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Cost Effectiveness and Resource Allocation

REVIEW

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Financial incentives in the management of diabetes: a systematic review

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Abstract

Methods Web of Science, Cochrane library and PubMed were systematically searched up to January 2024 to identify studies examining the impact of financial incentives on diabetes management in patients. Studies were evaluated based on the robustness of their methodology, participant numbers, and quality scores. The Cochrane risk-of-bias tool was applied for randomized controlled trials, while the Newcastle–Ottawa Scale was used for non-randomized controlled trials to assess study quality. Due to the heterogeneity of the included studies, a narrative synthesis approach was utilized.

Results In the study, we included 12 published research studies. Five studies investigated the influence of financial incentives on patient behavior, all demonstrating a significant positive impact on behaviors such as blood glucose monitoring, medication adherence, and physical activity. 10 studies analyzed the impact of financial incentives on HbA1c levels in diabetes patients. Among them, 5 studies reported that financial incentives could improve HbA1c levels through longitudinal historical comparisons. The other 5 studies did not find significant improvements compared to the control group. Three studies explored long-term effects, two studies targeting the adolescent population had no impact, and one study targeting adults had a positive impact.

Conclusions In summary, this review found that financial incentives can positively influence patient behavior and enhance compliance, but their impact on HbA1c levels is inconsistent. Financial incentives may help adult patients maintain behavior even after the withdrawal of incentives.

Keywords Financial incentives, HbA1c, Diabetes mellitus, Cost effective, Management, Diabetes self management

Introduction

According to the Centers for Disease Control and Prevention, in 2018, approximately 34.2 million people of all ages in the United States had diabetes, accounting for around 10.5% of the total population. Globally, approximately 5 million deaths were attributable to diabetes among individuals aged 20 to 99 years in 2017. This prevalence increased to 425 million adults in 2017 and is projected to rise by 48% to reach 629 million adults by 2045 [1]. Diabetes has reached an alarming prevalence in China, with a rate escalating to 11.2% between 2015 and 2017. And the awareness, treatment, and control rates of diabetes remain at low levels, standing at 36.5, 32.2, and 49.2%, respectively. The primary objectives of diabetes self-management are to prevent immediate

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health complications and delay the onset of long-term complications [2]. Achieving glycemic control, primarily through lifestyle changes and precise insulin dosing when necessary, offers clear benefits in delaying complications associated with both type 1 (T1D) and type 2 diabetes (T2D) [3].

The complexity of diabetes self-management extends beyond clinical settings, demanding significant efforts from patients outside the traditional healthcare environment. However, a mere 7% of adults with diabetes successfully adhere to all recommendations for optimal self-management [4]. Factors contributing to this low success rate range from difficulties in understanding appropriate self-management goals to challenges in making necessary lifestyle changes [5]. Furthermore, behavioral economics suggests that failures to adopt healthy behaviors may stem from 'present bias' or temporal discounting, wherein individuals prioritize small immediate rewards over larger, distant ones [6].

A recent, promising approach to addressing these challenges involves the application of rewards, particularly financial incentives, to motivate patients. Financial incentives, whether self-rewarded or provided by external sources such as corporations or health insurance companies, have gained traction in promoting health and wellness, with nearly 90% of U.S. corporate employers offering wellness-based incentives in 2013 (Business Group Health). These incentives have shown effectiveness in various health-related areas, including smoking cessation and disease management [7, 8].

Recently, an increasing number of studies are progressively exploring the role of financial incentives in the self-management of diabetes. However, the findings from these investigations lack consistency. This study is driven by the overarching objective to conduct a thorough synthesis and analysis of existing research, aiming to clarify whether incentive mechanisms contribute significantly to the management of individuals with diabetes. Furthermore, the research seeks to pinpoint effective reward measures that can enhance the overall care and control of diabetes in patients.

Method

Literature search

Searches were conducted in Web of Science, Cochrane Library, and PubMed for studies on the impact of financial incentives for diabetes patients on diabetes management and cost-effectiveness, including all relevant studies published up until January 2024. The following search terms were used: (financial incentives) AND (diabetes OR glycemia OR glucose). Additional studies were identified through a manual search of all references cited in retrieved articles. Our search was limited to studies published in the English language. The bibliographies of all eligible studies were examined to identify potential studies for inclusion. Due to the heterogeneity of the studies, narrative synthesis was used.

Eligibility criteria

Studies focused on the impact of financial incentives on self-management behaviors of diabetes patients, where incentives were contingent upon specific behaviors or outcomes, were included. The following types of studies were excluded: reviews, systematic reviews, and meta-analyses, guidelines, study protocols, surveys, editorials, and opinion pieces, abstracts, letters, case reports, and audits.

Financial incentives were defined as any form of cash or non-cash reward with a monetary value given directly to individuals. Studies assessing disincentives (such as fiscal penalties) were not included. In studies comparing multiple treatments, groups differing solely in the provision of financial incentives were examined.

Study selection

Two reviewers independently screened article records (Qingqing Zhang and Xue Wei). In cases of uncertainty, a third reviewer (Yu Lu) was consulted to make the final decision on inclusion. Full texts of potentially eligible articles were retrieved. One reviewer (Xue Wei) screened the full texts for eligibility, with consultation from another reviewer (Qingqing Zhang) in cases of uncertainty. Final decisions were reached through consensus. Exclusion criteria are detailed in the flowchart following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines.

Quality assessment

Given the expectation that the majority of included studies would report implementation data, we opted not to impose any methodological filters. Instead, to account for the diverse range of methodologies likely present in the selected papers, we followed the methodology outlined by Pinnock in 2015 [9]. Papers were categorized based on the robustness of their study design, the number of participants, and their quality score, as assessed using the Downs and Black checklist [10].

Data extraction

Data extraction from the included papers was conducted independently by two reviewers (Qingqing Zhang and Xue Wei). Any discrepancies were resolved through discussion. Information regarding the interventions was extracted under specific headings, including 'setting', 'risk of bias assessment', 'participants', 'intervention

groups', 'methods', 'outcomes', and 'results'. Additionally, linked papers associated with the included studies were reviewed to gather supplementary information on intervention descriptions, nested qualitative studies, and process evaluations, enhancing the available information and providing context.

