Public Health and Safety International Journal
Oktober 2026 | Vol. 6 | No. 02
E-ISSN : 2715-5854
DOI: https://doi.org/10.55642/phasij.v6i02.1377

Public Health and Safety International Journal (PHASIJ)

Effectiveness of Digital Health Interventions in Improving Noncommunicable Disease Prevention Behaviors: An Umbrella Review

Marcos Carvalho[*1]
Universidade da Paz (UNPAZ), Dili, Timor-Leste
e-mail: *[1]marcos_carvalho@unpaz.tl

Abstract

Noncommunicable diseases (NCDs) cause about three-quarters of global deaths, and their main risk factors are behavioral. This study aimed to synthesize the effectiveness of digital health interventions on NCD prevention behaviors: physical activity, diet, weight, tobacco, and alcohol use. We conducted an umbrella review (systematic review of reviews) following PRISMA 2020, with ten search queries run on 29-30 October 2026. Of 106 records, 16 reviews were included (11 systematic, 3 umbrella, and 2 scoping reviews) and synthesized narratively because their primary trials overlap. Evidence was most consistent for physical activity (standardized effect sizes 0.24-0.38 for daily steps; 1,329 additional steps per day) and for smoking cessation through text messaging (risk ratio [RR] 1.54; 95% confidence interval [CI] 1.19-2.00). Effects on diet were positive but heterogeneous, effects on weight were weak, and review-level evidence on alcohol was the most limited. Goal setting, self-monitoring with feedback, prompts, personalization, and human or social support were associated with larger effects. Evidence from low- and middle-income countries (LMICs), including those in Southeast Asia, remains limited. Digital health interventions can moderately improve NCD prevention behaviors, and intervention content matters more than the device; pairing them with existing community health workers is a plausible way to keep the benefit of human support at lower cost.

Keywords—digital health, noncommunicable diseases, umbrella review, low- and middle-income countries

INTRODUCTION

Noncommunicable diseases (NCDs) kill about 41 million people each year, or 74% of all deaths worldwide, and most premature NCD deaths occur in low- and middle-income countries (LMICs) [1]. The four main groups are cardiovascular diseases, cancers, chronic respiratory diseases, and diabetes, which share the same behavioral risk factors: tobacco use, physical inactivity, harmful use of alcohol, and unhealthy diets [1].

Because these risk factors are behavioral, prevention depends on helping large numbers of people change how they move, eat, smoke, and drink. Lifestyle interventions have proven beneficial, but the personal support that usually accompanies them is difficult to scale up and is not financially sustainable for most health systems [2]. Digital health interventions (DHIs), that is, the use of information and communication technologies such as text messages, mobile phone applications, wearable tracking devices, and web platforms to deliver or support behavior change, have been widely proposed as a way to extend this reach [2,3].

The DHI literature is vast but fragmented. More than 1,700 systematic reviews of DHIs were published between 2012 and 2022 [2], yet most address only a single channel (text messaging [4,5], activity trackers [6,7], or applications [8]), a single type of behavior, or a single clinical population. Their findings are also inconsistent: small to moderate benefits for physical activity [3,7,8], but mixed results for diet, body weight, and some app-based interventions [2]. The evidence is also concentrated in high-income countries and hospital care [9], whereas the populations bearing the greatest burden are served by health systems with limited human resources, uneven connectivity, and varying levels of digital literacy [10,11,12]. Southeast Asia

illustrates this gap: in Indonesia, a mobile technology program has been evaluated in rural primary care [13], but this remains a single study rather than a synthesis of prevention behaviors.

Two recent reviews have begun to fill this gap: a scoping review of experimental studies from 2018-2024 that mapped digital features for NCD prevention [14], and a review of studies in LMICs on physical activity and diet [11]. What is still lacking is a review of reviews that (a) covers the main prevention behaviors across channels, (b) reports effect sizes together with the intervention components that accompany them, and (c) reads the evidence from an LMIC perspective, with attention to Southeast Asia rather than to a single country. This review addresses three questions: (RQ1) how effective DHIs are in improving NCD prevention behaviors; (RQ2) which channels and intervention components are associated with larger effects; and (RQ3) which contextual factors influence effectiveness in LMICs, including Southeast Asian settings.

RESEARCH METHODS

A. Design and reporting

This study is a systematic review of reviews, also known as an umbrella review [15], reported in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 statement [16]. The unit of analysis was the review rather than the primary trial, because the research questions concern the overall direction and magnitude of effects across channels and behaviors. The protocol was not registered; eligibility criteria were set before screening.

