



# The Impact of Digital Health Interventions for the Management of Type 2 Diabetes on Health and Social Care Utilisation and Costs: A Systematic Review

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Accepted: 26 September 2022  
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## Abstract

**Background** Digital health interventions such as smartphone applications (mHealth) or Internet resources (eHealth) are increasingly used to improve the management of chronic conditions, such as type 2 diabetes mellitus. These digital health interventions can augment or replace traditional health services and may be paid for using healthcare budgets. While the impact of digital health interventions for the management of type 2 diabetes on health outcomes has been reviewed extensively, less attention has been paid to their economic impact.

**Objective** This study aims to critically review existing literature on the impact of digital health interventions for the management of type 2 diabetes on health and social care utilisation and costs.

**Methods** Studies that assessed the impact on health and social care utilisation of digital health interventions for type 2 diabetes were included in the study. We restricted the digital health interventions to information provision, self-management and behaviour management. Four databases were searched (MEDLINE, EMBASE, PsycINFO and EconLit) for articles published between January 2010 and March 2021. The studies were analysed using a narrative synthesis approach. The risk of bias and reporting quality were appraised using the ROBINS-I checklist.

**Results** The review included 22 studies. Overall, studies reported mixed evidence on the impact of digital health interventions on health and social care utilisation and costs, and suggested this impact differs according to the healthcare utilisation component. For example, digital health intervention use was associated with lower medication use and fewer outpatient appointments, whereas evidence on general practitioner visits and inpatient admissions was mixed. Most reviewed studies focus on a single component of healthcare utilisation.

**Conclusions** The review shows no clear evidence of an impact of digital health interventions on health and social care utilisation or costs. Further work is needed to assess the impact of digital health interventions across a broader range of care utilisation components and settings, including social and mental healthcare services.

**Clinical Trial Registration** The study protocol was registered on PROSPERO before searches began in April 2021 (registration number: CRD42020172621).

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## Key Points for Decision Makers

In this paper, we critically review and describe studies that assess the impact of digital health interventions in type 2 diabetes mellitus on healthcare utilization and cost.

We found that the impact of digital health may differ according to the care sector, such as medications or different types of appointments.

Drawing on the findings of this review, we propose some areas for further work, including an assessment of the impact of digital health interventions across a broader range of care utilisation components and settings, such as social and mental healthcare services.

## 1 Introduction

The number of digital health interventions (DHIs) delivered through devices such as smartphones, tablets or computers has increased exponentially [1]. Such DHIs have been used to facilitate remote access to effective treatments, improve the management of chronic conditions and promote healthy behaviours. Previous systematic reviews have synthesised evidence about the impact of DHIs on health outcomes and patient experience [2, 3]. However, the economic impact of DHIs is less well understood. On the one hand, one might expect DHIs to be cost saving because they may help deliver healthcare more efficiently. On the other hand, the implementation of DHIs may imply large investments by the health system, for example, restructuring care pathways and health services, implementation costs and staff training and upskilling. While economic evidence is rapidly emerging, the overall direction and magnitude of the economic impact of DHIs is unclear.

One of the areas where DHIs have received considerable attention is the management of type 2 diabetes [4]. Digital health interventions are particularly valuable in this context because they can facilitate the management of the condition and encourage behavioural change (e.g. diet and exercise) [5]. Studying the economic impact of DHIs in type 2 diabetes is crucial because the burden of disease is large [6], and hence, there is ample scope to deliver more health gains from scarce health and social care resources. A recent study [7] reviewed cost-effectiveness analyses of DHIs for the prevention and control of type 2 diabetes but the focus was on DHIs delivered through smartphones and included decision-analytical modelling studies.

Our study aims to critically review the impact of DHIs for the management of type 2 diabetes across a broad range of health and social care services and their associated costs. The review focuses on DHIs that seek to promote or manage health and well-being through supporting behavioural change and decision making of the patient diagnosed with type 2 diabetes, sometimes in combination with a healthcare professional. In this population, DHIs may be used for the management of the long-term condition. Such interventions are typically interactive, personalised, based on user input and may be provided at the individual or population level. This review aims to generate a deeper understanding of the economic impacts (on individuals and health systems) of more complex types of DHIs. Simpler forms of DHIs, such as diagnostic and monitoring devices, are much closer to the nature of conventional medical devices, and their economic impact has been reviewed elsewhere [8]. While we focus on a single long-term condition, we anticipate a similar economic impact of DHIs that support behavioural change and decision making across other chronic conditions, such as arthritis or heart disease.