Analysis and synthesis

Given the diversity among the included studies, conducting a meta-analysis was deemed inappropriate. Instead, a descriptive synthesis was performed to analyze and present the findings. We categorized our outcomes of interest into three main categories. Firstly, diabetes control was assessed through patients' HbA1c testing results. Secondly, individual behaviors, such as adherence to glucose testing, medication adherence, and engagement in physical activity, were evaluated. Lastly, we examined the cost-effectiveness of financial incentives. The results were synthesized using a Harvest Plot [11], where each bar represents an individual study. The color of the bar indicates the study design, the height reflects the number of participants, and the number corresponds to the Downs and Black quality score. The quality of the studies was assessed using the Cochrane risk-of-bias tool (RoB 2) for all randomised controlled trials (RCTs) and the Newcastle–Ottawa Scale (NOS) was used for non-RCTs.

Results

From the 1004 studies found, 12 studies were eligible for the systematic review (Fig. 1 is the PRISMA diagram with details of the selection process).

Study characteristics

The articles originated from various countries (Table 1): 8 [12–19] from the U.S., 1 [20] from Canada, 1 [21] from Austria, 1 [22] from Peru, and 1 [23] from Saudi Arabia. The study duration varied from 3 month to 2 years. The number of patients with diabetes included in 12 studies ranges from 17 to 3184. Among the 12 studies, two studies focused on youth, with an average age between 15.9 and 16.3 years old. Another study included diabetes patients aged 14 and above, while the remaining studies involved adult with diabetes. Apart from the two studies on T1D, three studies included T2D, four studies included patients with either T1D or T2D, and three studies did not specify the specific type of diabetes for their subjects.

Risk of bias of included studies

The selected RCT exhibited various biases, including selection bias, performance bias, detection bias, attrition bias, and reporting bias (Fig. 2). Concerning random sequence generation (selection bias), two studies of Fernandes et al. [15, 16] and Long et al. [12] lacked clear documentation on whether specific and reliable methods were used. Notably, blinding of participants and personnel (performance bias) was evident across the studies, with only Long et al. [12] and Miranda et al. [22] showing low risks in this aspect. Regarding blinding of outcome assessment (detection bias), five studies were affected, except for Long et al. [12] Due to the inherent nature of financial incentive schemes, participant blinding was not feasible, making allocation concealment a crucial source of bias.

According to the Newcastle–Ottawa Scale (NOS), the studies by Fernandes et al. [15, 16] and Misra-Hebert et al. [14] received a quality score of eight out of nine points. This score indicates a low risk of bias and reflects the robustness of the study design and outcome assessment. The main reason for the low scores of the studies of Nally et al. [19] and Al Kathiry et al. [23] was due to observational studies without a control group. Specific details of the risk of bias in the included studies are reported in Table 2.

Study quality and weight of evidence

The study designs varied and included: 8 population-level controlled trials, 1 retrospective controlled study, 3 historical control studies, 0 retrospective comparator study and quasi-experimental prospective study, as shown in Fig. 3. The quality scores ranged from 11 to 25, as shown in Fig. 4.

Features of the financial incentive

Eight studies provided cash rewards. Excluding rewards for research participation itself, the maximum reward amounts in other studies ranged from $149 to $717, with the exception of Sen et al.'s [13] study, which used a lottery incentive. Sen et al.'s [13] study included a high incentive arm with a 1% chance of yielding a reward of $100 daily, and a 1/5 chance of yielding a reward of $10 daily, as well as a low incentive arm with rewards of $50 and $5, respectively. Wong et al. [18] structured the daily financial incentives as loss-framed, mandating participants to meet daily blood glucose monitoring goals, including a minimum of 4 checks per day with at least 1 reading within the range of 3.9–10 mmol/L using a wireless glucometer. Over the 3-month intervention, participants received a $60 monthly incentive deposited into a virtual account, with $2 deducted for each day of nonadherence to monitoring targets.

Four studies utilized non-cash rewards. Misra-Hebert et al. [14] provided a 15% discount on health insurance premiums ($300–$600) for achieving clinical goals. Mashru et al. [20] offered a $5 gift card for every HbA1c test, up to a maximum of two gift cards. In two studies