B. Search strategy

Ten queries were run on 29 and 30 October 2026 through a web-based academic search engine indexing PubMed, PubMed Central, the Cochrane Library, and publisher platforms. The exact query strings, as run, and the number of records returned by each are listed in Table 1, so that the search can be reproduced. The first seven queries covered the review question, channels (text messaging, activity trackers), LMICs, tobacco, Indonesia, and World Health Organization (WHO) background data. Queries 8-10 were citation-chasing searches for reviews already identified, to retrieve their abstracts and methods. Nine queries returned 10 records each and one returned 16, for a total of 106 records. The number of records per query was therefore set by the search tool rather than by exhaustive retrieval; no structured search of bibliographic databases with controlled vocabulary (e.g., Medical Subject Headings) was performed, and no query targeted alcohol specifically. These constraints are reported as a major limitation in the Discussion.

Table 1 Search queries as run (29-30 October 2026) and records returned

No.	Query string as run	Records
1	systematic review digital health interventions non-communicable disease prevention behaviors	10
2	mHealth text messaging physical activity diet meta-analysis randomized trials	10
3	digital health interventions low- and middle-income countries NCD risk factors systematic review	10
4	smoking cessation mobile phone text messaging Cochrane review	10
5	digital health intervention Indonesia hypertension diabetes prevention mobile app trial	10
6	WHO noncommunicable diseases fact sheet deaths per year risk factors	16
7	wearable activity trackers physical activity systematic review meta-analysis engagement attrition digital interventions	10
8	Xiong 2023 npj Digital Medicine scoping review digital health NCD primary health care LMIC results studies included text messaging	10

No.	Query string as run	Records
9	Agoro Osom 2025 digital health interventions NCD prevention LMICs meta-analysis results studies included effect size physical activity	10
10	Tong Laranjo social features mHealth physical activity systematic review results retention engagement studies included	10
	Total records identified	**106**

C. Eligibility criteria

The criteria were structured using the PICOS (population, intervention, comparator, outcomes, and study design) framework. Population: adults or predominantly adult samples (general population, at-risk groups, or people with NCDs). Intervention: DHIs as the main component (text or instant messaging, applications, trackers, web-based programs, social media, or gamification). Comparator: any (usual care, minimal intervention, or no intervention); not required for scoping and umbrella reviews. Outcomes: physical activity, including daily steps and moderate-to-vigorous physical activity (MVPA), sedentary behavior, diet, body weight, tobacco use, and alcohol use; secondary outcomes: engagement, retention, and implementation factors. Design: systematic reviews with or without meta-analysis, umbrella reviews, and systematic scoping reviews published in English-language peer-reviewed journals in 2015-2026. Primary studies, preprints, theses, conference abstracts, protocols, news items, and fact sheets were excluded.

D. Study selection and data extraction

Duplicates were removed at the level of the same work, so that preprint, repository, and publisher copies of a single review were counted once. Titles and abstracts were screened, and full texts, or abstracts and methods sections, were then assessed against the criteria. Screening and extraction were performed by a single researcher using a structured form. Extracted data included authors, year, design, number of studies and participants, digital modality, target behavior, main effect estimates with 95% confidence intervals (CIs), and indicators of reporting quality (registered protocol, PRISMA, risk-of-bias tool, and meta-analytic pooling). Behavior change techniques (BCTs) were recorded as named by the review authors, using the vocabulary of the BCT Taxonomy v1 [17]. Because a single reviewer is a recognized source of error, three checks were added. First, every reference was resolved through its Digital Object Identifier (DOI) and matched against the publisher record (authors, title, journal, year, volume, and pages). Second, selected effect estimates (activity trackers, alcohol, and the ranges reported by the scoping review) were re-checked against the full text of the source review; where a review reported different values in its abstract and its results section, the abstract values were retained and the discrepancy is stated (Figure 2 note). Third, internal inconsistencies found in included reviews are reported in Section A of the results.

E. Quality appraisal and data analysis

A MeaSurement Tool to Assess systematic Reviews 2 (AMSTAR 2) [18] was not applied independently to each included review. Instead, the AMSTAR 2 ratings from the largest umbrella review [2] were used as context, and the quality indicators extracted for every review (registered protocol, PRISMA, risk-of-bias tool, and pooling) are reported in Section A of the results. Because most of the included reviews were published after the search of [2], they are not covered by those ratings; this is stated as a limitation. Because the included reviews overlap in their primary trials, effect sizes were not pooled across reviews, so that the same participants would not be counted more than once. The degree of overlap was not quantified, for example with the corrected covered area, because that requires a citation matrix of every primary study, and three of the included reviews are umbrella reviews whose units of analysis are reviews rather than trials; overlap is therefore handled by not pooling and by reporting each estimate with its source. Results

were synthesized narratively by behavior (RQ1), channel and component (RQ2), and context (RQ3). Standardized effect sizes with 95% CIs were plotted side by side (Figure 2).

RESULTS AND DISCUSSION

A. Screening and characteristics of the reviews

The ten queries yielded 106 records. After 58 duplicates were removed, 48 records were screened, and 23 were excluded at the title and abstract stage (WHO fact sheets, news items, background pages, older versions of Cochrane reviews, and impact summaries). Twenty-five reports were assessed for eligibility and 9 were excluded with reasons, leaving 16 reviews in the synthesis (Figure 1).

