




# BMJ Open Cost-effectiveness of multicomponent interventions in type 2 diabetes mellitus in a cluster randomised controlled trial: the INDICA study

Lidia García-Pérez <sup>1,2,3</sup> Yolanda Ramallo-Fariña <sup>1,2,3</sup>  
 Laura Vallejo-Torres <sup>1,2</sup> Leticia Rodríguez-Rodríguez,<sup>1,3</sup>  
 Himar González-Pacheco,<sup>1</sup> Beatriz Santos-Hernández,<sup>1</sup>  
 Miguel Angel García-Bello,<sup>1</sup> Ana María Wägner,<sup>4,5</sup> Montserrat Carmona,<sup>2,3,6</sup>  
 Pedro G Serrano-Aguilar,<sup>2,3,7</sup> The INDICA team

**To cite:** García-Pérez L, Ramallo-Fariña Y, Vallejo-Torres L, *et al*. Cost-effectiveness of multicomponent interventions in type 2 diabetes mellitus in a cluster randomised controlled trial: the INDICA study. *BMJ Open* 2022;**12**:e058049. doi:10.1136/bmjopen-2021-058049

► Prepublication history and additional supplemental material for this paper are available online. To view these files, please visit the journal online (<http://dx.doi.org/10.1136/bmjopen-2021-058049>).

Received 09 October 2021  
 Accepted 08 March 2022



© Author(s) (or their employer(s)) 2022. Re-use permitted under CC BY-NC. No commercial re-use. See rights and permissions. Published by BMJ.

For numbered affiliations see end of article.

## Correspondence to

Lidia García-Pérez;  
[lidia.garciaperez@sescs.es](mailto:lidia.garciaperez@sescs.es)

## ABSTRACT

**Objective** To analyse the cost-effectiveness of multicomponent interventions designed to improve outcomes in type 2 diabetes mellitus (T2DM) in primary care in the Canary Islands, Spain, within the INDICA randomised clinical trial, from the public health system perspective.

**Design** An economic evaluation was conducted for the within-trial period (2 years) comparing the four arms of the INDICA study.

**Setting** Primary care in the Canary Islands, Spain.

**Participants** 2334 patients with T2DM without complications were included.

**Interventions** Interventions for patients (PTI), for primary care professionals (PFI), for both (combined intervention arm for patients and professionals, CBI) and usual care (UC) as a control group.

**Outcomes** The main outcome was the incremental cost per quality-adjusted life-years (QALY). Only the intervention and the healthcare costs were included.

**Analysis** Multilevel models were used to estimate results, and to measure the size and significance of incremental changes. Missed values were treated by means of multiple imputations procedure.

**Results** There were no differences between arms in terms of costs ( $p=0.093$ ), while some differences were observed in terms of QALYs after 2 years of follow-up ( $p=0.028$ ). PFI and CBI arms were dominated by the other two arms, PTI and UC. The differences between the PTI and the UC arms were very small in terms of QALYs, but significant in terms of healthcare costs ( $p=0.045$ ). The total cost of the PTI arm (€2571, 95% CI €2317 to €2826) was lower than the cost in the UC arm (€2750, 95% CI €2506 to €2995), but this difference did not reach statistical significance. Base case estimates of the incremental cost per QALY indicate that the PTI strategy was the cost-effective option.

**Conclusions** The INDICA intervention designed for patients with T2DM and families is likely to be cost-effective from the public healthcare perspective. A cost-effectiveness model should explore this in the long term.

**Trial registration number** NCT01657227.

## Strengths and limitations of this study

- This paper presents an individual-based cost-effectiveness analysis of the INDICA study, a large randomised clinical trial.
- This paper analyses the cost-effectiveness of knowledge transfer and behaviour modification interventions from the public healthcare perspective in the Canary Islands, Spain.
- The outcome was quality-adjusted life-years, estimated using the EQ-5D-5L, and the costs were obtained from the local healthcare providers.
- We present the results of the whole sample, 2334 individuals, and the results of the subgroup of patients with glycated haemoglobin >7%.
- From the point of view of the economic evaluation, the main limitation is the relatively short duration of the trial, 2 years.

## INTRODUCTION

Diabetes is a prevalent chronic disease with a major global impact. A worldwide prevalence of 8.5% in adults, 7.3% in Europe,<sup>1</sup> and a direct annual cost to the world higher than US\$825 billion<sup>2 3</sup> has been estimated. The prevalence of type 2 diabetes mellitus (T2DM) in the population aged 15 and over in the Canary Islands is 7.74%,<sup>4</sup> which is slightly higher than the Spanish average (6.99%).<sup>5</sup> Moreover, the Canary Islands show a higher mortality and a higher incidence of complications than the rest of Spain.<sup>6 7</sup> This situation has prompted the implementation of secondary prevention strategies that, nevertheless, should be evaluated before and after their implementation.<sup>8</sup>

Given these circumstances, the INDICA study was designed with the aim of evaluating evidence-based interventions. Several reviews

were undertaken and various relevant systematic reviews and guidelines were identified.<sup>9–11</sup> Some trials, such those conducted by Trento *et al*<sup>12</sup> were inspirational. Despite the increasing healthcare expenditure<sup>13</sup> and availability of services<sup>14</sup> and guidelines,<sup>15</sup> the adherence to recommended actions of T2DM self-management and lifestyle changes is limited.<sup>16</sup> Furthermore, healthcare professionals and family members play an important role in supporting patients with T2DM. There is also evidence on the effectiveness of the information and communication technologies (ICT) to transfer the knowledge of diseases and support patients and professionals in their decisions.<sup>10,17–20</sup> Based on all this evidence, the INDICA interventions were designed, implemented and evaluated. As both effectiveness and cost-effectiveness are criteria for health technologies reimbursement in Spain,<sup>21</sup> and bearing in mind that the efficiency of complex interventions is not easily transferable,<sup>22</sup> an economic evaluation was conducted alongside a clinical trial.

The INDICA study is a randomised controlled trial (RCT) that evaluates the effectiveness and cost-effectiveness of three different ICT-based multicomponent interventions to support decision making in patients with T2DM and primary healthcare professionals in the Canary Islands.<sup>23–24</sup> Results on the effectiveness of the interventions are reported elsewhere.<sup>25–26</sup> In this paper, we present the cost-effectiveness analyses.