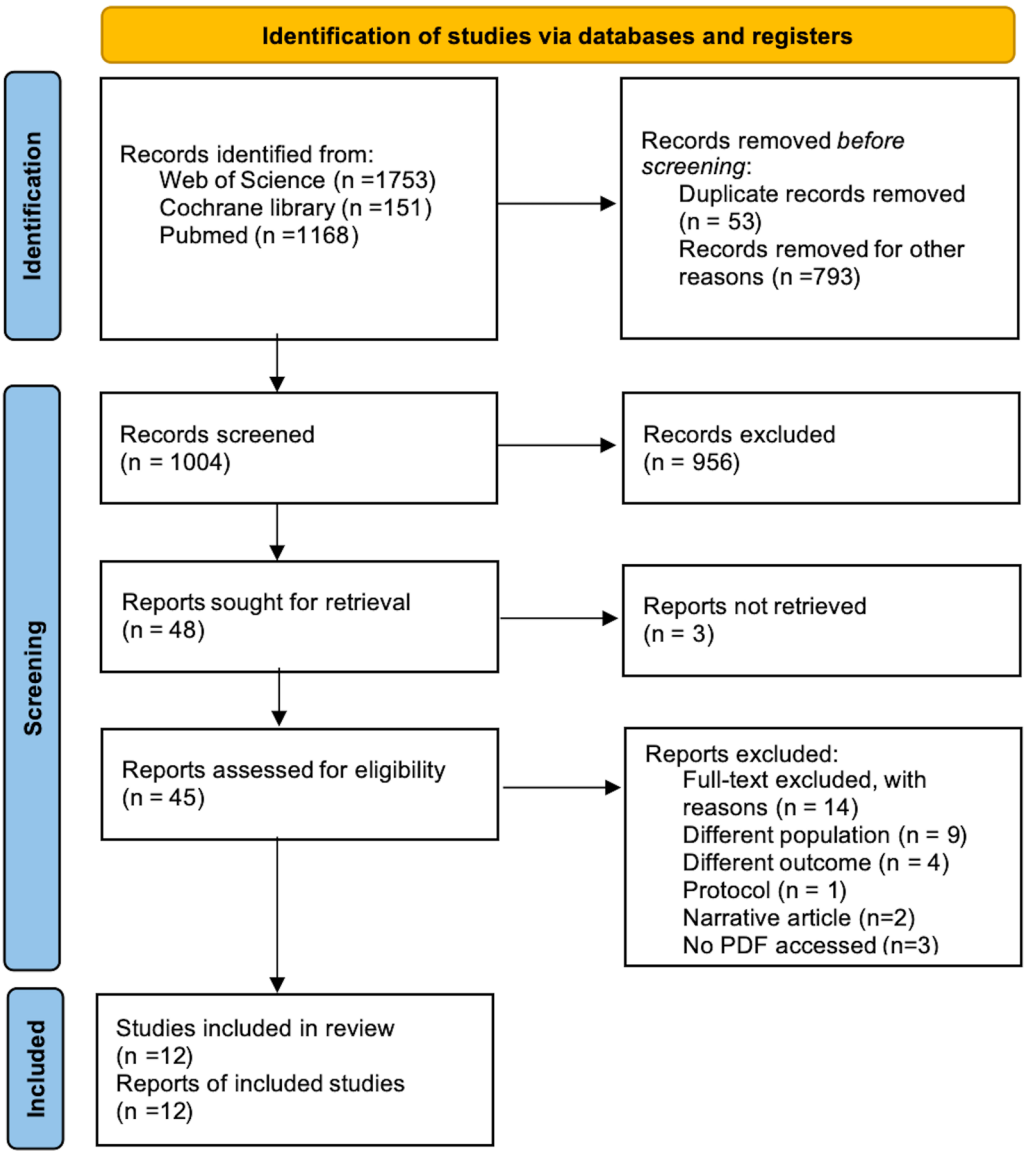

Fig. 1 Prisma flow diagram. Out of the 1004 studies found, detailed reviews were conducted on the full texts of 45 articles. Among these 45 articles, 12 publications met our eligibility criteria and were included in the final sample for our review

by Fernandes et al. [15, 16] participants have the opportunity to earn up to $320 in annual economic incentives, with one study utilizing debit cards for electronic payments upon achieving incentivized outcomes, while the other study provides various incentives such as gift cards, vouchers, and massages.

Impact of the financial incentive on individual behavior

Five studies explored the impact of financial incentive on patient behavior, all of which showed a significant positive impact on patient behavior, as shown in Fig. 4. Among them, Sen et al.'s [13] study that rewarded daily blood glucose monitoring demonstrated improved compliance with blood glucose monitoring, whether in the high or low incentive arm. Mashru et al.'s [20] study improved compliance with glycated hemoglobin (HbA1c) testing by incentivizing monitoring of HbA1c levels. Wong et al. [18] utilized daily financial incentives within the loss framework mentioned earlier to increase the proportion of days participants reached their blood glucose monitoring goals. Fernandes et al.'s [15, 16] study that rewarded blood glucose monitoring, diabetes education sessions, and various tests notably enhanced compliance rates for annual eye exams, screening for

Table 1 Characteristics of included studies

Study, country, registration number	Participants (*n*), age, duration	Features of the financial incentives	Intervention	Results		
				Individual behaviour	Diabetes control	Cost effectiveness
Long et al. [12], U.S, NCT01125956 (2010-05-19)	Diabetes (118), 50–70, 6-month	Cash, Arm3: $100 by dropping HbA1c by 1% and $200 by dropping it by 2% or to a HbA1c of 6.5%	Arm1: Control (*n* = 39) Arm2: Peer Mentoring (*n* = 39) Arm3: Financial incentive (*n* = 40)	–	*Mean change in HbA1c* Arm1: −0.01 (95% CI −0.52 to 0.51) Arm2: −1.08 (95% CI −1.62 to −0.54)* Arm3: −0.46 (95% CI −1.02 to 0.10) (*, vs. arm1 $P < 0.05$)	–
Sen et al. [13], U.S, NCT01282957(2011-01-25)	Diabetes (75), 54.3 (mean age), 3-month intervention and 3-month follow-up	Cash, Arm 2: lottery incentive with expected daily value of $2.8 for daily blood glucose monitoring Arm3: lottery incentive with expected daily value of $1.40 for daily blood glucose monitoring	Arm1: Control (*n* = 28) Arm2: Low-incentive (*n* = 26) Arm3: High-incentive (*n* = 21)	*Total adherence rates* *intervention period* Arm1: 58% Arm2: 81%* Arm3: 77%* *follow-up period* Arm1: 27% Arm2: 62%* Arm3: 35% (*, vs. arm1 $P < 0.05$)	–	–
Misra-Hebert et al. [14], U.S	Type 1 and 2 diabetes (3184), more than 90% of individuals aged over 40 years, 1 year	Noncash, 15% health insurance premium discount ($300-$600) tied to achievement of clinical goals	Employee Patients (E): financial incentive; Matched Non-Employee Comparison Group (C) 2010–2011 Cohort E (727); C (727) 2011–2012 Cohort E (865); C (865)	–	*Mean change year 2–year 1 in HbA1c* 2010–2011 Cohort E: −0.08; C: −0.05 2011–2012 Cohort E: −0.18*; C: −0.26* (*, vs. year 1, $P < 0.05$)	–

Table 1 (continued)

