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Effectiveness of enhanced diabetes care to patients of South Asian ethnicity: the United Kingdom Asian Diabetes Study (UKADS) - a cluster randomised controlled trial.

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Summary:

Background: Delivering high quality and evidence based healthcare to deprived sectors of the community is a major goal for society. We investigated the effectiveness of a culturally sensitive enhanced care package in UK general practice in improving cardiovascular risk factors in South Asian patients with type 2 diabetes.

Methods: 21 inner city practices were randomised to intervention (enhanced practice nurse time, link worker and diabetes specialist nurse support) (n=868) or control (standard care) (n=618) groups. Prescribing algorithms with clearly defined targets were provided for all practices. Main outcome measures comprised changes in blood pressure, total cholesterol and glycaemic control (HbA1c) after 2 years.

Findings: At baseline, groups were similar with respect to age, sex and cardiovascular risk factors.

Comparing treatment groups, after adjustment for confounders, and clustering, differences in diastolic blood pressure (1.91mmHg, P=0.0001) and mean arterial pressure (1.36mmHg, P=0.0180) were significant. There were no significant differences between groups for total cholesterol or HbA1c. Economic analysis indicates the nurse-led intervention was not cost-effective.

Across the whole study population systolic blood pressure, diastolic blood pressure and cholesterol decreased significantly by 4.9mmHg, 3.8mmHg and 0.45mmol/L respectively, but there was no change in HbA1c.

Interpretation: Additional, although limited, benefits were observed from our culturally enhanced care package over and above the secular changes achieved in the UK in recent years. Stricter targets in general practice and further measures to motivate patients are needed to maximise healthcare outcomes in South Asian patients with diabetes.

Introduction:

Patients of South Asian ethnic background (United Kingdom (UK) decennial census categories Indian, Pakistani, Bangladeshi and other Asians) with type 2 diabetes present special management challenges[1, 2]. In the UK, the prevalence of type 2 diabetes is 4 to 6 fold higher amongst South Asians[3], onset may be over a decade earlier, there is a higher risk of cardiovascular and renal complications, with higher morbidity and 50% higher mortality compared to white Europeans[4]. Healthcare delivery in this population is more challenging because of cultural, communication and comprehension difficulties which along with social deprivation further complicate the achievement of defined targets[5, 6]. Payments for UK general practices based on their achievement of quality (Quality and Outcomes Framework-QOF)[7] targets do not distinguish different ethnic groups.

Community based enhanced care packages have been associated with improved metabolic outcomes in certain ethnic groups[8] but have not been fully evaluated in large randomised controlled trials. Such trials are lacking in people of South Asian ethnicity[9]. The United Kingdom Asian Diabetes Study (UKADS) is an evaluation of a community based complex intervention aimed at reducing cardiovascular risk in South Asians with type 2 diabetes. The intervention package tailored to the needs of the South Asian community comprises protected additional practice nurse time, Asian link workers and diabetes specialist nurse input, working to protocols to achieve clearly defined targets. In line with recognised complex intervention evaluations[10] and following a protocol informed by a pilot study[11] we describe a large cluster randomised controlled trial that began in 2004. The UKADS study hypothesis was that an enhanced care package for diabetes, would improve cardiovascular risk profile in patients of South Asian origin, with established Type 2 diabetes.

Methods:

Twenty-one General Practices (seven in Coventry, and fourteen in Birmingham, UK) with a very high proportion of South Asians were included in the study. Nine practices were randomised to enhanced (intervention) and twelve to conventional (control) care; a common treatment algorithm was provided. All adult patients with type 2 diabetes were eligible for inclusion in the study.