## 2 Methods

The review protocol was registered on PROSPERO (CRD42020172621) [9]. The review includes quantitative assessments of the economic impact of DHIs for type 2 diabetes.

Studies met the inclusion criteria for this review if:

1. they included a population of adults (aged 18 years and above) with type 2 diabetes who had received a DHI for information provision, self-management or behaviour management;
2. comparators were standard care, or information provision or group information sessions, no comparator or other DHIs;
3. the outcomes considered were health and social care utilisation and cost;
4. they were evaluations undertaken in a public or private clinical setting internationally; and
5. they were reported in journal articles published in English.

Studies were excluded if they were studying a patient population with type 1 diabetes, gestational or other rarer forms of diabetes, or the DHI was focussed on comorbidities or complications of type 2 diabetes. They were also excluded if clinicians alone used the interventions, for example decision-support systems, and if the study outcomes were only cost-effectiveness modelling (not including patient-level data) or patient experience or satisfaction alone, not including reporting of health and social care utilisation and costs.

Four databases, MEDLINE, EMBASE, PsycINFO and EconLit, were searched for articles published between January 2010 and March 2021. A search strategy was developed in MEDLINE with the help of an information specialist to ensure proper use of search terms. This strategy was adapted for use in the other databases. Appendix 1 shows the search strategy for all databases. It combined key terms about DHIs, type 2 diabetes and the economic impact in terms of health and social care utilisation and costs.

The database searches were run in April 2021. Duplicates were removed using the Rayyan web application [10] and Endnote referencing software [11]. The first reviewer screened all the records using Microsoft Excel. A second reviewer screened 20% of the included abstracts and full texts for eligibility. Any disputes were discussed between the first and second reviewers. If the conflicts remained, they were referred to a third reviewer.

Templates for data extraction were piloted and adapted to enable key data to be extracted from the included papers. Information was extracted on the characteristics of the studies (i.e. number of participants and participant

characteristics, country, study type, length of follow-up, key outcome measures reported and their results), the impact on health and social care utilisation (e.g. self-reported or administrative data source changes in several types of health and social care utilisation) and the resulting impact on costs (e.g. how cost had changed in the reported follow-up period). The data extraction was reviewed by the third reviewer for quality assurance. The review results were analysed using a narrative synthesis approach, in which themes were identified within the study results that related to the aims of the study [12]. Because of the heterogeneity of the study designs and outcomes measures, it was not possible to perform a meta-analysis.

The ROBINS-I tool [13] was used to appraise all papers by the first reviewer and all studies were also appraised by a second reviewer. It is a quality assessment checklist designed to assess the overall risk of biases in the study design and analysis, including aspects related to: (1) confounding; (2) sample selection; (3) classification and measurement error; (4) deviations from study protocol; (4) missing data; and (5) reporting. Within each of these components, studies can be rated as 'low risk of bias' (comparable to a well-conducted randomised controlled trial [RCT]), 'moderate risk of bias' (sound for a non-randomised trial, but not comparable to a RCT), 'serious risk of bias' (the study has some significant issues that may affect the validity of the results), 'critical risk of bias' (too problematic to provide any useful evidence) and 'no information' (no information on which to base a judgement) if the design or analysis component has not been reported.

### 3 Results

The results of the searches are shown in the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) flowchart (Fig. 1). The database searches identified 617 papers after removing duplicates. These papers were then screened and assessed for eligibility. The reasons for papers to be excluded are outlined in the PRISMA flowchart. During abstract screening, many studies were excluded because they focused on a non-relevant DHI ( $n = 157$ ). For example, they did not consider a DHI at all, or focused on medical devices for type 2 diabetes and interventions that were targeted at clinicians such as decision support systems. Others were excluded because they did not consider impacts on healthcare utilisation and costs ( $n = 159$ ), focused on other types of diabetes or targeted complications (e.g. foot ulcers) of type 2 diabetes ( $n = 53$ ). Systematic reviews synthesising the impact of DHIs on health outcomes and patient experience were also excluded ( $n = 51$ ).

At full-text screening, studies were excluded mainly because they did not evaluate the impact on healthcare

utilisation and costs ( $n = 25$ ), did not focus on type 2 diabetes ( $n = 9$ ) or were not an impact study ( $n = 7$ ). Twenty-two studies were included in the review.

