing, decrease stress | Activities, assessments, analytical tools |
| Mindfit | https://mindfitapp.com/ | Decrease negative thoughts, improve mental health | Activities, mood tracker |
| Mindfulness With Petit Bambou | https://www.petitbambou.com/ | Create a clear, calm mind | Comprehensive mindfulness meditation exercises |
| MindShaker | None found | Improve positive thoughts | Coaching-style, asks the user questions, activities |
| MoodHacker | https://www.orcasinc.com/products/moodhacker/index.html | Improve mood, decrease negative thinking | Activities, mood tracker |
| Moodnotes | http://moodnotes.thriveport.com | Improve thinking, increase happiness and wellbeing | Thinking exercises, journaling |
| MoodSpace* | https://moodspace.org/ | Decrease stress, anxiety, depression | Activities, journaling, mindfulness meditation |
| My Wellbeing '17 | None found | Increase positivity, wellbeing, resilience | Aimed at university students, activities, mindfulness |
| On A Roll 21 | https://onaroll21.com/ | Increase wellbeing, optimism | Gamification, activities |
| Positive | https://www.positiveonline.org.uk | Improve thinking | Activities, mindfulness, newsfeed of positive articles |
| Positive Mindfulness Coach | https://12weekstowow.co.uk/positive-mindfulness-coach/ | Increase happiness, decrease negative thinking | Activities, designed to be used with a specific diet to lose weight |

* Indicates the app description contained a negative rather than positive focus

*(Continued on page 6)*


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**Table 3: Shortlisted apps referencing positive psychology in their app store descriptions** ***(continued from page 5)***

| | | | |
|---|---|---|---|
| Positive Mindset | None found | Create a positive mindset | Activities |
| Positivity Tracker | No longer available | | |
| Positvt* | http://positvtapp.com/ | Decrease depression | Activities, mood tracker |
| Smylife | http://smylifeapp.com/ | Improve "positiveness", wellbeing; decrease tension, anxiety | Activities, journaling, sharing positive experiences |
| SnapAppy | https://jamesalexanderlee.co.uk/snapappy | Improve wellbeing | Activities recognising positive things |
| Strong Minds | http://www.mindsupports.com/ | Increase positive thinking | Aimed at children, activities, recognise emotions, mindfulness |
| SuperBetter | https://www.superbetter.com/ | Increase resilience, motivation, optimism | Gamification, activities |
| Think Ups | http://www.mentalmint.com/think-ups/ | Increase happiness, focus, wellbeing; decrease stress, anxiety | Gamification, activities, mindfulness |
| Thought Workbench | No longer available | | |
| Uplifter | https://www.uplifter.app/ | Increase happiness, resilience; decrease depression | Activities, journaling, mood tracker |
| Welli | https://www.42yogis.com/wellness/item/embrace-positive-psychology-with-the-welli-app | Improve mental health | Activities, journaling, mindfulness |
| Whil | https://www.whil.com/ | Decrease stress; Increase resilience and mental wellbeing | Corporate – aimed at business, activities, mindfulness |

* Indicates the app description contained a negative rather than positive focus

publicly available apps for increasing happiness and wellbeing using a comprehensive and thorough applied treatment approach. There is therefore a need to take this a step further and review the app stores for apps that use any type of positive psychology intervention that may not necessarily mention this term in their descriptions. Secondly, there is a need to uncover which positive psychology interventions are more efficacious when delivered by an app. Thirdly, clinicians and consumers would benefit from knowing what the personal characteristics are for individuals who gain the most from a positive psychology app. In this respect, research using single-case designs would provide information about such individuals and in a timeframe that meets the speed of technological change in a profit-driven app industry.

## CONCLUSION

This paper is a snapshot of the influence of the theory and science of positive psychology on the development of apps that offer comprehensive treatments for increasing happiness and/or wellbeing, or decreasing symptoms of anxiety and/or depression. Until more research into the efficacy and effectiveness of positive psychology apps occurs, these new digital tools will struggle to gain endorsement by government authorities, clinicians, and, most importantly, consumers. By drawing on its own tradition of being scientifically rigorous, positive psychology could potentially fill the vacuum that currently exists in research on mental health apps as we enter a new age of smartphone psychology and psychotherapy. ■



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# *Appendix 1:* Conducting an App Store Systematic Review

## Adapted from the PRISMA Checklist

## (Moher, Liberati, Tetzlaff, Altman, & The PRISMA Group, 2009)

### TITLE

1. Identify the report as an app store systematic review (and meta-analysis if applicable) in the title.

### ABSTRACT

2. Provide a structured Abstract confirming that the review utilised this protocol, and, as applicable: background, objectives, app store sources, study eligibility criteria, app appraisal and synthesis methods, results, limitations, conclusions and implications of key findings, and systematic review registration number.