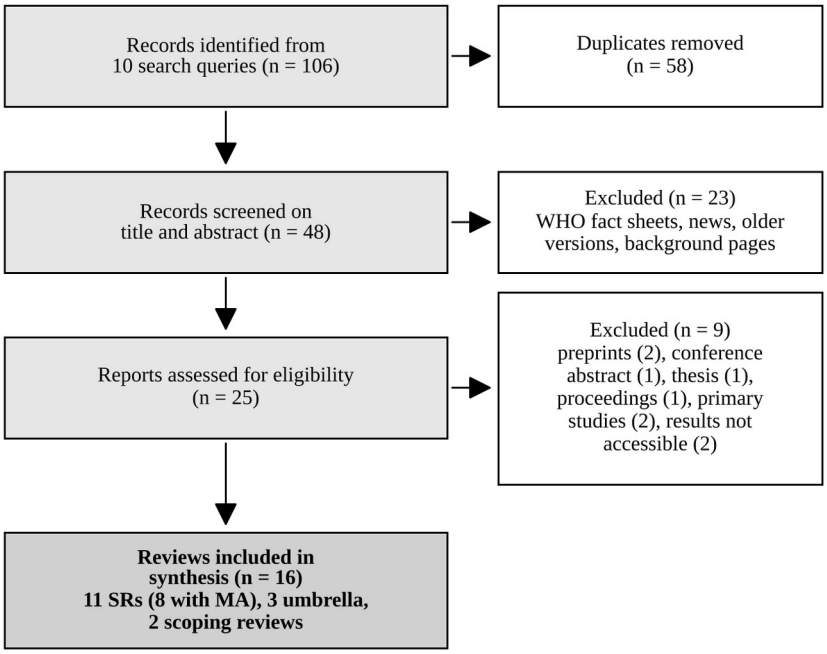


Figure 1 PRISMA flow diagram of record selection

The sixteen reviews were published in 2016-2025: 11 systematic reviews (8 with meta-analysis), 3 umbrella reviews, and 2 scoping reviews (Table 2). Six reviews focused on physical activity, four on multiple behaviors, one on tobacco, and five on LMICs or platform design. At least six reviews had a registered or published protocol [2,5,8,12,19,20]. Participant numbers were not summed because the reviews overlap.

Table 2 Characteristics of the 16 included reviews

Review	Design and evidence base	Channel and target	Main findings
Mair 2023 [2]	Umbrella; 85 reviews, >865,000 participants; AMSTAR 2 (4 high)	e- and mHealth; all behaviors	Behaviors improved; strong evidence for credible source, social support, prompts, goals, feedback, human coaches, personalization
Singh 2024 [3]	Umbrella + meta-meta-analysis; 47 MAs, 507 RCTs	Apps, web, SMS; activity, diet	+1,329 steps/day; +55.1 min/week MVPA; −426.3 min/week sedentary; −1.89 kg

Review	Design and evidence base	Channel and target	Main findings
Ferguson 2022 [6]	Umbrella; 39 reviews, 163,992 participants	Wearable trackers; activity	SMD 0.3-0.6; about 1,800 additional steps/day
Laranjo 2021 [8]	SR-MA of RCTs; 35 studies, n = 7,454	Apps and trackers; healthy adults	Small-to-moderate positive effects
Brickwood 2019 [7]	SR-MA of controlled trials	Consumer trackers; activity	Steps SMD 0.24; MVPA 0.27; sedentary −0.20 (ns)
Smith 2020 [4]	SR-MA; 59 studies; MA of 13 studies (n = 1,346)	One-way SMS; activity	Steps d = 0.38; MVPA d = 0.31 (ns)
Whittaker 2019 [5]	Cochrane SR-MA of RCTs, follow-up ≥6 months	SMS and apps; smoking cessation	RR 1.54 (13 studies; 14,133 participants)
Stephani 2016 [10]	SR of RCTs; 8 RCTs, 4,375 participants	mHealth in LMICs; diabetes, asthma, hypertension	Almost all positive; limited conclusions
Xiong 2023 [9]	Scoping; 52 studies	DHIs in LMIC primary care	Positive behavioral outcomes; mixed clinical outcomes; 14 of 28 WHO categories used
Agoro and Osom 2025 [11]	SR-MA	Apps, SMS, wearables; activity, diet in LMICs	Higher adherence with personalized feedback, gamification, social support
Shaluhiyah 2025 [14]	Systematic scoping; 20 experimental studies (12 RCTs)	Messaging, gamification, apps, wearables	Behavioral outcomes (e.g., physical activity, diet, sleep, diabetes self-care) improved by 4%-95% across 17 studies; range of single-study results, not pooled; largest for messaging
Tighe 2020 [21]	SR; 7 studies	Platform-like interventions; NCD self-management	Clinical benefits on multifaceted measures
Tong and Laranjo 2018 [22]	SR-MA of RCTs; 19 studies	Social features; physical activity	Retention >80%; MA not significant
Muller 2016 [12]	SR; 15 studies in 13 developing countries	SMS and internet; activity, diet	11 studies significant; effective for activity in 50%, diet in 70%
Duan 2021 [19]	SR-MA; 15 studies	Multibehavior eHealth in people with NCDs	Activity SMD 0.85; diet 0.78; weight −0.13 (ns)
Emeran 2024 [20]	SR-MA; 43 studies; low GRADE	One-way SMS; activity, weight	Activity d+ 0.14; weight d+ 0.04 (ns)