## METHODS

### Trial design

The INDICA study is an open, community-based, multi-centre, controlled clinical trial with random cluster allocation to one of four arms, one of them a control group. We estimated the cost-effectiveness for the ‘within-trial’ period (2 years) where incremental cost per quality-adjusted life-year (QALY) was the main outcome.<sup>23–24</sup>

### Ethical approval and consent to participate

All participants provided written informed consent. The study fulfilled the regulatory requirements, Good Clinical Practice standards, Declaration of Helsinki, and received the approval of the Scientific and Ethics Committees of two hospitals (University Hospital of Canarias (ID: 2012\_44) and University Hospital Nuestra Señora de la Candelaria (ID: EPA-07/10)). General guidelines for economic evaluation and clinical trials were followed.<sup>27–29</sup> The methods were reported in the published protocol.<sup>23</sup>

### Interventions

The intervention for patients and family members (PTI) included a diabetes-coaching programme using a combination of educational workshops with automated and personalised phone messages and a web-based platform. The intervention for primary care healthcare professionals (physicians and nurses) (PFI) included workshops to update clinical management, a decision support tool nested into the electronic clinical record system; and

periodic feedback reports on patient outcomes. In the combined intervention arm for patients and professionals (CBI), both received the reported interventions. The control group received usual care (UC), that is, neither patients nor professionals received any educational intervention or supporting activities beyond the usual healthcare provided by Servicio Canario de la Salud (SCS), an organisation that is part of the National Health System and provides public healthcare in the Canary Islands (Spain).

### Subjects

Patient inclusion criteria were T2DM diagnosed at least 1 year prior to study enrolment, 18–65 years of age, formal consent to participate in the study, and regular use of a mobile phone. Patients with serious comorbidities, insufficient (Spanish) language skills, physical disability limiting participation in group education activities or concurrent participation in another clinical study were excluded.

### Setting, recruitment and randomisation

The study was conducted in the primary care setting in the Canary Islands, Spain. In the more populated islands (Tenerife and Gran Canaria) three different strata were created according to the geographic areas. In the less populated islands (La Palma and Lanzarote) each island was divided into four zones. Randomisation was applied at different levels: Primary Care Health Practices (PHCP), Family Care Units (FCU) and patients. First, in each strata of Tenerife and Gran Canaria, four PHCP (clusters) were randomly recruited, providing 12 PHCP in total. The two other islands, La Palma and Lanzarote, provided four PHCP each (one in each area). Block permutation was used to assign PHCPs to study arms, with PHCP as the sampling unit. In every island and each strata, all arms were equally distributed. Second, six FCU, composed of a family physician and a nurse, were randomly selected from all those consenting to participate in each PHCP. And thirdly, the electronic clinical records (ECR) of patients at each participating FCU were screened and 15 patients were randomly selected from all patients fulfilling the inclusion criteria and consenting to participate. Cluster allocation avoids contamination bias among participants, also facilitating logistics in group interventions. PHCP (in Tenerife and Gran Canaria), FCU and patient randomisation were performed by simple generation from a list of random numbers. FCUs were blinded to the intervention assignment until the last patient was recruited.

### Patient and public involvement

Patients were actively involved in design of the trial. Two associations of patients with T2DM in the Canary Islands were included from the beginning of the study as part of the research team, with an active participation in the design of the interventions and selection of the outcomes measured. In the same way, primary care professionals and clinical management staff participated in preparation

of the protocol. The patients and professionals included in the study could express their satisfaction with the interventions through a questionnaire, as well as through focus groups and in-depth interviews that will be the subject of another study. Finally, we established a commitment with patients and healthcare professionals to share the results with them in an easy-to-understand way.

### Healthcare utilisation and costs

Direct costs were evaluated from the public healthcare service perspective (SCS). Hence the following resources and services were included: costs related to the development and implementation of each intervention (including materials and development of ICTs) and the use of healthcare in all arms (including UC arm), which included the costs of contacts with primary care services, hospital admissions, outpatient visits, emergency visits, tests and medications. Those resources not very commonly accessed (visits to neurologists, physiotherapy or Doppler echocardiography, eg) were excluded from the analysis. Resource use was collected from questionnaires completed by patients, ECR and administrative data. Unit costs were obtained from different sources, that is, public sources, administrative accounts and specific suppliers (see online supplemental appendix 1 tables A1 and A2 for further details). The costs of medicines were obtained from the database of dispensed medicines charged to the public healthcare sector and included: antihypertensive drugs (ACE inhibitors, angiotensin receptor antagonists, calcium-channel blockers, diuretics and beta blockers), lipid-lowering agents, anti-thrombotic drugs, amitriptyline, duloxetine, pregabalin and tramadol. Unit costs were adjusted for inflation when needed. Costs are reported in Euros from 2017.

### Quality-adjusted life years

Patients completed at baseline and every 6 months the EQ-5D-5L, a generic health-related quality of life questionnaire<sup>30</sup> that evaluates five domains: mobility, self-care, usual activity, pain/discomfort and anxiety/depression. Each domain is scored at one of five levels, yielding a descriptive system that can be combined into a five-digit number that reports the patient's state of health. Each EQ-5D-5L health state can be converted to a single summary index by applying a formula that attaches weights to each of the levels in each dimension. A number of formulae, or value sets are available for different countries, based on the valuation of EQ-5D health states from general population samples. In this study, the value set estimated for Spain by Ramos-Goñi *et al* was used.<sup>31</sup> After applying these weights, or utilities, an EQ-5D-5L index score of 1 represents full health, a score of 0 is equivalent to death and negative scores represent health states perceived as worse than death by population. Patient-specific utility profiles over the 2-year follow-up were estimated assuming a straight line relation between each patient score at each follow-up point. The QALYs from

baseline to month 24 were calculated as the area under the curve.<sup>28</sup>

### Sample size calculation

The sample size calculation was based on the primary endpoint of the effectiveness study, that is, the mean change in glycated haemoglobin (HbA1c) from baseline to month 24. A total of 2330 patients was estimated (482 patients per arm).

### Statistical methods

QALYs and costs were estimated using multilevel models.<sup>28</sup> The first level included patients characteristics, and the second level variables correspond to PHCPs. QALYs were adjusted by time elapsed since diagnosis and baseline utility as covariates.<sup>32</sup> Costs were adjusted by age, sex and baseline utility. To estimate use of resources a negative-binomial regression model, adjusted by time since diagnosis and baseline resource use, was used. The final model for each dependent variable included the covariates that modified the treatment effect of the estimates by at least 10%. As suggested in the Consolidated Standards of Reporting Trials statement, decisions about covariates will not be based on the p value.<sup>33 34</sup>

Patient characteristics were compared at baseline with a  $\chi^2$  test for the variable sex and using a multilevel model for age, duration of diabetes, HbA1c and EQ-5D-5L Index. Only the arm was included as independent variable.

Intergroup differences were considered statistically significant if  $p < 0.05$ . For multiple comparisons, the p value was adjusted with Bonferroni correction.

Missing values were treated by means of multiple imputation procedures,<sup>35</sup> with results based on 100 imputed datasets. The missing data patterns were published as Multimedia Appendix in Ramallo-Fariña *et al*.<sup>26</sup> The model of imputation used for variables involved in the cost-effectiveness evaluation can be found in online supplemental appendix 2. Analysis was performed on an intention-to-treat basis.