### 3.1 Study Characteristics

The key study characteristics are shown in Table 1. Most studies ( $n = 16$ , 73%) had over 100 participants and were conducted in North America ( $n = 8$ , 36%) or Europe ( $n = 9$ , 41%). Over half of the studies ( $n = 13$ , 59%) were conducted alongside RCTs. Almost half of the studies ( $n = 10$ , 45%) involved a comparison of DHI with treatment as usual, although this meant a variety of face-to-face services across a range of settings (e.g. primary and secondary care). Most studies considered relatively short follow-up periods: five (23%) had a follow-up of up to 6 months and 14 studies (64%) had a follow-up of 6–12 months.

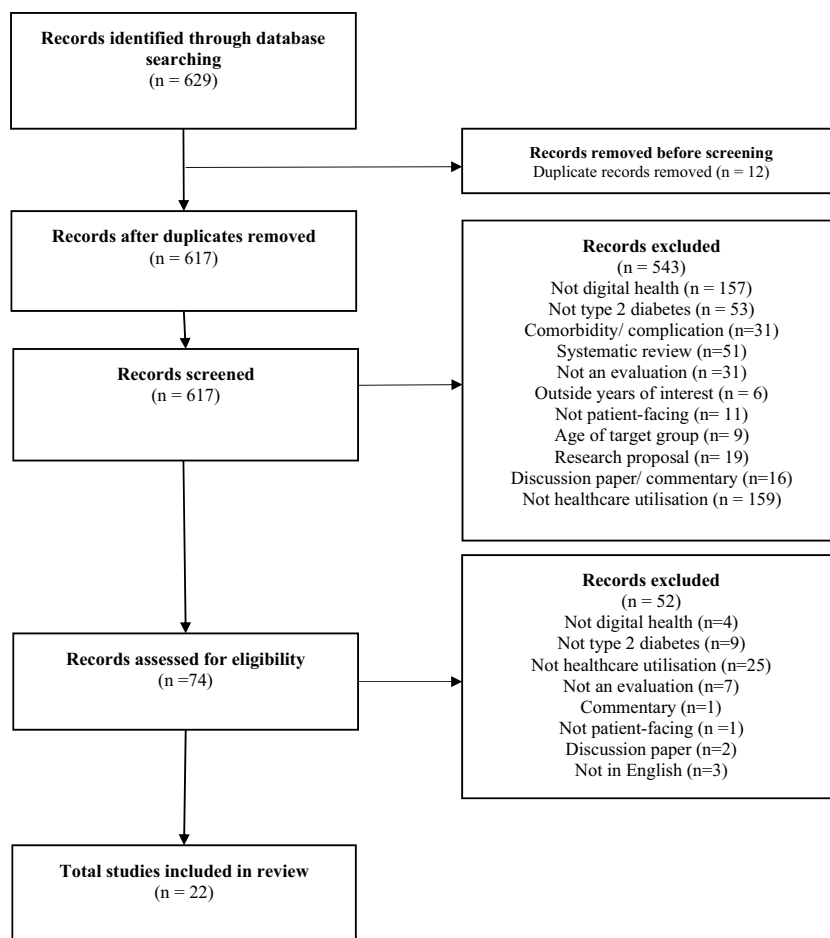
Most studies considered the impact of DHIs on a single component of healthcare utilisation or costs. For example, eight studies reported the impact on medication utilisation (e.g. metformin or insulin) [14–21]. A measurement of HbA1c over 6.5% corresponds to a diagnosis of type 2 diabetes, and management of the condition includes targeting a level of HbA1c below 7%. Five of these were studies in which most patients had HbA1c levels between 7 and 9% [14–18] and the rest had populations where the mean HbA1c level was higher. In the studies where the time since onset was recorded, patients varied from 'newly diagnosed' to later stages of the disease requiring insulin or treatment intensification.

Very few studies ( $n = 3$ , 17%) reported an impact across several primary and secondary care utilisation components [22–24], which included a mix of hospital, general practitioner (GP) and community diabetes-related services. Eight (36%) of the studies were based on self-management (patients monitoring their lifestyle and condition alone) [14, 16, 22, 24–28] and eight more on behaviour management (patients and professionals managing patients' lifestyle and condition) [15, 17, 20, 21, 29–32]. Four (18%) were based on self-management and information provision together [18, 19, 33, 34], one (5%) on behaviour and self-management [23], and another on behaviour management and information provision [35].