SR, systematic review; MA, meta-analysis; RCT, randomized controlled trial; MVPA, moderate-to-vigorous physical activity; ns, not significant; LMIC, low- and middle-income country; DHI, digital health intervention; SMS, short message service; SMD, standardized mean difference; d, Cohen's d; d+, weighted mean d; RR, risk ratio; AMSTAR 2, A MeaSurement Tool to Assess systematic Reviews 2; GRADE, Grading of Recommendations Assessment, Development and

Evaluation. For Shaluhiyah 2025, 4%-95% is the spread of percentage improvements in heterogeneous behavioral outcomes reported by individual studies (lowest for general health, nutrition, and sleep; highest for diabetes self-care, both delivered through messaging groups), not a pooled effect.

The methodological quality of reviews in this field is generally low. In the largest umbrella review, only 4 of 85 reviews were rated high on AMSTAR 2, with 22 rated moderate, 29 low, and 30 critically low [2]. Of the 16 reviews included here, at least five used a formal appraisal tool (the Cochrane risk-of-bias tool; risk of bias with GRADE; a checklist based on the Consolidated Standards of Reporting Trials [CONSORT]; Joanna Briggs Institute [JBI] tools; and the Mixed Methods Appraisal Tool [MMAT] with GRADE). Internal inconsistencies were found in two reviews: the number of included studies differs between text and tables in Agoro and Osom (12 vs 10) [11] and in Shaluhiyah et al. (20 vs 21) [14], and the former appraised quality with a scale designed for narrative reviews rather than a risk-of-bias tool; their findings are therefore given less weight. Because behavioral trials are rarely blinded, performance bias is a common concern: one meta-analysis rated the certainty of its activity and weight evidence as low [20], whereas the Cochrane review rated its main smoking finding as moderate certainty [5].

B. Effectiveness by behavior (RQ1)

Physical activity had the strongest and most consistent evidence (Figure 2 and Table 3). A meta-analysis of consumer activity trackers found small increases in daily steps (standardized mean difference [SMD] 0.24; 95% CI 0.16-0.33), moderate-to-vigorous physical activity (MVPA; SMD 0.27), and energy expenditure (SMD 0.28), but the reduction in sedentary behavior was not significant (SMD −0.20; 95% CI −0.43 to 0.03) [7]. One-way text messages increased objectively measured steps (Cohen's d = 0.38; 95% CI 0.19-0.58), but their effect on MVPA was not significant (d = 0.31) [4]. A meta-analysis focusing specifically on one-way messages found a smaller effect on overall activity (weighted mean d+ 0.14; 95% CI 0.05-0.23; I^2 = 65%) with low certainty of evidence [20].

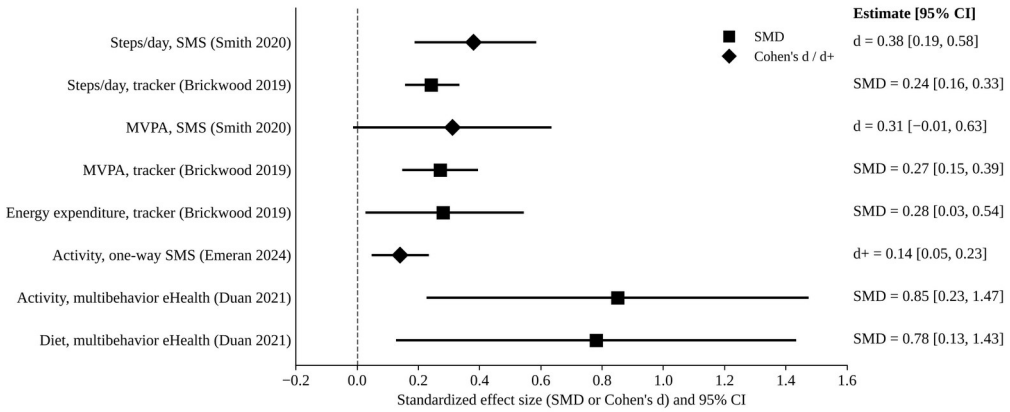


Figure 2 Standardized effect sizes of DHIs on physical activity and diet (SMD or Cohen's d, 95% CI)

Note: Brickwood 2019 [7] and Duan 2021 [19] report standardized mean differences (SMD, squares); Smith 2020 [4] reports Cohen's d and Emeran 2024 [20] a weighted mean d (d+) (diamonds). Both metrics express the difference between groups in standard deviation units and are shown side by side for comparison only; they were not pooled. Values for [7] are those in its abstract; its results section reports slightly different estimates (e.g., steps SMD 0.23, 95% CI 0.15-0.32).