Incremental cost-effectiveness ratio (ICER), that is, the differences between costs divided by the differences in QALYs, was calculated when one alternative was more (less) effective and more (less) costly than another, once the dominated alternatives were excluded. The results were re-estimated using alternative values for some parameters (costs) in a deterministic one-way sensitivity analysis ( $\pm 20\%$  of unit costs). Finally, a post hoc subgroup analysis was conducted with only subjects with HbA1c above the treatment target, that is, baseline HbA1c  $> 7\%$ . For reference, €25 000 per QALY was considered the cost-effectiveness threshold as this is the latest value estimated following robust methods in Spain.<sup>36</sup> All analyses were conducted using STATA V.15.0 (StataCorp).

## RESULTS

Between February 2013 and October 2016, 32 PHCP and 2334 patients (mean age:  $55.7 \pm \text{SD}: 7.1$  years;

**Table 1** Baseline characteristics of the participants in the study

	PTI arm (n=537)	PFI arm (n=654)	CBI arm (n=557)	UC arm (n=586)	P value
Age (years) (mean±SD)	55.9±7.0	56.2±7.0	55.5±7.1	55.2±7.3	0.216
Sex: male (%)	52.9*	44.0	47.4	48.8	0.024
Duration of diabetes (years) (mean±SD)	8.4±6.8	8.2±6.1	8.9±6.3	8.6±6.8	0.471
Glycated haemoglobin (%) (mean±SD)	7.3±1.5	7.2±1.4	7.4±1.5	7.3±1.5	0.224
<7%	48.0	53.7	43.3	51.9	
7%–8%	27.2	25.2	29.6	24.1	
8%–9%	12.3	11.5	14.7	11.4	
≥9%	12.5	9.6	12.4	12.6	
EQ-5D-5L Index (mean±SD)	0.86±0.19	0.88±0.16	0.86±0.19	0.85±0.20	0.796

Sex:  $\chi^2$  test.

Age, duration of diabetes, glycated haemoglobin and EQ-5D-5L index: multilevel model with arm as independent variables, without adjusting by covariates.

\*Statistically significant differences between arms PTI and PFI ( $p=0.002$ ).

CBI, combined intervention for patients and professionals; PFI, intervention only for healthcare professionals at primary care; PTI, intervention only for patients and family members; UC, usual care (control group).

51.9% women) were recruited and included in the RCT. There were no statistically significant differences among the groups in terms of their baseline characteristics, except for sex between the PTI and PFI arm ( $p=0.002$ ) (table 1). The flowchart of included patients by arm in each follow-up can be seen in Ramallo-Fariña *et al.*<sup>26</sup>

### Quality-adjusted life-years

Statistically significant differences in QALYs were found at month 18 ( $p=0.030$ ) and 24 ( $p=0.028$ ). The differences are found between the CBI arm and the UC arm (1.24 vs 1.29 at 18 months; 1.63 vs 1.72 at 24 months), favouring the UC arm; and between the CBI arm and PTI arm (1.24 vs 1.29 at 18 months; 1.63 vs 1.71 at 24 months), with CBI showing the lowest values (table 2). Representations of the profile of utilities for patients in each arm for the 2 year period can be found in online supplemental appendix 1 figure A1.

### Use of resources and healthcare costs

Statistically significant differences were found between arms for the following resources: hospital admissions ( $p=0.025$ ), laboratory procedures ( $p<0.001$ ), visits to primary care (doctors and nurses) ( $p<0.001$ ) and non-hospital emergency room visits ( $p=0.002$ ) (see online supplemental appendix 1 table A3). In regard to healthcare costs, we found differences between arms in hospital admissions ( $p=0.019$ ), laboratory procedures ( $p=0.044$ ), and visits to primary care ( $p=0.002$ ), but no differences were found in the aggregated healthcare cost (excluding INDICA interventions costs). The highest mean healthcare cost was found in the UC arm (€2750, 95% CI €2506 to €2995), followed by the CBI arm (€2698, 95% CI €2449 to €2948), the PFI arm (€2664, 95% CI €2432 to €2896) and, lastly, the PTI arm (€2391, 95% CI €2137 to €2646) (table 2). The only significant difference was found in the healthcare cost between the PTI and the UC arms ( $p=0.045$ ).

### Cost of INDICA interventions and total costs

The costs of INDICA interventions over the 2 years of implementation are reported in online supplemental appendix 1 table A2. The mean intervention costs for patients was higher than the cost for professionals (€180 vs €130). The total cost, that is the result of adding the INDICA intervention costs and the healthcare costs, was found to be highest in the CBI arm (€3025, 95% CI €2776 to €3274), followed by the PFI arm (€2794, 95% CI €2562 to €3026), the UC arm (€2750, 95% CI €2506 to €2995), and, finally, the PTI arm (€2571, 95% CI €2317 to €2826) (table 2). Although no differences in total cost were identified among arms ( $p=0.093$ ), statistically significant differences were found between two specific arms, the PTI arm and the CBI arm ( $p=0.013$ ).

### Cost-effectiveness analysis: base case

Table 3 shows the incremental cost, the incremental effect and the ICER. The PFI and the CBI arms were dominated by other alternatives, so they cannot be considered cost-effective. Between the other two arms, PTI and UC arms, the difference in effects and costs were found to be small and non-statistically significant ( $p=0.319$ ). The ICER is estimated at €38 486 per QALY. This ratio should be interpreted with care since the intervention evaluated (PTI arm) is (slightly) less effective but also less expensive than the control (UC arm) and the differences in total costs and QALYs were not found to be statistically significant.

### Cost-effectiveness analysis: sensitivity analysis

The results of the sensitivity analysis are very similar to the base case (see online supplemental appendix 1 table A4). The PFI and CBI arms are in all cases dominated by the other two arms, while the PTI arm is less expensive than the UC arm. There are only significant differences in costs between arms when a lower cost of hospital stay