### 3.2 Summary of Study Results

The study results are summarised in Table 2. Overall, the direction of the impact of DHIs on health and social care utilisation was mixed, irrespective of the mode of delivery of the DHIs. Four (18%) studies reported an increase in healthcare utilisation [20–22, 33], seven (32%) studies suggested a reduction in care utilisation [16, 18, 24, 27,

**Fig. 1** Preferred reporting items for systematic reviews and meta-analyses (PRISMA) flowchart



28, 30, 34], and five (23%) studies reported both positive and negative economic impacts [17, 25, 26, 31, 32]. Of those studies that reported costs ( $n = 7$ , 31%), six suggested a decrease in costs [15, 19, 24, 28, 29, 35], and one reported increased costs [23]. The magnitude of the cost impact in these studies was relatively small, usually less than \$500 saving per patient over a time horizon of 6–12 months.

The reviewed studies suggest that the impact of DHIs might differ according to the component of healthcare utilisation. For example, DHIs were mostly associated with lower medication use [14–21, 28, 31, 36] and fewer outpatient visits [25, 28–32, 34, 35]. In the studies where the time since onset was recorded, patients varied from ‘newly diagnosed’ to later stages of the disease requiring insulin or treatment intensification. Whereas, the impact of DHIs on GP visits [25, 26, 28, 30, 32, 35], hospital accident and emergency [25–27, 32] and inpatient admission [25, 27, 30, 35] was mixed. In studies that reported impacts across multiple healthcare components and settings of care, the evidence was also mixed [22–24, 35]. None of the studies reported impacts on social care or mental healthcare utilisation.

### 3.3 Quality Assessment

Results of the quality assessment are shown in Table 3. Overall, the risk of bias was relatively low across the reviewed studies [13]. Across the studies included, the most common issues were a lack of appropriate analysis methods for confounding, and missing data (lack of follow-up data for much of the original sample because of a high dropout, or a lack of information about methods for adjusting for missing data).

Twelve (55%) RCTs were included in the analysis [15–17, 19, 23–26, 29, 32, 34, 35] with the vast majority being judged ‘low risk’ in all categories. The remaining ten (45%) [14, 18, 20–22, 27, 28, 30, 31, 33] studies were non-randomised, with three of them being rated ‘high risk’ because of potential issues with confounding [22, 27, 30]. Two studies were judged as having ‘moderate risk’ [20, 30] because of sample selection issues. Two of the observational studies provided insufficient information on missing data [21, 31] and were classified as ‘no information’.

**Table 1** Summary of study characteristics

Number of participants	Number of studies ( <i>n</i> = 22)	Percentage of studies (%)
< 50	4	18
50–100	2	9
101–200	7	32
> 200	9	41
Country		
Europe	9	41
North America	8	36
Other	5	23
Study design		
RCT	12	55
Non-randomised study	10	45
Length of follow-up (months)		
<6	5	23
6–12	14	64
>12	3	14
Control group		
TAU/standard care	12	55
Other DHI	3	14
None	7	32
Economic outcome*		
Health and social care utilisation	18	82
Cost	7	32
Care component		
Medication	8	36
Hospital episode	3	14
Multiple items	11	50
DHI type		
Self-management	8	36
Behaviour management	8	36
Other	6	27

\*Three studies reported both service use and costs [24, 28, 35]

*DHI* digital health intervention, *RCT* randomised controlled trial, *TAU* treatment as usual

## 4 Discussion

### 4.1 Summary of Findings

This study critically assessed published evidence on the economic impact of DHIs for type 2 diabetes on health and social care utilisation and costs. Overall, the review suggests that the direction of the impact of DHIs on healthcare utilisation is mixed and might differ according to the healthcare utilisation component. In particular, DHIs seem to be associated with a reduction in medication and fewer diabetes-related outpatient appointments. The vast majority of studies evaluating the impact of DHIs on healthcare costs reported a decrease in costs. The overall risk of biases in the

reviewed studies is relatively low; the vast majority of the non-randomised studies was rated ‘low’ or ‘moderate’ risk across most bias components.

### 4.2 Contributions

This is the first study to comprehensively review the economic impact of DHIs for type 2 diabetes. Overall, our review suggests that the case for an economic benefit is not as clear as the clinical benefit shown in previous systematic reviews [3, 37]. The study also shows that the existing evidence base is limited because of the short follow-ups of many studies evaluating interventions for type 2 diabetes, and the difficulty in comparing heterogeneous results for the impact on service utilisation and costs. We have also shown that studies report a limited number of cost dimensions and do not show a benefit as clearly in the costliest types of care (e.g. hospital admissions). However, the studies have included participants at a range of various stages of the disease in terms of the time since diagnosis and the duration of type 2 diabetes symptoms (which may or may not be linked).