Study, country, registration number	Participants (*n*), age, duration	Features of the financial incentives	Intervention	Results		
				Individual behaviour	Diabetes control	Cost effectiveness
Fernandes et al. [15], U.S	Type 1 and 2 diabetes (320), >18, 11–20 month	Noncash, up to $320/year, blood glucose monitoring ≤ $20; diabetes education session ≤ $20; pneumococcal or influenza vaccination ≤ $10; retinal eye examination ≤ $20; urine microalbumin test ≤ $10; cholesterol testing ≤ $20; HbA1c testing ≤ $20; reduction in HbA1c by 1% ≤ $20; HbA1c at 7% goal ≤ $50; blood pressure control < 140/90 mmHg ≤ $20; low density lipoprotein cholesterol < 100 mg/dL ≤ $20; if applicable, smoking cessation class ≤ $20; counseling with behavioral health ≤ $20; and achieve weight loss of 7% ≤ $50 for those with a BMI ≤ 25	Arm1: Control (*n* = 159) Arm2: Financial incentive (*n* = 161)	–	No statistically significant improvements in HbA1c	No reduction in total health cost

Table 1 (continued)

Study, country, registration number	Participants (*n*), age, duration	Features of the financial incentives	Intervention	Results		
				Individual behaviour	Diabetes control	Cost effectiveness
Fernandes et al. [16], U.S	Type 1 and 2 diabetes (2003), 54.1 (mean age), 1–2 year	Noncash, up to $320/year, blood glucose monitoring ≤ $20; diabetes education session ≤ $20; pneumococcal or influenza vaccination ≤ $10; retinal eye examination ≤ $20; urine microalbumin test ≤ $10; cholesterol testing ≤ $20; HbA1c testing ≤ $20; reduction in HbA1c by 1% ≤ $20; HbA1c at 7% goal ≤ $50; blood pressure control < 140/90 mmHg ≤ $20; low density lipoprotein cholesterol < 100 mg/dL ≤ $20; if applicable, smoking cessation class ≤ $20; counseling with behavioral health ≤ $20; and achieve weight loss of 7% ≤ $50 for those with a BMI ≤ 25	Arm1: Financial incentive (*n* = 2003)	Percentage of annual eye exams increased from 38.7 to 46.9%; Screening for microalbumin increased from 38.6 to 50%; Attendance of diabetes education sessions increased from 16.8 to 41.6%; Testing for HbA1c and lipids increased from 54.3 to 77.1% and 45.6 to 62.6% respectively	Mean HbA1c decreased from 8.56 to 8.24% ($P < 0.0001$)	The amount billed and paid increased by 60.0 and 61.9%, respectively
Miranda et al. [22], Peru, NCT02891382 (2016-09-07)	Type 2 diabetes (54), 55 (mean age), 3-month	Cash, $25 for lost one kilogram in two weeks; $62 by dropping HbA1c < 1%; $124 by dropping it HbA1c ≥ 1% or to a HbA1c ≤ 6.5%. (In Arm 1 and Arm 2, the participant received the reward. In Arm 3, both the participant and their partner received 50% of the cash reward each.)	Arm1: Individual incentives (*n* = 18) Arm2: Mixed incentives-altruism (*n* = 18) Arm3: Mixed incentives-cooperation (*n* = 18)	–	*Mean change in HbA1c* Arm1: −1.4 ± 1.4* Arm2: −0.9 ± 1.2*# Arm3: −1.1 ± 1.6*# (*, vs. baseline within arm $P < 0.05$; #, vs. arm1 $P = 0.05$)	–

Table 1 (continued)

Study, country, registration number	Participants (*n*), age, duration	Features of the financial incentives	Intervention	Results		
				Individual behaviour	Diabetes control	Cost effectiveness
Egede et al. [17], U.S, NCT02722499 (2016-03-30)	Type 2 diabetes (60), 57.4 (mean age), 3-month	Cash, up to $300, Arm1: absolute percentage drop in HbA1c; Arm2: uploading glucose measurements using home testing, and absolute percentage drop in HbA1c; Arm3: uploading glucose measurements using home testing, attending weekly phone educational sessions, and absolute percentage drop in HbA1c	Arm1: Low frequency incentive ($n=20$) Arm2: Moderate frequency incentive ($n=20$) Arm3: High frequency incentive ($n=20$)	–	*3-month mean drop in HbA1c* Arm1: −1.25%* Arm2: −1.73%* Arm3: −1.74%* (*, vs. baseline within arm $P<0.05$)	*Incremental cost effectiveness ratios (ICER) to decrease HbA1c by 1%* Arm1: −1100 (95% CI −2363 to 162) Arm2: −1100 (95% CI −1716 to −484) Arm3: −1100 (95% CI −1549 to −651)
Bilger et al. [21], Austria, NCT02224417 (2014-08-25)	Diabetes (240), 55.23 (mean age), 6-month	Cash, up to $10.36 weekly, Arm2: $2.59 weekly by measuring blood glucose on three non-consecutive days, $0.37 daily by taking medication, and $0.74 daily by completing 8000 steps, Arm3: $1.48 weekly for achieving one pre-meal glucose reading within 4–7 mmol/L, $5.18 for two such readings, or $10.36 for three readings within this range in a week	Arm1: usual care plus ($n=61$) Arm2: process-based incentive ($n=87$) Arm3: outcome-based incentive ($n=92$)	*Incremental effect of incentive (Arm2+Arm3 vs. Arm1)* 1.Mean no. of glucose readings days 0.40 (95% CI 0.04 to 0.76) 2.Mean no. of medication adherent days 0.72 (95% CI 0.05 to 1.38) 3.Mean no. of physically active days 1.12 (95% CI 0.38 to 1.86) *Incremental effect of Arm3 vs. Arm2* 1.Mean no. of glucose readings days −0.06 (95% CI −0.45 to 0.32) 2.Mean no. of medication adherent days −0.64 (95% CI −1.32 to 0.04) 3.Mean no. of physically active days −1.37 (95% CI −2.13 to −0.06)	*Incremental effect of incentive (Arm2+Arm3 vs. Arm1)* 1.Mean change in HbA1c −0.31 (95% CI −0.67 to 0.06) 2.Proportion of participants who had improvement in HbA1c at month 6 0.18 (95% CI 0.04 to 0.31) 3.Mean no. of glucose readings within acceptable range 0.32 (95% CI 0.07 to 0.57) *Incremental effect of Arm3 vs. Arm2* 1.Mean change in HbA1c −0.05 (95% CI −0.42 to 0.31) 2.Proportion of participants who had improvement in HbA1c at month 6 −0.02 (95% CI −0.14 to 0.11) 3.Mean no. of glucose readings within acceptable range 0.07 (95% CI −0.21 to 0.34)	–