The umbrella reviews agree on the direction of effect. A meta-meta-analysis of 507 trials estimated an additional 1,329 steps per day (95% CI 593.9-2,065.7), an additional 55.1 minutes per week of MVPA, and 426.3 fewer minutes per week of sedentary behavior [3]; a review of 39

reviews put the increase at about 1,800 steps per day, sustained over time [6]. The results are not uniform, however: several meta-analyses found no significant effect of mobile health (mHealth) on total activity or walking, and in some reviews only 50%-62.5% of mHealth interventions outperformed the control condition [2]. Among people with NCDs, multibehavior electronic health (eHealth) programs reported a large but imprecise effect on activity (SMD 0.85; 95% CI 0.23-1.47) [19].

For tobacco, the Cochrane review found moderate-certainty evidence that automated text messaging increased smoking abstinence at six months or longer compared with minimal support (risk ratio [RR] 1.54; 95% CI 1.19-2.00; $I^2 = 71\%$; 13 studies, 14,133 participants), and that adding text messaging to other support was also beneficial (RR 1.59); certainty for apps was low [5].

Alcohol use, although one of the five risk factors examined, had the thinnest evidence base in this review. None of the 16 included reviews targeted alcohol as its primary outcome. The only quantitative estimate came indirectly through the umbrella review [2], which summarized a Cochrane review rated high quality on AMSTAR 2 (34,390 participants): personalized digital interventions reduced consumption by 22.8 g per week (95% CI 15.4-30.3) at the longest follow-up, with moderate-quality evidence, and behavior substitution, problem solving, and credible source were the techniques associated with larger reductions [2]. The LMIC-focused reviews concentrated on physical activity, diet, and disease management [9-12], so the effect of digital alcohol interventions in these settings could not be assessed, and no query in this review targeted alcohol (Table 1). The alcohol findings should therefore be read as an evidence gap of this review, not as evidence of no effect; a dedicated review of digital interventions for harmful alcohol use, particularly in LMICs, is needed.

Effects on diet were positive but variable: an additional 0.57 servings of fruit and vegetables per day (95% CI 0.11-1.02) and 1.89 kg lower body weight [3]; among people with NCDs, eHealth improved diet (SMD 0.78) but not body weight (SMD −0.13) [19], and one-way text messaging alone had no effect on body weight (d+ 0.04; 22 studies) [20]. In developing countries, 70% of interventions were effective for diet and 50% for physical activity, with a moderate risk of bias [12].

Table 3 Summary of effects by behavior

Behavior	Main evidence	Direction and size of effect	Limitations
Physical activity	Meta-analyses of trackers, apps, SMS [3,4,7,8,20]	Small-moderate; SMD 0.24-0.38 (steps); +1,329 steps/day	Heterogeneity; some non-significant; short follow-up
Sedentary behavior	Tracker meta-analysis and meta-meta-analysis [3,7]	−426.3 min/week [3]; SMD −0.20 ns [7]	Weakest outcome
Tobacco	Cochrane review [5]	RR 1.54 for text messaging vs minimal support	Moderate certainty; low for apps
Alcohol	Cochrane review within [2]	−22.8 g/week at longest follow-up	Indirect, single review; self-reported intake; no LMIC data (evidence gap)
Diet	Meta-meta-analysis and MA in people with NCDs [3,19]	+0.57 servings/day; SMD 0.78 in people with NCDs	Wide CIs; self-report
Body weight	[2,3,19,20]	−1.89 kg; SMD −0.13 and d+ 0.04 ns	Only about half of studies significant

C. Channels and intervention components (RQ2)

Text and instant messaging are the simplest and most widely evaluated channels. Messaging has the best controlled evidence for tobacco [5] and positive effects on steps [4], but one-way messages alone have minimal effects on activity and none on body weight [20]; reviews from LMICs emphasize its value where smartphone access and digital literacy are limited [11,12]. Apps and trackers have the best evidence for steps and MVPA [6,7,8], but the effects of apps alone on body weight and smoking cessation are weaker [2,5]. Social features are commonly used, but a meta-analysis of randomized controlled trials (RCTs) found no significant effect, and evidence that these features increase engagement is limited [22]. Multi-feature programs tend to have broader effects than single features [14].

The umbrella review coded BCTs and graded the evidence by health domain: the components supported in more than one domain were credible source, social support, prompts and cues, graded tasks, goal setting and planning, feedback and monitoring, human coaches, and personalization [2]. Table 4 combines these with component-level findings from the other reviews.