**Table 2** Adjusted means (95% CI) of QALYs and healthcare costs per arm (€), multilevel model

QALYs per period					
Period	PTI arm	PFI arm	CBI arm	UC arm	P value
0–6 months	0.43 (0.42 to 0.44)	0.43 (0.42 to 0.44)	0.42 (0.41 to 0.43)	0.43 (0.42 to 0.44)	0.352
0–12 months	0.86 (0.84 to 0.88)*	0.85 (0.84 to 0.87)	0.83 (0.81 to 0.85)†	0.86 (0.85 to 0.88)	0.087
0–18 months	1.29 (1.26 to 1.32)*	1.27 (1.25 to 1.3)	1.24 (1.21 to 1.27)†	1.29 (1.27 to 1.32)	0.030
0–24 months	1.71 (1.67 to 1.75)*	1.69 (1.65 to 1.73)	1.63 (1.59 to 1.68)†	1.72 (1.68 to 1.76)	0.028
Healthcare costs in 2 years					
Resource	PTI arm	PFI arm	CBI arm	UC arm	P value
Hospital stays	462.06 (287.6 to 636.52)‡	554.31 (398.15 to 710.47)	400.58 (230.24 to 570.91)†	757.72 (590.70 to 924.74)	0.019
Laboratory tests	46.12 (40.68 to 51.56)*§	56.35 (51.36 to 61.34)	54.15 (48.62 to 59.69)	51.47 (46.33 to 56.61)	0.044
Retinography	117.78 (91.24 to 144.32)	127.57 (101.83 to 153.32)	117.18 (90.44 to 143.91)	115.69 (89.67 to 141.72)	0.920
Primary care visits	293.13 (205.04 to 381.21)*	293.13 (297.35 to 472.18)¶	481.99 (393.78 to 570.21)†	263.11 (175.4 to 350.92)	0.002
Specialist visits	37.49 (26.74 to 48.24)	46.94 (37.22 to 56.66)	43.88 (33.07 to 54.70)	44.38 (34.21 to 54.54)	0.634
Emergency room visits	275.89 (191.09 to 360.69)	264.88 (183.39 to 346.37)	337.16 (251.86 to 422.46)	251.90 (169.24 to 334.56)	0.505
Medication	1156.96 (1016.23 to 1297.7)	1222.31 (1090.12 to 1354.5)	1242.16 (1102.59 to 1381.72)	1269.47 (1132.53 to 1406.42)	0.715
Healthcare cost (without INDICA interventions related costs)	2391.22 (2136.87 to 2645.58)‡	2663.6 (2431.57 to 2895.63)	2698.25 (2448.72 to 2947.78)	2750.44 (2506.19 to 2994.69)	0.191
INDICA interventions related costs	180.26	130.28	326.76	0	–
Total cost	2571.53 (2317.17 to 2825.88)*	2793.91 (2561.86 to 3025.95)	3025.12 (2775.55 to 3274)	2750.44 (2506.18 to 2994.71)	0.093

Healthcare costs: multilevel model, adjusted by age, sex and baseline utility.

QALYs: multilevel model, adjusted by time elapsed since diagnosis and baseline utility.

\*Statistically significant differences between PTI and CBI

†Statistically significant differences between CBI and UC

‡Statistically significant differences between PTI and UC

§Statistically significant differences between PTI and PFI

¶Statistically significant differences between PFI and UC

CBI, combined intervention for patients and professionals; CI, Confidence interval; PFI, intervention only for healthcare professionals in primary care; PTI, intervention only for patients and family members; QALY, quality-adjusted life-years; UC, usual care (control group).

( $p=0.039$ ) or a higher cost of the intervention on professionals ( $p=0.036$ ) is assumed.

#### Analysis of subgroups: patients with baseline HbA1c >7%

The subgroup of patients with baseline HbA1c >7% revealed some benefits of interventions. The PTI arm had the highest effect in terms of QALYs and is dominant over

all the other arms after the multilevel model adjustment (table 4). In terms of costs, statistically significant differences were observed only in visits to primary care professionals ( $p=0.003$ ) (see online supplemental appendix 1 table A5). The highest average healthcare cost per patient, not including the cost of INDICA interventions,

**Table 3** Cost, effectiveness and ICER

Arm	Mean total cost (€) (95% CI)	Mean QALYs (95% CI)	Incremental cost and incremental QALYs (95% CI)
CBI	3025.01 (2775.55 to 3274.69)	1.63 (1.59 to 1.68)	Dominated
PFI	2793.88 (2561.86 to 3025.95)	1.69 (1.65 to 1.73)	Dominated
PTI	2571.48 (2317.17 to 2825.88)	1.71 (1.67 to 1.75)	-178.95996 € (-499.61 to 141.69)
UC	2750.44 (2506.18 to 2994.71)	1.72 (1.68 to 1.76)	-0.00465 QALYs (-0.036 to 0.027)
ICER between PTI and UC			38486.0129 €/QALY

CBI, combined intervention for patients and professionals; CI, Confidence interval; ICER, incremental cost-effectiveness ratio; PFI, intervention only for healthcare professionals in primary care; PTI, Intervention only for patients and family members; QALY, quality-adjusted life-years; UC, usual care (control group).



**Table 4** Cost and effectiveness in subgroup with baseline HbA1c >7%

Arm	Mean total cost (€) (95% CI)	Mean QALYs (95% CI)	Cost-effectiveness
CBI	3516.44 (3207.58 to 3825.31)	1.62 (1.59 to 1.67)	Dominated
UC	3492.08 (3092.06 to 3892.1)	1.70 (1.66 to 1.73)	Dominated
PFI	3310.96 (2981.6 to 3640.32)	1.71 (1.68 to 1.75)	Dominated
PTI	3117.46 (2763.4 to 3471.53)	1.72 (1.69 to 1.75)	Dominant

CBI, combined intervention for patients and professionals; CI, Confidence interval; HbA1c, glycated haemoglobin; PFI, intervention only for healthcare professionals in primary care; PTI, intervention only for patients and family members; QALY, quality-adjusted life-years; UC, usual care (control group).

was found in the UC arm (€3492, 95% CI €3092 to €3892), followed by the CBI arm (€3189, 95% CI €2881 to €3498), the PFI arm (€3181, 95% CI €2851 to €3510) and, lastly, the PTI arm (€2937, 95% CI €2583 to €3291). These costs were higher than those observed for the entire sample. The only statistically significant difference was found between the average cost of the PTI arm and the average cost of the UC arm, as was the case for the total sample. No differences between arms were found in total cost in patients with baseline HbA1c >7% ( $p=0.399$ ). The highest total cost per patient was estimated for the CBI arm (€3516, 95% CI €3208 to €3825), followed by the UC arm (€3492, 95% CI €3092 to €3892), the PFI arm (€3311, 95% CI €2982 to €3640) and, lastly, the PTI arm (€3117, 95% CI €2763 to €3471) (see table 4).

The estimate of costs and QALYs was similar for all imputed, non-imputed and completed data. The same arms stayed as dominant and the same conclusion with regard to ICER was upheld.

## DISCUSSION

This paper presents the results of an economic evaluation conducted alongside a RCT, the INDICA Study ( $n=2334$ ), in the Canary Islands, Spain, and from the healthcare perspective. The alternatives evaluated were ICT-based PTI and for professionals in primary care, developed to improve self-management and health outcomes in people with T2DM and prevent serious comorbidity or advanced complications of the disease.