Table 1 (continued)

Study, country, registration number	Participants (*n*), age, duration	Features of the financial incentives	Intervention	Results		
				Individual behaviour	Diabetes control	Cost effectiveness
Mashru et al. [20], Canada	Type 1 or 2 diabetes (116), >18, 2-years	Noncash, $5 gift card for every HbA1c test, up to a maximum of two gift cards	Arm1: financial incentive + remind letter ($n=60$) Arm2: remind letter ($n=56$)	*Average number of HbA1c tests completed* Arm1: 4.23 ± 2.18* Arm2: 3.65 ± 2.01 (*, vs. Arm2 $P<0.05$)	–	–
Al Kathiry et al. [23], Saudi Arabia	Type 2 diabetes (702), 56.14 (mean age), 9-month	Cash, $400 to patients and $534 to physicians for achieving the target HbA1c level	Arm1: financial incentive	–	The average HbA1c difference between the first and the third visits was 0.69 (±SD = 2.80) with $P<0.001$	–
Wong et al. [18], U.S	Type 1 Diabetes (90), 16.3 (mean age), 3-month intervention and 3-month follow-up	Cash, Participants were required to achieve daily blood glucose monitoring goals of at least 4 checks per day, with at least 1 reading within the range of 3.9–10 mmol/L, using a wireless glucometer, with a $60 monthly incentive deposited into a virtual account during the 3-month intervention, with $2 deducted for each day of nonadherence to monitoring goals	Arm1: Control ($n=45$) Arm2: Financial incentive ($n=45$)	*Proportion of participant-days achieving glucose monitoring goals* *Incentive Period* Arm1: 18.9 Arm2: 50* *Follow-up Period* Arm1: 8.7 Arm2: 15.3 (*, vs. Arm1 $P<0.05$)	*Mean change in HbA1c* *Incentive Period* Arm1: −0.24 (95% CI −0.66 to 0.17) Arm2: −0.56 (95% CI −0.97 to −0.14) *Follow-up Period* Arm1: −0.17 (95% CI −0.51 to 0.17) Arm2: −0.43 (95% CI −0.89 to 0.03)	–

Table 1 (continued)

Study, country, registration number	Participants (*n*), age, duration	Features of the financial incentives	Intervention	Results		
				Individual behaviour	Diabetes control	Cost effectiveness
Nally et al. [19], U.S	Type 1 Diabetes (17), 15.9 (mean age), 16-week intervention and 8-week follow-up	Cash, up to $717, $1 daily for wearing and calibrating the CGM twice daily and $1 daily for administering at least 3 mealtime insulin boluses daily. $3 bonus for remaining in auto mode at least 70% of the time in the first week, and the bonuses increased by $5 per week for each consecutive week up to a cap of $13 per week, $5 weekly reinforcements for uploading their insulin pump and CGM data to CareLink, $10 per week in weeks 7 to 16 for informing study staff by email or text that they had reviewed their CareLink data and how they planned to adjust their treatment regimen during the following week, $90 for reviewing the CareLink Sensor Daily Overlay Report derived from the insulin pump and CGM	Arm1: Financial incentive (17)	–	*Mean HbA1c levels* baseline: 8.6 6-week: 8.1* 12-week: 8.1* 16-week: 8.0* 24-week: 8.3 (*, vs. baseline $P < 0.05$)	–

HbA1c glycated haemoglobin, *CGM* continuous glucose monitoring

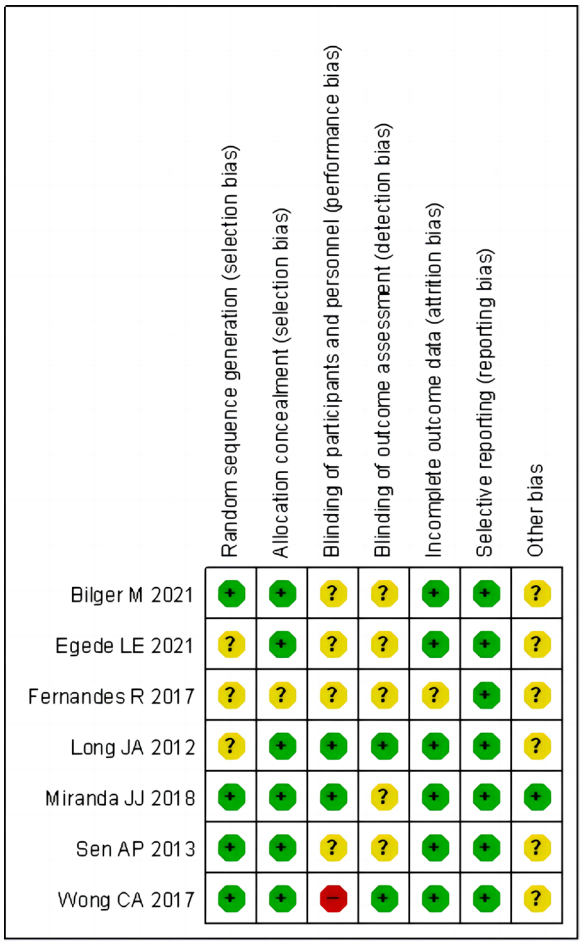

Fig. 2 Risk of bias summary

diabetic nephropathy, attendance at diabetes education sessions, and testing for HbA1c and lipids. Furthermore, Bilger et al. [21] implemented both process-based incentives (blood glucose testing, medication adherence, and exercise), and outcome-based incentives for attaining pre-meal blood glucose levels within 4–7 mmol/L, with results indicating increased blood glucose monitoring frequency, medication compliance, and physical activity adherence compared to the control group.