A recent study [7] reviewed the cost-effectiveness evidence on mHealth interventions for type 2 diabetes and suggested that, overall, these tend to provide good value for money. This does not necessarily mean that the mHealth interventions considered in that study led to lower costs as they can be cost effective even if they are more costly than the comparator. However, this review [7] focused on (modelling-based) cost-effectiveness analyses, and interventions delivered through smartphones, whereas our study included a broader range of DHIs and all types of economic impact evaluations. By reviewing a more comprehensive range of impact studies, we find that the economic impact of DHIs may not be as well understood as suggested by the previous review.

Our review also found that the economic impact of DHIs might differ across the different types of healthcare utilisation. In fact, it suggests that potential economic benefits are most likely to materialise in certain care components such as medication and insulin use, or outpatient attendances [15, 16, 18, 19, 29, 34]. Unlike previous reviews [7], our study considered the impact of DHIs on both health and social care utilisation and costs, but found no evidence on the impact on social, community and informal care services.

### 4.3 Limitations

One of the limitations of this review is that it did not consider grey literature or studies published in languages other than English. It was deemed important to include high-quality evidence and full evaluations such as RCTs and large

Table 2 Summary of study results

First author (year)	Country	N	Study design	Follow-up	Intervention approach	Mode of delivery	Control	Health and social care utilisation category	Effect on health care utilisation	Effect on cost
Agarwal (2019)	Canada	223	RCT	3 months	Self-management	App	Usual care	Primary, outpatient, emergency and inpatient	Mixed	
Al Hayek (2021)	Saudi Arabia	105	Prospective observational	12 weeks	Self-management	App	None	Total healthcare	Increase	
Arora (2014)	USA	128	RCT		Self-management	Text	Usual care	Primary and emergency	Mixed	
Fico (2020)	Italy, Czech Republic, Spain	7*	Prospective observational	4 weeks	Self-management	Web	None	Medication	No difference	
Fountoulakis (2015)	Greece	105	RCT	12 months	Behaviour management	Web	Usual care	Outpatient		Decrease
Gilmer (2019)	Mexico	301	RCT and simulation model	5, 10, 15 and 20 years	Behaviour management/self-management	App	Usual care	Total healthcare		Increase
Gordon (2014)	Australia	120	RCT	6 months	Behaviour management	Mobile and web	Usual care	Medication		Decrease
Katz (2012)	USA	32	Prospective observational	56 weeks treatment group, 10 weeks control group	Self-management	App	None	Emergency and inpatient	Decrease	
Kempf (2017)	Germany	202	RCT	12 months	Self-management	Web	Other DHI	Medication	Decrease	
Li (2018)	UK	374	RCT	12 months	Self-management	Web	Other DHI	Total healthcare	Decrease	Decrease
Lorig (2016)	USA	1242	Prospective observational	12 months	Self-management/information provision	Web	Face-to-face	Diagnostic tests	Increase	
Lu (2020)	China	120	RCT	6 months	Self-management/information provision	Web	Usual care	Medication		Decrease
Luley (2011)	Germany	70	RCT	6 months	Behaviour management	Web	Usual care	Medication	Mixed	
Maxwell (2016)	USA	26	Prospective observational	6 months	Behaviour management	Web	None	Medication	Increase	
McGloin (2020)	USA	40	Prospective observational	12 weeks	Behaviour management	Web	None	Primary, outpatient and inpatient	Decrease	
Menon (2017)	Australia	103	Retrospective observational	1 month	Behaviour management	Web	Face-to-face	Medication	Increase	
Musacchio (2011)	Italy	1004	Retrospective observational	12 months	Behaviour management	Web	None	Medication and outpatient	Mixed	

Table 2 (continued)