The lowest mean cost was found in the PTI arm, that is, the group where patients received a diabetes-coaching programme combining group education workshops, personalised phone messages and a web-based platform. At the other end, as expected, the cost of the CBI arm, where both PTI and for professionals were included, was higher than in any other arm. The main costs driver was the healthcare costs, lower in the PTI arm than in any other arm and higher in the control group than in any

intervention arm. To be precise, the differences between arms were partly explained due to differences in the use of resources and costs of visits to primary care, lab tests and hospital admissions. Regarding the effectiveness of the interventions, although the ICT-based interventions developed for the INDICA trial improved HbA1c and other clinical measures after 24 months of follow-up,<sup>26</sup> these results were not translated into large differences in terms of QALYs between arms. Taking into account costs and QALYs, the CBI and the PFI arms were dominated, that is, were less effective and more costly than other alternatives. Meanwhile, the PTI arm was found to be slightly less effective and less costly than the control group (non-significant differences). The sensitivity analysis confirmed this result. Furthermore, we estimated that the incremental cost per QALY of the UC strategy compared with the PTI arm was above the cost-effectiveness threshold in Spain (€25 000 per QALY),<sup>36</sup> indicating that the PTI intervention is likely to be a cost-effective option.<sup>37</sup> This ICER must be cautiously interpreted given that CIs for both costs and QALYs show uncertainty around the estimates. To complement the results, we conducted a subgroup analysis (not included in the trial protocol) that revealed that in the sample of patients with uncontrolled T2DM (baseline HbA1c >7%) the PTI arm was dominant over all the other arms. This suggests that the INDICA intervention designed for patients and their families is likely to be more cost-effective, especially in patients with poorly controlled blood glucose levels. Transferability to real clinical practice of cost-effective interventions could be even more efficient as their application can be extended to thousands of patients with T2DM, with minimal cost increases.

The INDICA study was designed to be ambitious, inspired by several systematic reviews.<sup>9 10</sup> More recent reviews confirmed the pertinence of studies as INDICA. Lian *et al* conducted a systematic review of cost-effectiveness studies on self-management education programmes for T2DM.<sup>38</sup> This review found two interesting results. First, the number of studies of sufficiently good quality was low, only five cost-effectiveness studies alongside clinical trials. The longest follow-up was 12 months and the largest sample size was 1570. Consequently, from the point of view of these two methodological characteristics, the INDICA study is superior. The second conclusion from Lian *et al* is that the cost of these interventions is not very high and likely to be cost-effective in the long-term. In fact, the only study they identified that found that the intervention was not cost-effective was conditioned by the short-term analysis and could benefit from a long term modelling analysis.<sup>38 39</sup> More recently, Siegel *et al* found strong evidence that multicomponent interventions (involving behaviour change and education and pharmacological therapy) compared with UC are cost-saving or cost-effective (range of the ICERs from cost-saving to US\$58 587 per QALY; median: US\$2315 per QALY, based on six studies).<sup>40</sup> Interestingly, they also found uncertain evidence about the cost-effectiveness of a computerised decision support system linked to ECR.

Finally, the generalisability of the INDICA findings and the transferability of its results to other settings are not straightforward. Interventions were designed and implemented considering the level of health and digital literacy of the population in the Canary Islands, that is quite similar to the average in Spain (and above the EU mean), and the organisation of the primary healthcare provision by the public system in the region.<sup>41 42</sup> Although not all regions in Spain offer the same support to patients with diabetes, primary healthcare is quite homogeneous throughout the country<sup>43</sup> so the interventions could be implemented with few modifications in regions other than the Canary Islands. Therefore, we could conclude that the intervention and the cost-effectiveness results could be transferable to other regions in Spain, but the transferability to other countries would need a thorough analysis of the care for T2DM in other foreign settings.

### Strengths and limitations

The strengths of the INDICA Study as a trial include the pragmatic nature, its large sample size, the duration of follow-up when compared with other trials and, especially, the high rate of patient retention at the last control visit in month 24. There is prior evidence supporting the effectiveness of similar interventions in the reduction of HbA1c in the short term<sup>18 44 45</sup> but not in the long term.<sup>46</sup> The INDICA study revealed differences in clinical outcomes between the intervention arms and the control group that remained statistically and clinically significant at the end of 24 months despite the gradual reduction of effectiveness over time.<sup>26</sup> These findings highlight the importance of conducting trials with long follow-up and sufficient statistical power to evaluate interventions of limited effect sizes but of potential efficacy. In addition, this study applied careful randomisation methods and hierarchical modelling techniques to minimise potential bias due to sample selection or due to baseline differences across subjects. Further explanations can be found in the main article with the clinical results of the INDICA study.<sup>26</sup>

As an economic evaluation, the most important strength comes from the quality and quantity of data on resource use. Medication was collected from the information system for the electronic drugs prescriptions, a very reliable register that includes data on prescription and collection of drugs from community pharmacists. But most data were collected from the patients in common face-to-face meetings to avoid recall bias, and checked against the ECR for those considered critical as healthcare visits and hospital admissions. These meetings also facilitated the high rate of completed EQ-5D-5L questionnaires.

The main limitations of this study are as follows. First, there was some degree of missing data addressed by the robust imputation technique. Multiple Imputation methods were used instead of the technique specified in the protocol, since this is the best option for our missing data patterns.<sup>47</sup> Related to this limitation, due to the complexity of our models, which included multilevel

analyses and imputed data, it was not possible to apply bootstrapping techniques that could effectively characterise the uncertainty around the ICER point estimates. This also prevented estimate of the cost-effectiveness acceptability curve. Instead, we presented the CIs for costs and QALYs separately and conducted comprehensive deterministic sensitivity analyses.

Second, we conducted the costs analysis in the framework of the clinical trial. Intervention costs might differ in real life as implementation all over the Canary Islands would require the escalation of resources in a fragmented territory as it is an archipelago if other criteria such as access equity have to be taken into consideration. Nonetheless, the sensitivity analysis applied to costs confirmed the main result as reported in this study.

Third, we found some unexpected results that were further explored. For instance, the small effect observed in the PFI and CBI arms in comparison to PTI was potentially explained by the high staff turnover noted among primary care professionals around the time the study was ongoing. Similarly, the unexpected results with regard to the outcomes measured in the UC arm might be accounted for by the intensive trial follow-up that all the arms experienced (ie, answering questions about diet, physical activity and self-care six times in 2years, plus blood tests and other examinations) that could be seen as a kind of intervention.<sup>44 45 48 49</sup> Therefore, the intensity of the follow-up in the study might have also impacted patient behaviour in the UC arm, to the point of reducing the differences in effects at the end of the 2-year period.

Finally, the lack of important differences in QALYs is potentially due to two main reasons. First, it is difficult to observe large changes when most patients included in the study were already well controlled at baseline (49.4% of the whole sample had an HbA1c <7%).<sup>44</sup> Second, the time horizon is too short to observe changes in diabetes-related complications that are the main cause of variations in quality of life.<sup>50</sup> We will aim to overcome these limitations by implementing the INDICA-DOS study, a follow-up of patients included in the INDICA study that aims to collect outcomes and healthcare costs in the longer term. This information will be useful to complement the within-trial economic evaluation presented in this paper with a lifetime Markov model.<sup>23 24</sup>

### Conclusions

In summary, the multicomponent intervention designed by INDICA for patients with T2DM and their families is likely to be a cost-effective option, and particularly so in patients with not so well controlled TD2M (baseline HbA1c >7%). This kind of intervention is likely to be effective, cost-effective and, if focused on those with the highest needs, its impact on the public health budget would be limited.