Impact of the financial incentive on diabetes control

Ten studies analyzed the impact of financial incentive on HbA1c levels in diabetes patients, as shown in Fig. 4. Among them, 5 studies reported that financial incentive can improve HbA1c levels through longitudinal historical comparison. One of the five studies, an observational study with 2003 participants by Fernandes et al. [15, 16] also conducted a 320 RCT, showing no statistically significant change in HbA1c levels compared to the control group. Miranda et al. [22] investigated the impact of "supportive" partners on behavior changes in type 2 diabetes patients receiving cash rewards. The results indicated that in Arm 2 (patients with partners but cash rewards given to patients), HbA1c decreased by 0.9; in Arm 3 (participants with partners but cash evenly distributed to patients and partners), HbA1c decreased by 1.1; and in Arm 1 (patients without partners, receiving cash rewards), HbA1c decreased by 1.4. The *P*-values for both Arm 2 and Arm 3 compared to Arm 1 were 0.05. In Egede et al.'s [17] study, participants were divided into three arms: Arm 1 received a single incentive for absolute HbA1c reduction, Arm 2 received a two-part incentive for home glucose testing and absolute HbA1c reduction, and Arm 3 received a multiple-component incentive for home testing, attendance of weekly telephone education classes, and absolute HbA1c reduction. Participants in Arm 1 exhibited an average HbA1c reduction of 1.25%, in Arm 2 the reduction was 1.73%, and in Arm 3 it was 1.74%, all of which were significantly different from baseline ($P=0.002$ for Arm 1, $P<0.001$ for Arms 2 and 3). Al Kathiry et al. [23] provided financial incentives to patients and his/her physician for achieving a significant decrease in HbA1c levels, resulting in a mean HbA1c difference of 0.69 ($\pm SD=2.80$) between the first and third visits, with a *P*-value of <0.001.

In 10 studies investigating the impact of financial incentives on HbA1c levels in diabetes patients, 5 studies did not find significant improvement compared to the control group. The research findings from Bilger et al. [21] indicated no statistically significant difference in HbA1c levels compared to the control group. However, the proportion of participants showing improvement

Table 2 The Newcastle–Ottawa quality assessment scale of including studies

Study	Selection	Comparability	Assessment of outcome	Quality score
Fernandes et al. [16]	4	2	2	8
Al Kathiry et al. [23]	3		3	5
Nally et al. [19]	2		1	3
Misra-Hebert et al. [14]	5	2	2	8

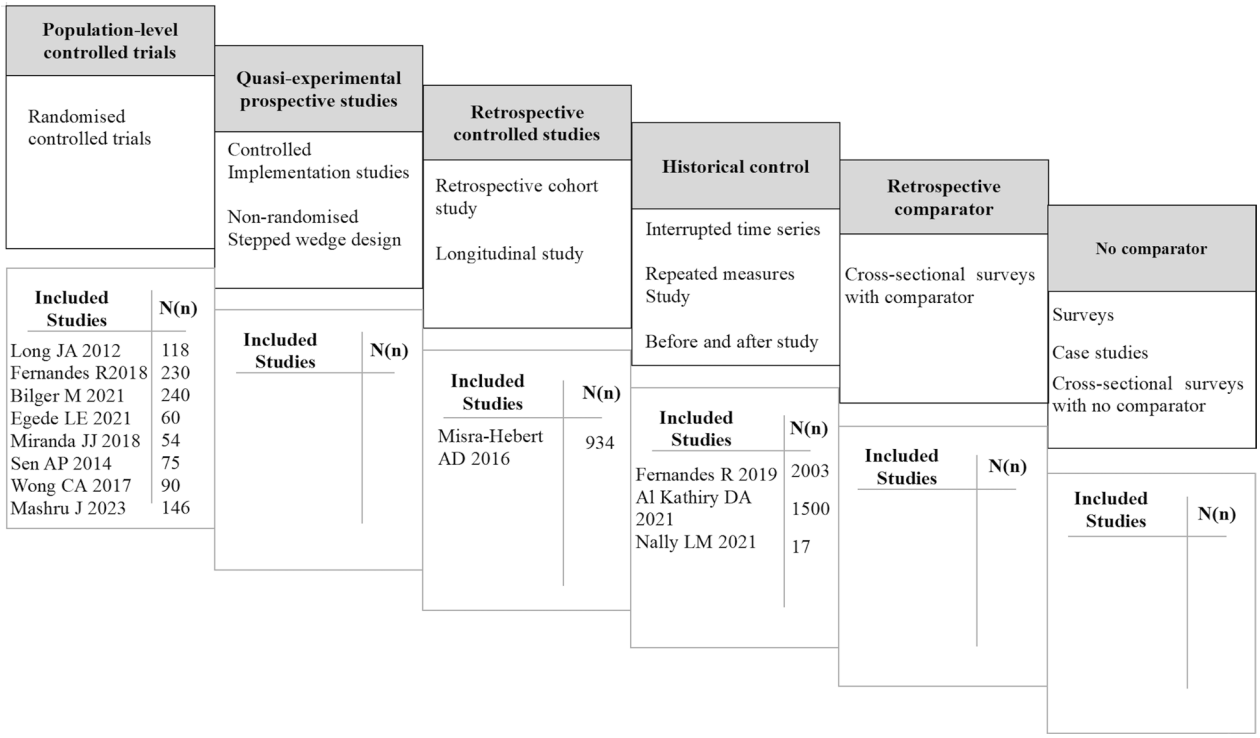

Fig. 3 Hierarchy of included studies. Hierarchy based on: randomisation and status of comparator groups; prospective/retrospective design