First author (year)	Country	N	Study design	Follow-up	Intervention approach	Mode of delivery	Control	Health and social care utilisation category	Effect on health care utilisation	Effect on cost
Nicolucci (2015)	Italy	302	RCT	12 months	Self-management/information provision	Web	Usual care	Outpatient	Decrease	Decrease
Roelofsens (2016)	The Netherlands	633	Prospective observational	12 months	Self-management/information provision	Web	Other DHI	Medication	Decrease	Decrease
Warren (2018)	Australia	126	RCT	6 months	Behaviour management/information provision	Tablet and web	Usual care	Primary, outpatient, emergency and inpatient	Decrease	Decrease
Wild (2016)	UK	307	RCT	9 months	Behaviour management	Web	Usual care	Primary and emergency	Mixed	Decrease
Yu (2020)	Taiwan	97	Prospective observational	8 months	Self-management	App	None	Medication, primary and outpatient	Decrease	Decrease

DHI digital health intervention, RCT randomised controlled trial

observational studies on the impacts of digital health, which are less likely to be reported outside journal articles.

Our study was not able to disentangle potential drivers of the impact of DHIs on health and social care utilisation and costs. Characteristics such as age, duration of disease, ethnicity or gender may have an impact on clinical and economic outcomes, but the reviewed studies have not considered whether the economic impact of DHIs varies across these factors. One notable exception is the evaluation of the HeLP-Diabetes programme, which adjusted for age and disease duration in the economic analysis [24]. Poduval et al.'s qualitative analysis as part of the same study finds that the shorter the duration of diabetes since diagnosis, the greater the likelihood of completing an intervention [38], and hence the higher the costs incurred.

The mix of results found in this review may have been partially explained by differences in care pathways and health financing systems across the different countries included in the review. However, this review was not able to disentangle this, and determine whether the findings are generalisable across jurisdictions. In addition, this review was not able to dissect whether the economic impact of DHIs differs according to whether the DHI complements or substitutes face-to-face health services. The heterogeneity of DHI types in terms of their function (self-management or behaviour management as defined previously) did not appear to have a clear effect on the impact of DHIs. However, the proportion of DHIs reducing service use or cost was slightly higher in DHIS for self-management (seven out of 12) [16, 18, 19, 24, 27, 28, 34] than when service users used the DHIs with healthcare professionals [15, 29, 30, 35].

#### 4.4 Implications for Future Research

This review has identified some gaps in the literature about the impact of digital health for type 2 diabetes on healthcare utilisation. First, DHIs are likely lead to a broad range of health and non-health cost impacts, including those outside the healthcare sector [39]. Hence, studies should account for the potential economic impact across a broader range of sectors, such as social and community care settings, informal care and productivity impacts. Second, DHI software updates and iterations are an important consideration that has received little attention in the reviewed studies. Because digital health is a rapidly moving field, DHIs are likely to be updated during an evaluation. As a result, the interventions themselves may change during an evaluation and it will be important to assess the extent to which the evolving nature of DHIs impacts on health and social care utilisation. Third, further work is warranted to explore which type of patients benefit most from these DHIs and which elements of the DHIs drive this (e.g. therapeutic elements or dose), and how this heterogeneity may impact health and social

**Table 3** Risk of bias

Author (Year)	Potential sources of bias						
	Confounding of intervention effect	Participant selection for characteristics identified post-allocation to a group	Poorly defined or ambiguous interventions	Deviation from intended interventions	Missing data influencing the effect of outcomes	Measurement of outcomes	Selection of the reported result
Agarwal (2019) [25]							
Al Hayek (2021) [22]							
Arora (2014) [26]							
Fico (2020) [14]							
Fountoulakis (2015) [29]							
Gilmer (2019) [23]							
Gordon (2014) [15]							
Katz (2012) [27]							
Kempf (2017) [16]							
Li (2018) [24]							
Lorig (2016) [33]							
Lu (2020) [19]							
Luley (2011) [17]							
Maxwell (2016) [20]							
McGloin (2020) [30]							
Menon (2017) [21]							
Musacchio (2011) [31]							
Nicolucci (2015) [34]							
Roelofsen (2016) [18]							
Warren (2018) [35]							
Wild (2016) [32]							
Yu (2020) [28]							

**Key for risk of bias table**

	Critical risk
	Serious risk
	Moderate risk
	Low risk
	No Information

care utilisation. This is important so that adaptations and iterations of DHIs target the populations that are most likely to benefit from the DHIs and lead to greater savings to the health system.

## 5 Conclusions

The review found mixed evidence on the economic impact of DHIs. Reviewed studies suggested that this impact might differ according to the care component, with DHIs being associated with a reduction in medication and diabetes-related outpatient appointments, but not GP visits or hospital admissions. Future work should consider exploring the economic impact of DHIs across a broader range of care components and settings, and whether this impact is mediated by patient or contextual factors.