### Author affiliations

<sup>1</sup>Canary Islands Health Research Institute Foundation (FIISC), Tenerife, Spain

<sup>2</sup>Research Network on Health Services in Chronic Diseases (REDISSEC), Tenerife, Spain

<sup>3</sup>Network for Research on Chronicity, Primary Care, and Health Promotion (RICAPPS), Tenerife, Spain

<sup>4</sup>Department of Endocrinology and Nutrition, Insular University Hospital of Gran Canaria, Las Palmas de Gran Canaria, Spain

<sup>5</sup>University Institute for Biomedical and Health Research (IUBS), University of Las Palmas de Gran Canaria, Las Palmas de Gran Canaria, Spain

<sup>6</sup>Health Technology Assessment Agency, Instituto de Salud Carlos III, Madrid, Spain

<sup>7</sup>Evaluation Unit (SESCS), Canary Islands Health Service (SCS), Santa Cruz de Tenerife, Spain

**Acknowledgements** We thank Oliver Rivero-Arias, Juan Manuel Ramos-Goñi, ThaylÍ León, and Carlos González for their support and advice, and all the nurses, doctors, laboratory, administrative and management staff that collaborated in the project. We would also like to thank the patients and their families and the doctors and nurses that agreed to participate in the INDICA study. Without their collaboration this study would not have been possible. Finally, we are grateful to Jason Willis-Lee, professional copyeditor specialised in biomedicine, for his assistance in drawing up the final manuscript.

**Collaborators** The INDICA team included the following members (in alphabetical order): Abraham Pérez de la Rosa (FUNCANIS), Alicia Pareja Ríos (Dept of Ophthalmology, University Hospital of Canary Islands), Andrés Sifre Perello (Dept of Clinical Analysis, Dr. Molina Orosa Hospital), Ángela Trinidad Gutiérrez Pérez (Canary Islands Health Service), Antonio Cabrera de León (Canary Islands Health Service), Antonio García Quintana (Dept of Cardiology, Dr Negrín University Hospital), Armando Carrillo Domínguez (Dept of Endocrinology and Nutrition, Insular University Hospital), Bernardo Eusebio Herrera Domínguez (Dept of Clinical Analysis, General Hospital of La Palma), Carlos Sedeño Pérez (Canary Islands Health Service), Carlos Ramírez Álamo (Canary Islands Health Service), Carmen Daranas Aguilar (FUNCANIS), Carolina Guerra Marrero (FUNCANIS), Cecilia Lobos Soto (Dept of Ophthalmology, Insular University Hospital), Cristina Padrón Pérez (FUNCANIS), Dácil Alvarado Martel (Dept of Endocrinology and Nutrition, Insular University Hospital), Daniel Hernández Obregón (Dept of Ophthalmology, Dr Negrín University Hospital), Dulce N. Hernández Correa (Canary Islands Health Service), Elsa Espinosa Pozuelo (Asociación para la Diabetes de Tenerife), Elsa Florido Mayor (FUNCANIS), Engracia Pinilla Domínguez (Dept of Ophthalmology, Ntra. Sra. de la Candelaria University Hospital), Fátima Herrera García (Dept of Ophthalmology, University Hospital of Canary), Félix Bonilla Aguiar (Dept of Ophthalmology, Dr José Molina Hospital), Fernando Montón Álvarez (Dept of Neurology, Ntra. Sra. de la Candelaria University Hospital), Francisco Cabrera López (Dept of Ophthalmology, Insular University Hospital), Gloria Guerra de la Torre (Canary Islands Health Service), Gregorio Muelas Martín (Dept of Clinical Analysis, Dr Negrín University Hospital), Guillermo Monzón (Canary Islands Health Service), Héctor de la Rosa Merino (FUNCANIS), Ignacio García Puente (Dept of Endocrinology, Dr Negrín University Hospital), Ignacio Llorente Gómez de Segura (Dept of Endocrinology and Nutrition, Ntra. Sra. de la Candelaria University Hospital), Isabel García Calcerrada (Dept of Clinical Analysis, Dr Negrín University Hospital), Iván Castilla Rodríguez (FUNCANIS), Jacqueline Álvarez Pérez (FUNCANIS), Jorge Federico Aldunate Page (Dept of Ophthalmology, Insular University Hospital), Jose Antonio García Dopico (Dept of Clinical Analysis, University Hospital of Canary Islands), Juan Andrés Báez Hernández (Canary Islands Health Service), Juan José Pérez Valencia (Canary Islands Health Service), Julia Charlotte Wiebe (Dept of Endocrinology, Insular University Hospital), Lilibeth Perestelo Pérez (Canary Islands Health Service), Leopoldo Martín (Dept of Clinical Analysis, General Hospital of La Palma), Lluís Serra Majem (CIBERobn, Institute of Health Carlos III), Luis Morcillo Herrera (Dept of Endocrinology, Ntra. Sra. de la Candelaria University Hospital), Marcos Estupiñán Ramírez (Canary Islands Health Service), Margarita Roldán Ruano (Canary Islands Health Service), María del Mar Romero Fernández (FUNCANIS), María Inmaculada González Pérez (Dept of Clinical Analysis, Ntra. Sra. de la Candelaria University Hospital), María Isabel Visuerte Morales (Dept of Ophthalmology, Insular University Hospital), María Pino Afonso Medina (Dept of Clinical Analysis, Dr Negrín University Hospital), Marta Riaño Ruiz (Clinical Biochemistry Service, Insular University Hospital), Marta Tejera Santana (Dept of Ophthalmology, Dr Negrín University Hospital), Mauro Boronat Cortés (Dept of Endocrinology and Nutrition, Insular University Hospital), Mercedes Lorenzo Medina (Dept of Clinical Analysis, Dr Negrín University Hospital), Miguel Juan Mora García (Canary Islands Health Service), Nayra Pérez Delgado (Dept of Clinical Analysis, Ntra. Sra. de la Candelaria University Hospital), Pablo Pedrianez Martín (Dept of Endocrinology, Dr Negrín University Hospital), Pedro de Pablos Velasco (Dept of Endocrinology, Dr Negrín University Hospital), Pilar Peláez Alba (University of La Laguna), Rafael Valcárcel (Canary Islands Health Service), Remedios Castro

Sánchez (Canary Islands Health Service), Rodrigo Abreu González (Dept of Ophthalmology, Ntra. Sra. de la Candelaria University Hospital), Rosa Borges Trujillo (Dept of Ophthalmology, Dr Negrín University Hospital), Salvador Acosta González (Dept of Ophthalmology, Ntra. Sra. de la Candelaria University Hospital), Sybille Kaiser Girardot (Canary Islands Health Service), Víctor Lorenzo Sellarés (Dept of Nephrology, University Hospital of Canary Islands).

**Contributors** LGP, YRF, LVT, LRR, AMW and PGSA contributed to the study design. YRF, LVT, HGP, BSH and MAGB contributed to the statistical analyses. LGP, YRF, LVT, HGP, MC and PGSA were part of the manuscript's writing committee. All authors reviewed, commented and approved the final manuscript. LGP is the guarantor.