Table 4 Components associated with larger effects

Component	Review findings	Evidence
Credible source or human coach	Associated with better outcomes across domains; human coaches increased weight loss and activity [2]	Strong
Prompts and cues	Effective across domains; text messaging among the groups associated with activity effects [2]	Strong
Goal setting, action planning	Larger effects for activity, chronic conditions, alcohol, and tobacco [2]	Strong
Self-monitoring and feedback	Strong for chronic conditions and tobacco; mixed for activity alone [2,6,7]	Moderate-strong
Personalization	Personalized content and feedback improved outcomes and adherence [2,11]	Strong
Social support	Larger effects; engagement benefit of social features not yet demonstrated [2,11,22]	Moderate
Number of components	More is better in some reviews, but not all [2,14]	Mixed
Gamification and theory-based design	Higher adherence; larger activity effects for theory-based interventions [11,14,19]	Limited

D. Context, engagement, and evidence from low- and middle-income countries (RQ3)

Attrition is a recognized problem in mHealth physical activity interventions [22]; in LMICs, low digital literacy, limited internet access, and declining long-term engagement are barriers, whereas adherence is higher with personalized feedback, gamification, and social support [11]. Review-level evidence from these countries is scarce, comes mostly from urban areas, and is of moderate quality: an early review included eight trials, almost all of them positive [10]; a later review of 15 studies found that 11 had significant effects on activity or diet, most of them from Asia [12]. A scoping review of primary care found that only 14 of the 28 WHO categories of digital interventions were used, and that uptake depended on political commitment, interactivity, user-centered design, and integration with existing systems [9]. Culture- and country-specific interventions were more effective [11], and messaging platforms predominated because they are affordable and easy to scale up [14].

None of the included reviews focused on Southeast Asia or on any single country in the region, including Indonesia and Timor-Leste. The only regional evidence identified was a primary study, used here as context: in rural Malang, Indonesia, a mobile technology-assisted primary care program covered 11,098 participants in four intervention villages and 10,981 in four control villages; after adjustment, the risk of all-cause mortality was 18% lower in the intervention

villages (95% CI 4-30), but the design was quasi-experimental and the program also relied on community health volunteers (cadres) and nurses, so this association cannot be read as evidence that the technology alone was responsible [13].

E. Discussion

Overall, DHIs produce moderate but fairly consistent improvements in physical activity and smoking cessation, positive but more variable effects on diet, and as yet unconvincing effects on body weight and sedentary behavior. This pattern suggests that the channel is the vehicle, whereas the behavior change content does the work: text messages, apps, and trackers all improve activity when they deliver the same ingredients, namely goals, prompts, progress feedback, and support [2,4,7,8]. This is consistent with the finding that interventions using more behavior change techniques, and those grounded in theory, tend to perform better [2,19], and it may explain why one-way messages alone have minimal effects on activity and none on body weight [20]. An awkward finding concerns the human role: human coaches are repeatedly associated with larger effects, yet this is precisely the component that constrains scalability and cost [2]. Figure 3 summarizes the emerging framework.

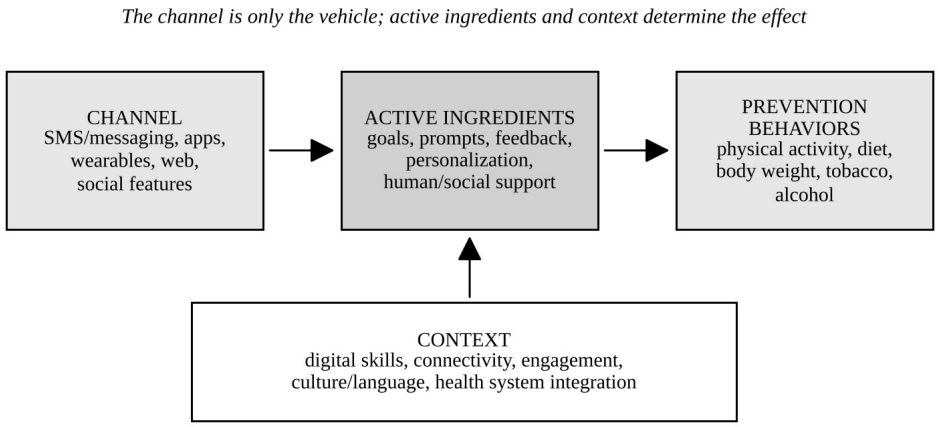


Figure 3 Conceptual framework: channels, active ingredients, and context

The tension between human support and scalability need not be resolved by choosing one or the other. Primary care in many LMICs already relies on community health workers, such as the health cadres of Indonesia, who are embedded in their communities and cost far less than professional coaches. A tiered model could let digital tools deliver the frequent, low-cost components (automated prompts, self-monitoring, and progress feedback) and reserve human contact for the points at which it is most likely to matter: goal setting at enrolment, periodic review of progress, and follow-up of participants whose engagement falls. In such a model the platform also supports the cadre, through checklists, reminders, and lists of participants who need contact, rather than replacing them. The Malang program illustrates this combination, since it paired a mobile technology with cadres and nurses [13], and integration with existing systems was one of the factors that determined uptake of DHIs in LMIC primary care [9]. Whether such a hybrid keeps most of the benefit of human coaching at a fraction of its cost has not been tested in the reviews identified here; trials comparing digital-only, cadre-supported, and professional-coach arms, with cost data, are needed.