## Appendix 1: Search strategies

### MEDLINE

- "diabetes mellitus, type 2"/ or "adult onset diabetes mellitus".mp. or "type 2 diabetes".mp. or "t2dm".mp.
- "Mobile applications"/ or "Telemedicine"/ or "Mobile application\*".mp. or "Telemedicine".mp. or "Digital Health".mp. or "App\* on prescription".mp. or "app".mp. or "Digital prescribing".mp. or "Wearable\*".mp. or "Digital Therapeutic\*".mp. or ("Digital" adj5 "Medicine").mp. or "blood glucose monitoring".mp. or "internet".mp. or "mHealth".mp. or "eHealth".mp. or "remote delivery".mp. or "online".mp. or "website".mp.
- "Health Resources"/ or "health expenditures"/ or "health care use".mp. or "health care utili?ation".mp. or "health service use".mp. or "health service utili?ation".mp. or



"social care use".mp. or "social care utilization".mp. or "social service use".mp. or "health care cost\*".mp. or "health care expenditure".mp. or "medical cost\*".mp. or "medical expenditure".mp. or "primary care cost\*".mp. or "hospital care cost\*".mp. or "health care visit\*".mp. or "medical consultation\*".mp. or "medical appointment\*".mp. or "doctor visit\*".mp. or "GP visit\*".mp. or "hospital outpatient visit\*".mp. or "hospital admission\*".mp. or "specialist visit\*".mp. or "specialist referral\*".mp. or "help-seeking".mp. or "medication".mp. or "insulin use".mp. or "diabetic medicine\*".mp. or "blood glucose-lowering drug\*".mp. or "blood sugar-lowering drug\*".mp.

- 4 1 and 2 and 3
- 5 limit 4 to dt=20100101-20210331
- 6 limit 5 to (english language and humans)
- 7 limit 6 to journal article
- 8 remove duplicates from 7

## EMBASE

- 1 "Type 2 Diabetes".ti,ab,kw. or "Non Insulin Dependent Diabetes Mellitus"/ or "Adult Onset Diabetes".ti,ab,kw. or "t2dm".ti,ab,kw.
- 2 "Mobile application"/ or "Mobile application\*".ti,ab,kw. or "Telemedicine\*".ti,ab,kw. or "Telemedicine"/ or "Digital Health".ti,ab,kw. or "app".ti,ab,kw. or "App\* on prescription".ti,ab,kw. or "Digital prescribing".ti,ab,kw. or "Wearable\*".ti,ab,kw. or "Digital Therapeutic\*".ti,ab,kw. or ("Digital" adj5 "Medicine").ti,ab,kw. or "blood glucose monitoring".ti,ab,kw. or "mHealth".ti,ab,kw. or "eHealth".ti,ab,kw. or "remote delivery".ti,ab,kw. or "online".ti,ab,kw. or "website".ti,ab,kw. or "internet".ti,ab,kw.
- 3 "health care utilisation"/ or "health care delivery"/ or "health care cost"/ or "healthcare expenditure\*".ti,ab,kw. or "health care use".ti,ab,kw. or "health care utilization".ti,ab,kw. or "health care cost\*".ti,ab,kw. or "health expenditure\*".ti,ab,kw. or "health service use".ti,ab,kw. or "health care utilization".ti,ab,kw. or "social care use".ti,ab,kw. or "social care utilization".ti,ab,kw. or "social service use".ti,ab,kw. or "health care expenditure\*".ti,ab,kw. or "medical cost\*".ti,ab,kw. or "medical expenditure\*".ti,ab,kw. or "primary care cost\*".ti,ab,kw. or "hospital care cost\*".ti,ab,kw. or "health care visit\*".ti,ab,kw. or "medical consultation\*".ti,ab,kw. or "medical appointment\*".ti,ab,kw. or "doctor visit\*".ti,ab,kw. or "GP visit\*".ti,ab,kw. or "hospital outpatient visit\*".ti,ab,kw. or "hospital admission\*".ti,ab,kw. or "specialist visit\*".ti,ab,kw. or "specialist referral\*".ti,ab,kw. or "help-seeking".ti,ab,kw. or "medication\*".ti,ab,kw. or "insulin use".ti,ab,kw. or "diabetic medicine\*".ti,ab,kw. or "blood glucose-lowering drug\*".ti,ab,kw. or "blood

sugar-lowering drug\*".ti,ab,kw. or "medical spending".ti,ab,kw. or "service use".ti,ab,kw. or "health resource\*".ti,ab,kw.