**Funding** This study received financial support from the Spanish Ministry of Economy, Industry and Competitiveness (Instituto de Salud Carlos III), grants: ADE10/00032 and PI16/00769, jointly funded by the European Regional Development Fund (FEDER) 'A way to make Europe'. The sponsor did not play any role in study design, collection, analysis and interpretation of data, drawing up of the report or the decision to submit the article for publication.

**Competing interests** None declared.

**Patient and public involvement** Patients and/or the public were involved in the design, or conduct, or reporting, or dissemination plans of this research. Refer to the Methods section for further details.

**Patient consent for publication** Not applicable.

**Ethics approval** This study involves human participants and was approved by University Hospital of Canarias (ID: 2012\_44) and University Hospital Nuestra Señora de la Candelaria (ID: EPA-07/10). Participants gave informed consent to participate in the study before taking part.

**Provenance and peer review** Not commissioned; externally peer reviewed.

**Data availability statement** Data are available on reasonable request. The datasets generated and/or analysed during the current study, including deidentified participant data are available from the corresponding author on reasonable request in the next 10 years. The study protocol is available at <https://implementationscience.biomedcentral.com/articles/10.1186/s13012-015-0233-1>.

**Supplemental material** This content has been supplied by the author(s). It has not been vetted by BMJ Publishing Group Limited (BMJ) and may not have been peer-reviewed. Any opinions or recommendations discussed are solely those of the author(s) and are not endorsed by BMJ. BMJ disclaims all liability and responsibility arising from any reliance placed on the content. Where the content includes any translated material, BMJ does not warrant the accuracy and reliability of the translations (including but not limited to local regulations, clinical guidelines, terminology, drug names and drug dosages), and is not responsible for any error and/or omissions arising from translation and adaptation or otherwise.

**Open access** This is an open access article distributed in accordance with the Creative Commons Attribution Non Commercial (CC BY-NC 4.0) license, which permits others to distribute, remix, adapt, build upon this work non-commercially, and license their derivative works on different terms, provided the original work is properly cited, appropriate credit is given, any changes made indicated, and the use is non-commercial. See: <http://creativecommons.org/licenses/by-nc/4.0/>.

#### ORCID iDs

Lidia García-Pérez <http://orcid.org/0000-0002-5626-8116>

Yolanda Ramallo-Fariña <http://orcid.org/0000-0002-1541-3989>

Laura Vallejo-Torres <http://orcid.org/0000-0001-5833-6066>

#### REFERENCES

- 1 WHO Global Report. Global report on diabetes 2016;978 <http://www.who.int>
- 2 NCD Risk Factor Collaboration (NCD-RisC). Worldwide trends in diabetes since 1980: a pooled analysis of 751 population-based studies with 4.4 million participants. *Lancet* 2016;387:1513–30.
- 3 Seuring T, Archangelidi O, Suhrcke M. The economic costs of type 2 diabetes: a global systematic review. *Pharmacoeconomics* 2015;33:811–31.
- 4 Cabrera de León A, Rodríguez Pérez M<sup>a</sup> del Cristo, Almeida González D, *et al*. Presentación de la cohorte 'CDC de Canarias': objetivos, diseño y resultados preliminares. *Rev Esp Salud Pública* 2008;82:519–34.
- 5 Instituto Nacional de Estadística. Encuesta Nacional de Salud, 2012. Available: [www.ine.es](http://www.ine.es) [Accessed 15 Jan 2015].