The following implications for LMICs in Southeast Asia, such as Indonesia and Timor-Leste, are inferences from the reviews rather than their findings, because none of the reviews was specific to the region. First, start with the channels people already use: messaging platforms have the lowest barriers and the strongest controlled evidence for tobacco [4,5,14], but they must include goals, feedback, and support [11,20]. Second, design the active ingredients in local languages (e.g., Bahasa Indonesia or Tetum) and in culturally relevant terms [2,11]. Third,

combine digital tools with low-cost human support from existing health workers and cadres, as outlined above [2,9], and integrate them with the health system [9]. Fourth, evaluate interventions with objective outcomes, a follow-up of at least 12 months, and reporting of engagement and retention [14,22].

The limitations of this review include screening and extraction by a single researcher, the absence of a registered protocol, and a search of ten queries through a web search engine that returned a capped number of records per query, rather than structured searches of multiple bibliographic databases (e.g., PubMed, Scopus, and the Cochrane Library) without limits on the number of records, so relevant reviews may have been missed; the review should therefore be read as a transparent but non-exhaustive synthesis. Some reviews were summarized from their abstracts, methods sections, and umbrella-review tables, which limited the detail of extraction; AMSTAR 2 was not applied independently to each review, and most included reviews postdate the ratings used as context [2]; trial overlap precluded pooling of effects and was not quantified; alcohol was not searched specifically and is represented only indirectly; outcomes were often self-reported with short follow-up; publication bias cannot be ruled out; only English-language sources were considered; and the Southeast Asian evidence comes from a single Indonesian primary study that may not apply to other settings.

CONCLUSION

DHIs can moderately improve NCD prevention behaviors, most reliably physical activity and smoking cessation. Their effect depends on what is delivered rather than on the device: goals, prompts, feedback, personalization, and human or social support recur in the programs with stronger evidence. For LMICs, including those in Southeast Asia, low-barrier messaging combined with these active ingredients and with existing health workers and cadres is the most defensible starting point, although this inference still needs to be tested in the region.

RECOMMENDATIONS

Future research should include factorial and micro-randomized trials to identify the components that matter, trials with at least 12 months of follow-up and objective outcomes, cost-effectiveness analyses in primary care, trials of scalable alternatives to human coaches such as conversational agents [2], engagement strategies and equity analyses, adequately powered randomized trials in Southeast Asian LMICs, including Indonesia and Timor-Leste, particularly in primary prevention, a dedicated review of digital interventions for harmful alcohol use, and an update of this review using structured database searches, duplicate screening, and independent AMSTAR 2 appraisal.

ACKNOWLEDGMENTS

The literature search, data extraction, initial draft, and English translation of the manuscript were assisted by an artificial intelligence model (Claude, Anthropic), which was used as a tool and is not an author. AI-assisted outputs were checked as follows: every reference was resolved through its DOI and matched against the publisher record, and no reference without a verifiable record was retained; every effect estimate, confidence interval, and sample size in the text, Tables 2-4, and Figure 2 was compared manually by the author with the source review; and all interpretive statements were reviewed and revised by the author. The author takes full responsibility for the accuracy of the data and for the final text.

REFERENCES

[1] World Health Organization, 2023, Noncommunicable diseases: key facts, WHO, Geneva, https://www.who.int/news-room/fact-sheets/detail/noncommunicable-diseases, accessed 30 October 2026.

[2] Mair, J. L., Salamanca-Sanabria, A., Augsburger, M., Frese, B. F., Abend, S., Jakob, R., et

al., 2023, Effective behavior change techniques in digital health interventions for the prevention or management of noncommunicable diseases: an umbrella review, Ann Behav Med, vol 57 no 10, pp. 817-835, doi:10.1093/abm/kaad041.

[3] Singh, B., Ahmed, M., Staiano, A. E., Gough, C., Petersen, J., Vandelanotte, C., et al., 2024, A systematic umbrella review and meta-meta-analysis of eHealth and mHealth interventions for improving lifestyle behaviours, npj Digit Med, vol 7, 179, doi:10.1038/s41746-024-01172-y.

[4] Smith, D. M., Duque, L., Huffman, J. C., Healy, B. C., Celano, C. M., 2020, Text message interventions for physical activity: a systematic review and meta-analysis, Am J Prev Med, vol 58 no 1, pp. 142-151, doi:10.1016/j.amepre.2019.08.014.

[5] Whittaker, R., McRobbie, H., Bullen, C., Rodgers, A., Gu, Y., Dobson, R., 2019, Mobile phone text messaging and app-based interventions for smoking cessation, Cochrane Database Syst Rev, no 10, CD006611, doi:10.1002/14651858.CD006611.pub5.