- 4 1 and 2 and 3
- 5 limit 4 to dc=20100101-20210331
- 6 limit 5 to (human and english language)
- 7 limit 6 to (article and journal)
- 8 remove duplicates from 7

## PsychInfo

- 1 exp "Type 2 Diabetes"/ or "Adult Onset Diabetes".mp. or "diabetes mellitus type 2".mp. or "type 2 diabetes".mp. or "t2dm".mp.
- 2 exp "Mobile Applications"/ or "Mobile Application\*".mp. or exp "Computer Applications"/ or "Telemedicine".mp. or exp "Telemedicine"/ or "Digital Health".mp. or exp "Digital Interventions"/ or "Digital Prescribing".mp. or exp "Wearable Devices"/ or "App\* on prescription".mp. or "app".mp. or "Digital Therapeutic\*".mp. or ("Digital" adj5 "Medicine").mp. or "blood glucose monitoring".mp. or "internet".mp. or "mHealth".mp. or "eHealth".mp. or "remote delivery".mp. or "online".mp. or "website".mp.
- 3 exp "Health Care Utilization"/ or exp "Health Care Services"/ or exp "Health Care Costs"/ or "Health Care Cost\*".mp. or "health expenditure\*".mp. or "medical spending".mp. or "Health Resource\*".mp. or "health care use".mp. or "health service use".mp. or "health service utilization".mp. or "social care use".mp. or "social care utilization".mp. or "social service use".mp. or "health care expenditure\*".mp. or "medical cost\*".mp. or "medical expenditure\*".mp. or "primary care cost\*".mp. or "hospital care cost\*".mp. or "health care visit\*".mp. or "medical consultation\*".mp. or "medical appointment\*".mp. or "doctor visit\*".mp. or "GP visit\*".mp. or "hospital outpatient visit\*".mp. or "hospital admission\*".mp. or "specialist visit\*".mp. or "specialist referral\*".mp. or "help-seeking".mp. or "medication\*".mp. or "insulin use".mp. or "diabetic medicine\*".mp. or "blood glucose-lowering drug\*".mp. or "blood sugar-lowering drug\*".mp.
- 4 1 and 2 and 3
- 5 limit 4 to up="20100101-20210331"
- 6 limit 5 to (human and english language)
- 7 limit 6 to journal article
- 8 remove duplicates from 7

## EconLit

- 1 TX diabetes mellitus type 2 or type 2 diabetes or t2dm or adult-onset diabetes

- 2 TX mobile application? or telemedicine or mobile application? or app or mobile app? or mhealth or ehealth or digital health or digital medicine or digital prescribing or wearable\* or digital therapeutic\* or digital medicine or blood glucose monitoring
- 3 TX health resource utilization or health care service? or health resource? or medical spending or service use or healthcare utilization or health care cost? or outpatient visit? or health care use or health service use or health service utilization or social care use or social care utilization or social service use or health care expenditure? or medical cost? or medical expenditure? or primary care cost? or hospital care cost? or health care visit? or medical consultation? or medical appointment? or doctor visit? or GP visit? hospital outpatient visit? or hospital admission? or specialist visit? or specialist referral? or help-seeking or medication or insulin use or diabetic medicine or blood glucose-lowering drug? or blood sugar-lowering drug?
- 4 SR1 OR S2 OR S3
- 5 Limiters - Published Date: 20100101-20210331

## Declarations

**Funding** Tiyi Morris has been funded through a National Institute for Health Research Applied Research Collaborations North Thames PhD studentship. The views expressed in this publication are those of the author(s) and not necessarily those of the National Institute for Health Research or the Department of Health and Social Care.

**Conflicts of interest/competing interests** Tiyi Morris, Fiona Aspinall, Jean Ledger, Keyi Li and Manuel Gomes have no conflicts of interest that are directly relevant to the content of this article.

**Ethics approval** Not applicable.

**Consent to participate** Not applicable.

**Availability of data and material** Not applicable.

**Code availability** Not applicable.

**Authors' contributions** All authors contributed to the study conception and design. Material preparation, data collection and analysis were performed by TM, FA, KL and MG. The first draft of the manuscript was written by TM and all authors commented on previous versions of the manuscript. All authors read and approved the final manuscript.

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