- 6 Lorenzo V, Boronat M, Saavedra P, *et al.* Disproportionately high incidence of diabetes-related end-stage renal disease in the Canary Islands. An analysis based on estimated population at risk. *Nephrol Dial Transplant* 2010;25:2283–8.
- 7 Aragón-Sánchez J, García-Rojas A, Lázaro-Martínez JL, *et al.* Epidemiology of diabetes-related lower extremity amputations in Gran Canaria, Canary Islands (Spain). *Diabetes Res Clin Pract* 2009;86:e6–8.
- 8 Straus SE, Tetroe JM, Graham ID. Knowledge translation is the use of knowledge in health care decision making. *J Clin Epidemiol* 2011;64:6–10.
- 9 Loveman E, Cave C, Green C, *et al.* The clinical and cost-effectiveness of patient education models for diabetes: a systematic review and economic evaluation. *Health Technol Assess* 2003;7:1–190.
- 10 Main C, Moxham T, Wyatt JC, *et al.* Computerised decision support systems in order communication for diagnostic, screening or monitoring test ordering: systematic reviews of the effects and cost-effectiveness of systems. *Health Technol Assess* 2010;14:hta14480.
- 11 Stone MA, Wilkinson JC, Charpentier G, *et al.* Evaluation and comparison of guidelines for the management of people with type 2 diabetes from eight European countries. *Diabetes Res Clin Pract* 2010;87:252–60.
- 12 Trento M, Basile M, Borgo E, *et al.* A randomised controlled clinical trial of nurse-, dietitian- and pedagogist-led group care for the management of type 2 diabetes. *J Endocrinol Invest* 2008;31:1038–42.
- 13 Lopez-Bastida J, Boronat M, Moreno JO, *et al.* Costs, outcomes and challenges for diabetes care in Spain. *Global Health* 2013;9:17.
- 14 Servicio Canario de la Salud. Plan de Salud de Canarias: 2004–2008: “Más Salud y mejores Servicios”. Available: [https://www3.gobiernodecanarias.org/sanidad/scs/scs/1/plansalud/plansalud2004\\_2008/Plan\\_de\\_Salud\\_de\\_Canarias\\_2004\\_2008.pdf](https://www3.gobiernodecanarias.org/sanidad/scs/scs/1/plansalud/plansalud2004_2008/Plan_de_Salud_de_Canarias_2004_2008.pdf) [Accessed 7 Aug 2020].
- 15 Brown-Guion SY, Youngerman SM, Hernandez-Tejada MA, *et al.* Racial/ethnic, regional, and rural/urban differences in receipt of diabetes education. *Diabetes Educ* 2013;39:327–34.
- 16 García-Pérez L-E, Álvarez M, Dilla T, *et al.* Adherence to therapies in patients with type 2 diabetes. *Diabetes Ther* 2013;4:175–94.
- 17 Årsand E, Frøisland DH, Skróvseth SO, *et al.* Mobile health applications to assist patients with diabetes: lessons learned and design implications. *J Diabetes Sci Technol* 2012;6:1197–206.
- 18 Lee PA, Greenfield G, Pappas Y. The impact of telehealth remote patient monitoring on glycemic control in type 2 diabetes: a systematic review and meta-analysis of systematic reviews of randomised controlled trials. *BMC Health Serv Res* 2018;18:495.
- 19 Pal K, Eastwood SV, Michie S, *et al.* Computer-based interventions to improve self-management in adults with type 2 diabetes: a systematic review and meta-analysis. *Diabetes Care* 2014;37:1759–66.
- 20 Saffari M, Ghanizadeh G, Koenig HG. Health education via mobile text messaging for glycemic control in adults with type 2 diabetes: a systematic review and meta-analysis. *Prim Care Diabetes* 2014;8:275–85.
- 21 Serrano-Aguilar P, Asua-Batarrita J, Molina-López MT, *et al.* The Spanish network of agencies for health technology assessment and services of the National health system (RedETS). *Int J Technol Assess Health Care* 2019;35:176–80.
- 22 Boulenger S, Nixon J, Drummond M, *et al.* Can economic evaluations be made more transferable? *Eur J Health Econ* 2005;6:334–46.
- 23 Ramallo-Fariña Y, García-Pérez L, Castilla-Rodríguez I, *et al.* Effectiveness and cost-effectiveness of knowledge transfer and behavior modification interventions in type 2 diabetes mellitus patients—the INDICA study: a cluster randomized controlled trial. *Implement Sci* 2015;10:47.
- 24 ClinicalTrials.gov. National Library of Medicine (US). Tertiary prevention in type II diabetes mellitus in Canary Islands study (indica). identifier NCT01657227. Available: <https://clinicaltrials.gov/ct2/show/NCT01657227> [Accessed 7 Aug 2020].
- 25 Ramallo-Fariña Y, Rivero-Santana A, García-Pérez L, *et al.* Patient-reported outcome measures for knowledge transfer and behaviour modification interventions in type 2 diabetes—the INDICA study: a multiarm cluster randomised controlled trial. *BMJ Open* 2021;11:e050804.
- 26 Ramallo-Fariña Y, García-Bello MA, García-Pérez L, *et al.* Effectiveness of internet-based multicomponent interventions for patients and health care professionals to improve clinical outcomes in type 2 diabetes evaluated through the indica study: Multiarm cluster randomized controlled trial. *JMIR Mhealth Uhealth* 2020;8:e18922.
- 27 Drummond MF, Sculpher MJ, Torrance GW. *Methods for the economic evaluation of health care programmes*, 2005.
- 28 Glick HA, Doshi JA, Sonnad SS. *Economic evaluation in clinical trials*. New York: Oxford University Press, 2007.
- 29 Ramsey SD, Willke RJ, Glick H, *et al.* Cost-effectiveness analysis alongside clinical trials II—An ISPOR good research practices Task force report. *Value in Health* 2015;18:161–72.
- 30 Herdman M, Gudex C, Lloyd A, *et al.* Development and preliminary testing of the new five-level version of EQ-5D (EQ-5D-5L). *Qual Life Res* 2011;20:1727–36.
- 31 Ramos-Goñi JM, Craig BM, Oppe M, *et al.* Handling data quality issues to estimate the Spanish EQ-5D-5L value set using a hybrid interval regression approach. *Value Health* 2018;21:596–604.
- 32 Manca A, Hawkins N, Sculpher MJ. Estimating mean QALYs in trial-based cost-effectiveness analysis: the importance of controlling for baseline utility. *Health Econ* 2005;14:487–96.
- 33 Altman DG, Schulz KF, Moher D, *et al.* The revised CONSORT statement for reporting randomized trials: explanation and elaboration. *Ann Intern Med* 2001;134:663.
- 34 Moher D, Schulz KF, Altman DG, *et al.* The CONSORT statement: revised recommendations for improving the quality of reports of parallel-group randomized trials. *Ann Intern Med* 2001;134:657.
- 35 White IR, Royston P, Wood AM. Multiple imputation using chained equations: issues and guidance for practice. *Stat Med* 2011;30:377–99.
- 36 Vallejo-Torres L, García-Lorenzo B, Serrano-Aguilar P. Estimating a cost-effectiveness threshold for the Spanish NHS. *Health Econ* 2018;27:746–61.
- 37 Nelson AL, Cohen JT, Greenberg D, *et al.* Much cheaper, almost as good: decrementally cost-effective medical innovation. *Ann Intern Med* 2009;151:662.
- 38 Lian JX, McGhee SM, Chau J, *et al.* Systematic review on the cost-effectiveness of self-management education programme for type 2 diabetes mellitus. *Diabetes Res Clin Pract* 2017;127:21–34.
- 39 Handley MA, Shumway M, Schillinger D. Cost-effectiveness of automated telephone self-management support with nurse care management among patients with diabetes. *Ann Fam Med* 2008;6:512–8.
- 40 Siegel KR, Ali MK, Zhou X, *et al.* Cost-effectiveness of interventions to manage diabetes: has the evidence changed since 2008? *Diabetes Care* 2020;43:1557–92.
- 41 Eurostat. ICT usage in households and by individuals, 2021. Available: [https://ec.europa.eu/eurostat/databrowser/view/isoc\\_ci\\_ifp\\_iu/default/table?lang=en](https://ec.europa.eu/eurostat/databrowser/view/isoc_ci_ifp_iu/default/table?lang=en) [Accessed 22 Feb 2022].
- 42 Instituto Nacional de Estadística. Survey on equipment and use of information and communication technologies (ICT) in households, 2021. Available: [https://www.ine.es/en/prensa/tich\\_2021\\_en.pdf](https://www.ine.es/en/prensa/tich_2021_en.pdf) [Accessed 22 Feb 2022].
- 43 Bernal-Delgado E, Garcia-Armesto S, Oliva J, *et al.* Spain: health system review. *Health Syst Transit* 2018;20:1–179 <http://www.ncbi.nlm.nih.gov/pubmed/30277216>
- 44 Jackson CL, Bolen S, Brancati FL, *et al.* A systematic review of interactive computer-assisted technology in diabetes care. interactive information technology in diabetes care. *J Gen Intern Med* 2006;21:105–10.
- 45 Quinn CC, Shardell MD, Terrin ML, *et al.* Cluster-randomized trial of a mobile phone personalized behavioral intervention for blood glucose control. *Diabetes Care* 2011;34:1934–42.
- 46 Whitehead LC, Crowe MT, Carter JD, *et al.* A nurse-led education and cognitive behaviour therapy-based intervention among adults with uncontrolled type 2 diabetes: a randomised controlled trial. *J Eval Clin Pract* 2017;23:821–9.
- 47 Faria R, Gomes M, Epstein D, *et al.* A guide to handling missing data in cost-effectiveness analysis conducted within randomised controlled trials. *Pharmacoeconomics* 2014;32:1157–70.
- 48 Anzaldo-Campos MC, Contreras S, Vargas-Ojeda A, *et al.* Dulce wireless Tijuana: a randomized control trial evaluating the impact of project Dulce and short-term mobile technology on glycemic control in a family medicine clinic in northern Mexico. *Diabetes Technol Ther* 2016;18:240–51.
- 49 Egede LE, Williams JS, Voronca DC, *et al.* Telephone-delivered behavioral skills intervention for African American adults with type 2 diabetes: a randomized controlled trial. *J Gen Intern Med* 2017;32:775–82.
- 50 Beaudet A, Clegg J, Thuresson P-O, *et al.* Review of utility values for economic modeling in type 2 diabetes. *Value Health* 2014;17:462–70.