[6] Ferguson, T., Olds, T., Curtis, R., Blake, H., Crozier, A. J., Dankiw, K., et al., 2022, Effectiveness of wearable activity trackers to increase physical activity and improve health: a systematic review of systematic reviews and meta-analyses, Lancet Digit Health, vol 4 no 8, pp. e615-e626, doi:10.1016/S2589-7500(22)00111-X.

[7] Brickwood, K. J., Watson, G., O'Brien, J., Williams, A. D., 2019, Consumer-based wearable activity trackers increase physical activity participation: systematic review and meta-analysis, JMIR Mhealth Uhealth, vol 7 no 4, e11819, doi:10.2196/11819.

[8] Laranjo, L., Ding, D., Heleno, B., et al., 2021, Do smartphone applications and activity trackers increase physical activity in adults? Systematic review, meta-analysis and metaregression, Br J Sports Med, vol 55 no 8, pp. 422-432, doi:10.1136/bjsports-2020-102892.

[9] Xiong, S., Lu, H., Peoples, N., Duman, E. K., Najarro, A., Ni, Z., et al., 2023, Digital health interventions for non-communicable disease management in primary health care in low- and middle-income countries, npj Digit Med, vol 6, 12, doi:10.1038/s41746-023-00764-4.

[10] Stephani, V., Opoku, D., Quentin, W., 2016, A systematic review of randomized controlled trials of mHealth interventions against non-communicable diseases in developing countries, BMC Public Health, vol 16, 572, doi:10.1186/s12889-016-3226-3.

[11] Agoro, O. N., Osom, A. L., 2025, Effectiveness of digital health interventions for NCD prevention in LMICs: a systematic review and meta-analysis, Science International, vol 13 no 1, pp. 58-69, doi:10.17311/sciintl.2025.58.69.

[12] Muller, A. M., Alley, S., Schoeppe, S., Vandelanotte, C., 2016, The effectiveness of e- and mHealth interventions to promote physical activity and healthy diets in developing countries: a systematic review, Int J Behav Nutr Phys Act, vol 13, 109, doi:10.1186/s12966-016-0434-2.

[13] Maharani, A., Sujarwoto, Praveen, D., Oceandy, D., Tampubolon, G., Patel, A., 2024, Implementation of mobile-health technology is associated with five-year survival among individuals in rural areas of Indonesia, PLOS Digit Health, vol 3 no 4, e0000476, doi:10.1371/journal.pdig.0000476.

[14] Shaluhiyah, Z., Qatrannada, S. A., Kusumawati, A., Miah, M. S., 2025, The effect of digital health intervention in promoting healthy behavior: a systematic scoping review on strategies to prevent non-communicable diseases, Dialogues Health, vol 7, 100258, doi:10.1016/j.dialog.2025.100258.

[15] Aromataris, E., Fernandez, R., Godfrey, C. M., Holly, C., Khalil, H., Tungpunkom, P., 2015, Summarizing systematic reviews: methodological development, conduct and reporting of an umbrella review approach, Int J Evid Based Healthc, vol 13 no 3, pp. 132-140, doi:10.1097/XEB.0000000000000055.

[16] Page, M. J., McKenzie, J. E., Bossuyt, P. M., et al., 2021, The PRISMA 2020 statement: an updated guideline for reporting systematic reviews, BMJ, vol 372, n71, doi:10.1136/bmj.n71.

[17] Michie, S., Richardson, M., Johnston, M., et al., 2013, 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, vol 46 no 1, pp. 81-95, doi:10.1007/s12160-013-9486-6.

[18] Shea, B. J., Reeves, B. C., Wells, G., et al., 2017, AMSTAR 2: a critical appraisal tool for systematic reviews that include randomised or non-randomised studies of healthcare interventions, or both, BMJ, vol 358, j4008, doi:10.1136/bmj.j4008.

[19] Duan, Y., Shang, B., Liang, W., Du, G., Yang, M., Rhodes, R. E., 2021, Effects of eHealth-based multiple health behavior change interventions on physical activity, healthy diet, and weight in people with noncommunicable diseases: systematic review and meta-analysis, J Med Internet Res, vol 23 no 2, e23786, doi:10.2196/23786.

[20] Emeran, A., Burrows, R., Loyson, J., Behardien, M. R., Wiemers, L., Lambert, E., 2024, The effect of text message-based mHealth interventions on physical activity and weight loss: a systematic review and meta-analysis, Am J Lifestyle Med, vol 20 no 6, pp. 952-974, doi:10.1177/15598276241268324.

[21] Tighe, S. A., Ball, K., Kensing, F., Kayser, L., et al., 2020, Toward a digital platform for the self-management of noncommunicable disease: systematic review of platform-like interventions, J Med Internet Res, vol 22 no 10, e16774, doi:10.2196/16774.

[22] Tong, H. L., Laranjo, L., 2018, The use of social features in mobile health interventions to promote physical activity: a systematic review, npj Digit Med, vol 1, 43, doi:10.1038/s41746-018-0051-3.