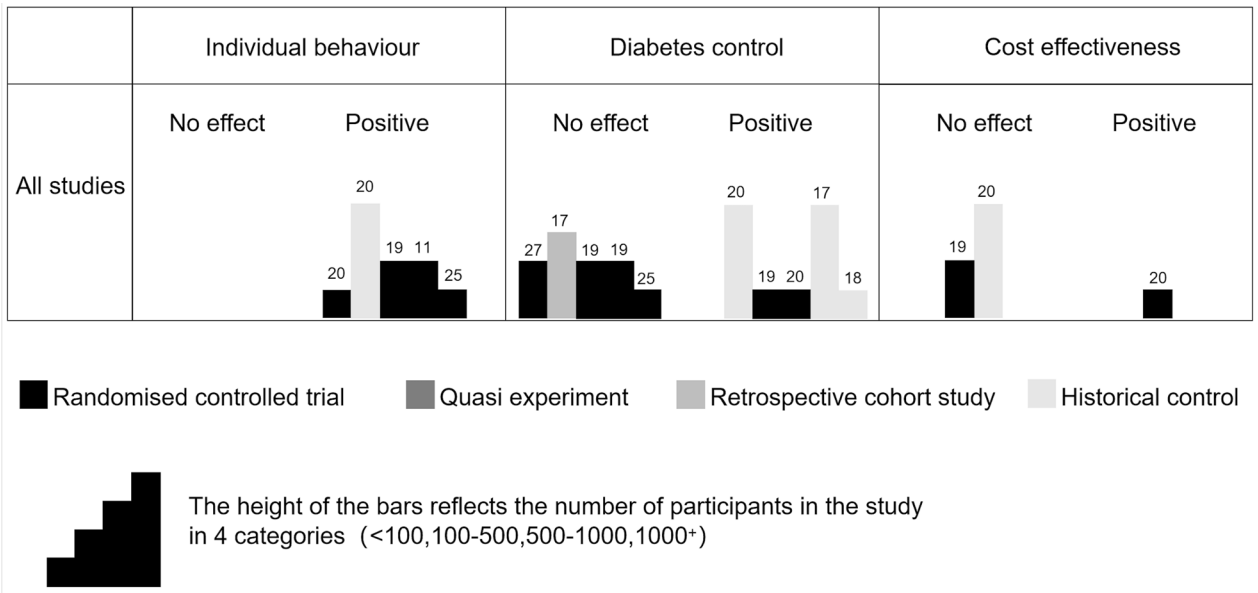

Fig. 4 Harvest plot. Visualizing the Impact of Financial Incentive Schemes on individual behavior, diabetes Control and cost-effectiveness. Each bar in the chart represents an individual study. The color of the bar indicates the study design, while the height reflects the number of participants in the study. Additionally, the number displayed on each bar represents the Downs and Black quality score

in HbA1c at month 6 and the mean number of glucose readings within an acceptable range were significantly higher than those in the control group.

The long-term effects of financial incentives

Three studies explored long-term effects, two studies targeting the adolescent population had no impact, and one study targeting adults had a positive impact. En AP et al. found that following a 3-month follow-up period, the compliance rates for daily blood glucose monitoring were significantly higher in the low incentive arm (62%) compared to the high incentive arm (35%, $P=0.015$) and the control group (27%, $P=0.002$). During the 3-month follow-up period, Wong et al. [18] observed no significant enhancement in compliance with blood glucose monitoring targets (15.3 vs. 8.7%, $P=0.20$), and there was no significant discrepancy in the change in HbA1c levels from baseline between groups. Nally et al. [19] demonstrated a rebound in HbA1c levels to baseline during the 8-week follow-up period.

The cost-effectiveness of financial incentives

Three studies, involving two incentive measures, examined the cost-effectiveness of financial incentives, as shown in Fig. 4. Fernandes et al. [15, 16] conducted a pre-post observational study with 2,003 participants and a RCT with 320 participants. The cost analysis, encompassing expenses related to outpatient, inpatient, emergency room, skilled nursing, hospice, prescription drugs, and dental care, indicated an increase in both billed (60%) and paid (61.9%) amounts in the observational study, while the RCT showed no change. Egede et al. [17] assessed the cost-effectiveness of three economic incentive structures, outlined above, for attaining a 1% decrease in HbA1c levels among adult diabetes patients. The cost analysis factored in intervention costs, healthcare visit expenses over a 3-month period, and the cost of missed workdays due to illness. Incremental cost-effectiveness ratios (ICERs) for achieving the target reduction were $1,100 for all three arms. Statistically significant ICERs were observed for Arms 2 and 3 ($P<0.001$), suggesting their cost-effectiveness.

Discussion

Statement of principal findings

A total of 12 studies reporting on financial incentives in diabetes management met the inclusion criteria and were included in the review. Five studies investigated the influence of financial incentives on patient behavior, all demonstrating a significant positive impact on behaviors such as blood glucose monitoring, medication adherence, and physical activity. 10 studies analyzed the impact of financial incentives on HbA1c levels in diabetes patients. Among them, 5 studies reported that financial incentives could improve HbA1c levels through longitudinal historical comparisons. The other 5 studies did not find significant improvements compared to the control group.

Interpretation of findings in relation to previously published work

The consistent findings support the notion that financial incentives can enhance patient compliance, as observed in other studies [24, 25]. However, in contrast to prior studies, this review did not identify a correlation between blood glucose monitoring frequency and glycemic control [26, 27]. The reasons for these pessimistic results are multifaceted. Firstly, patients with diabetes can be categorized into three stages [28, 29]: the "unbearable" stage, occurring before and after diagnosis, characterized by the urgent need to acquire knowledge, skills, and behaviors about diabetes driven by fear of complications; the "stable" stage, where individuals have developed effective self-management procedures and gained basic knowledge, resulting in increased confidence and reduced fear of complications; and the "change" stage, encompassing both acute and chronic changes in self-management, motivation, and support needs for diabetes. The financial incentive frame for patients with diabetes must take into account the changes of self-management, incentive and support needs over time. Secondly, the sample size analyzed by the RCTs with a control group on the impact of economic incentives on HbA1c levels is relatively small, ranging from 90 to 320 participants. Designing RCTs with larger sample sizes would help validate the findings observed in observational studies. Thirdly, factors beyond adherence to blood glucose monitoring may exert a greater influence on HbA1c levels, such as inadequate responses to high glucose levels. Additionally, Bilger et al.'s [21] findings suggest no statistically significant difference in HbA1c levels compared to the control group. However, the proportion of participants showing improvement in HbA1c at month 6 and the mean number of glucose readings within an acceptable range were significantly higher than those in the control group. When analyzing the results, it's beneficial to consider additional indicators beyond glycated hemoglobin, such as the mean number of glucose readings within an acceptable range, to understand the effectiveness of interventions in promoting improvements in HbA1c levels. Moreover, when the HbA1c levels of participants significantly decrease, rewarding their attending physician can also help improve HbA1c levels, which needs further validation through randomized controlled trial studies.