### INTRODUCTION

3. In the Introduction, describe the rationale for the app store review in the context of what is already known.

**4.** Provide an explicit statement of questions being addressed with reference to an adapted PICOS model for app store reviews (all of these may not be relevant to every app store review):
a) Population of the group of apps being examined; what do the apps have in common?
b) What type of interventions / activities are being used by the app?
c) What types of comparison apps are being analysed (if appropriate)?
d) What are the stated outcomes of the apps being analysed?
e) What type of systematic, theoretical framework is being used by the app?

### METHODS

5. Indicate if a review protocol has been published or is otherwise publicly accessible, if and where it can be accessed (e.g., Web address), and, if available, provide registration information including registration number.

6. Specify app characteristics; refer to adapted PICOS model for app store reviews again if appropriate; and report other characteristics (e.g., app availability, app cost, app user ratings, app language, app development information) used as criteria for eligibility, giving rationale.

7. Describe all information sources (e.g., app store types with dates of coverage, contact with app developers to identify research [particularly published research in peer-reviewed forums] and confirmation of developers' associations and credentials) in the search, and dates of the search, including start and end dates.

8. Present full electronic search strategy for at least one app store, including any limits used (as far as the app store search options will allow), such that it could be repeated. Note any differences in the search options available between different app stores.

9. State the process for selecting apps (i.e., screening, eligibility, included in systematic review, and, if applicable, included in the meta-analysis). This should state whether apps were reviewed based on their store descriptions, or if apps were individually downloaded and verified through actual use.

10. Describe method of data extraction from apps (e.g., more than one investigator duplicating the process) and any processes for obtaining and confirming data from investigators.

11. List and define all variables for which data were sought (e.g., PICOS, funding sources) and any assumptions and simplifications made.

12. Describe methods used for assessing risk of bias of individual apps (e.g., has the research on efficacy and effectiveness been completed by authors with an association to the app), and how this information is to be used in any data synthesis or critical analysis.

13. State the principal summary measures (if applicable) and descriptive statistics, including the limits of such statistics.


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14. Describe the methods of handling data and combining results of studies, if relevant. If conducting a meta-analysis, include an assessment of consistency.

15. Specify any assessment of risk of bias that may affect the cumulative research evidence that is located after conducting the app store review (e.g., publication bias, selective reporting within studies, independence / non-independence of research authors etc.).

16. Describe methods or aspects of additional analyses that may be unique to the present app store review, if appropriate, indicating why they are appropriate and stating their purpose.

## RESULTS

17. Give numbers of apps screened, assessed for eligibility, and included in the review, with reasons for exclusions at each stage, ideally with a flow diagram.

18. For each app, present characteristics for which data were extracted (e.g., targeted purpose of each app, developer characteristics, theoretical framework of the app, PICOS etc.). Provide a list, in a Table within the main body of the text if the list is small, or in an Appendix or accessible online format if the list is large.

19. Present data on risk of bias of each app and, if available, any outcome level assessment (see item 12).

20. In identifying literature for evidence claimed by an app, provide summary data for intervention groups proportionate to the aims of the app store review (e.g., demographic statistics, effect estimates and confidence intervals, etc.). If appropriate, consider using visual summary techniques, such as forest plots.

21. If relevant, present results of each meta-analysis done, including confidence intervals and measures of consistency.

22. Present results of any assessment of risk of bias across apps, and/or across any research that has been found relating to the final list of apps in the review (see Item 15).

23. If appropriate, give results of additional analyses (see Item 16).

## DISCUSSION

24. Summarise the main findings including the strength of evidence for each app. Consider the relevance of findings in relation to the industry / sector that this group of apps belongs, being as precise and focused as possible. If appropriate, rather than stating the implications of findings in a general sense (e.g., for the "health industry"), narrow the focus (e.g., for the "treatment of diabetes").

25. Discuss limitations at study and outcome level (e.g., risk of bias), and at review-level (e.g., limitations of search options in app stores, reporting bias). Authors of the review should provide a disclosure of their role in any developmental capacity or association with any apps within the group of apps being reviewed.

26. Provide a general interpretation of the results in the context of other evidence, and implications for future research.

## FUNDING

27. Describe sources of funding for the app store review and other support (e.g., supply of data); role of funders for the systematic review (e.g., did the funders specify a preferred publication route).

## REFERENCES

**Moher, D., Liberati, A., Tetzlaff, J., Altman, D. G., & The PRISMA Group.** (2009). Preferred reporting items for systematic reviews and meta-analyses: The PRISMA statement. *Annals of Internal Medicine, 151*(4), 264-269. doi:10.3736/jcim20090918



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