Sustainability of behavioral change and long-term health outcomes

While financial incentives have shown considerable promise in improving short-term behaviors such as medication adherence and regular monitoring in diabetes management, the long-term sustainability of these effects remains uncertain. Research suggests that behavior may revert to baseline levels after incentives are withdrawn. For example, Fernandes et al. [15, 16] observed improvements in short-term diabetes outcomes such as blood glucose monitoring, but these were not sustained in the long term once financial rewards were removed [16]. Another study highlighted that financial incentives are more effective for simpler, one-off behaviors but have diminishing returns for complex, sustained behaviors like continuous diabetes management [30]. Moreover, reliance on external rewards may diminish intrinsic motivation, making it difficult for patients to maintain behavior once the incentive is no longer available [21].

Recent studies suggest that integrating financial incentives with intrinsic motivation strategies—such as patient education, empowerment, and behavioral support—could result in more sustainable behavioral changes. A study by Egede et al. indicated that multi-component incentive structures, which combined financial rewards with educational support, led to better health outcomes in diabetes management [17]. Another approach could involve providing smaller, more frequent rewards, which have been shown to foster intrinsic motivation while maintaining adherence over time [31].

Future studies should focus on hybrid models combining financial incentives with behavioral interventions, as well as: (1) Testing intermittent or periodic financial incentives to sustain motivation without creating dependency on continuous external rewards [17]; (2) Conducting long-term studies to assess whether short-term improvements in HbA1c translate into reduced complications and healthcare costs [14].

The cost-effectiveness of financial incentives

The cost-effectiveness of financial incentives in diabetes management has been highlighted in various studies. For instance, Egede et al. demonstrated that the ICER for achieving a 1% reduction in HbA1c through financial incentives was approximately $1100. This makes financial incentives a cost-effective short-term strategy to improve glycemic control [17]. In comparison, lifestyle interventions, such as those employed in the Diabetes Prevention Program, have been shown to have ICERs between $2500 and $5000 per Quality-Adjusted Life Year. These programs, while effective, are more resource-intensive and require a sustained effort over time [32]. Similarly, medication adherence interventions, such as pharmacist-led adherence programs, report ICERs ranging from $1000 to $3000 per 1% reduction in HbA1c, depending on the population and intervention used [33]. Financial incentives, which typically involve fewer resources and lower costs compared to lifestyle and medication adherence programs, offer a competitive and practical alternative, particularly for short-term improvements in glycemic control. However, the long-term cost-effectiveness of financial incentives is less well-studied, and additional research is needed to evaluate whether these interventions lead to sustained cost reductions in healthcare over time.

Heterogeneity of study designs and impact on reported outcomes

The included studies exhibit considerable methodological diversity, ranging from RCTs to quasi-experimental and cohort studies. RCTs generally provide a higher level of evidence due to their ability to reduce bias through randomization, blinding, and control groups. However, only a minority of the included studies utilized this design, with others employing observational or quasi-experimental designs, which may introduce confounding factors and limit the internal validity of the findings [14, 17]. For example, Egede et al. [17] and Misra-Hebert et al. [14] used robust designs with longer follow-up periods to assess financial incentives, reporting stronger associations between incentive interventions and glycemic control improvements [34]. In contrast, studies that used quasi-experimental methods or cohort designs, such as Fernandes et al. [15, 16] tended to report more variable outcomes, possibly due to the increased risk of selection bias and other uncontrolled variables.

The quality of the included studies was assessed using the Cochrane Risk of Bias tool for RCTs and the Newcastle–Ottawa Scale for non-randomized studies. Higher-quality studies generally reported more consistent results, particularly regarding the positive effects of financial incentives on diabetes management. Lower-quality studies, characterized by the lack of randomization or control groups, often presented more ambiguous or conflicting results, highlighting the need to interpret their findings cautiously [35]. For instance, studies with higher NOS scores showed a clear correlation between financial incentives and improved adherence to self-care behaviors, while lower-quality studies were less definitive. This suggests that methodological rigor significantly impacts the reliability of reported outcomes.

Limitations

The diversity of methodologies employed in studies examining financial incentives provided to patients with diabetes for self-management has posed challenges in

comparing findings across research endeavors. Hence, we followed the methodology outlined in Pinnock et al. [9] and categorized studies based on the robustness of their methodologies, participant numbers, and quality scores. However, several questions on the quality checklist utilized in this review were not suitable for the included papers, resulting in lower quality scores. While 8 RCTs were encompassed, 2 RCTs lacked a control group without financial incentives. Additionally, the risk of bias in certain studies could not be fully evaluated and was thus classified as unclear. Several articles did not adequately elucidate the random sequence generation mode, rendering it challenging to ascertain whether selection bias was at a low risk. Furthermore, we included some non-RCTs, which are acknowledged to carry a higher risk of bias compared to RCTs. However, they were included in this review as they met our inclusion criteria and are discussed accordingly. Given the heterogeneity of the study designs, we conducted a narrative analysis rather than a meta-analysis. Consequently, we were unable to generate funnel plots to assess the extent of publication bias.

Conclusion

In summary, this review found that financial incentives can positively influence patient behavior and enhance compliance, but their impact on HbA1c levels is inconsistent. Financial incentives may help adult patients maintain behavior even after the withdrawal of incentives. However, methodological diversity and limitations in study quality warrant caution in interpreting findings. A large-sample, controlled randomized controlled trial is crucial for comprehensively investigating the impact of financial incentives on HbA1c improvement, assessing long-term effects, and evaluating cost-effectiveness.

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XW and QQZ extracted and analyzed data from the included papers. JZ drew figures and tables. YCW and YL were major contributors in writing the manuscript. All authors read and approved the final manuscript.

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Declarations

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