Protocol and targets

Enhanced care included an additional practice nurse session (4 hours) per week supported by link workers and a community diabetes specialist nurse. Patients in the intervention group were followed up on average every two months in weekly clinics run by the practice nurses. Practice nurses worked with primary care physicians to implement the protocol and encourage appropriate prescribing, provide face-to-face patient education in clinic setting and achieve targets for blood pressure, lipid and glycaemic control. Each patient was contacted by a link worker before and between appointments to encourage clinic attendance. In addition, link workers provided interpretation and additional educational input to the patients in the community setting in local languages to improve compliance and understanding and to encourage dietary and lifestyle changes. The community diabetes specialist nurse attended some of the research clinics and provided additional educational and clinical support, including insulin initiation, to the practice teams. All staff had formal training and experience in delivering diabetes care in the practice setting. The standard of care provided by the practice nurse and the link worker was monitored by the specialist nurse in regularly observed sessions.

Practices were encouraged to adhere to treatment protocols and to achieve targets. The study targets followed internationally accepted norms and were HbA_{1c} 7.0% (accepted target at the time of commencement of study), total Cholesterol 4.0 mmol/l (160mg/dl)

and blood pressure 130/80 mmHg if no microvascular complications (as recommended by the Joint British Societies and international bodies)[12-14] and 125/75 mmHg if microalbuminuria or proteinuria was present. Control practices received the same treatment protocols and the practices managed patients with their existing resources. The study protocol was approved by East Birmingham and Coventry Primary Care Trust Ethical Committees. Graphical representation of components and timings of the complex intervention are outlined in figure 1[15].

Primary outcomes were follow-up measurements for blood pressure, total cholesterol and HbA_{1c}, with secondary outcomes waist circumference, body mass index (BMI) and Framingham 10 years Coronary Heart Disease (CHD) risk score[16], microalbuminuria and plasma creatinine.

Passive monitoring was undertaken for adverse events and practices were encouraged to report any incidents related to the intervention.

Sample size estimation and power

This was a cluster randomized trial with general practice the unit of randomisation. Sample size estimations were made based on the observed differences and intra-class correlations (ICC-defined as between groups/ within groups variance) from the pilot study or an ICC = 0.05, which is derived from published estimates for primary care studies[17, 18]. In all estimations, power was set to 80%, and the 2-sided probability value to P=0.05. Estimates were made for differences in changes in systolic blood pressure (7mmHg, with standard deviation (s.d.) 21.25 and ICC=0.035), total cholesterol (0.45mmol/l, s.d.=1.1, ICC=0.05) and HbA_{1c} (0.75, s.d=2.1, ICC= 0.05). All estimates from above data values resulted in 16-18 clusters of 80-100 patients being needed allowing for 10% drop-out rate, as observed in the pilot study. Rationale for these effect sizes was that they were similar

to those observed in the pilot study, changes of this magnitude would be clinically significant and also they reflected prescribing algorithm targets.

Statistical methods

Data were analysed using the SAS software package. Baseline variables were compared between groups using χ^2 tests of independence, with t-tests for continuous variables, which were first assessed for normality.

Primary and secondary outcomes were continuous. In the main intervention evaluation, final measured outcomes were modelled, with grand mean centred baseline measures included as covariates. To adjust for clustering and potential confounding effects, the SAS PROC MIXED procedure was used to fit hierarchical, combined fixed and random effects models[19, 20]. In all cases, mixed models included fixed effects for area (Birmingham vs. Coventry), gender, age at diagnosis of diabetes, duration of diabetes and corresponding grand mean centred baseline measurement. For HbA1c, treatment with insulin at baseline was included in final models. Terms for anti-hypertensive treatments, angiotensin-converting enzyme inhibitors (ACE) or angiotensin receptor blockers (ARB) at baseline were included in blood pressure models. For total cholesterol, statins and fibrates were included. Random effects were fitted, within a subject term for General Practice, allowing for different intercepts and regression slopes for each individual practice (random coefficients models) .

Restricted maximum likelihood models (REML) models were used to analyse data. The correlation structure used in reported results was “unstructured” in all cases; “Variance components” structures were considered. SAS graphics options were used to plot and evaluate residuals and influential data points, which were then removed and models re-run; results presented do not exclude outliers.

For the main intention to treat analysis comparing outcomes, all patients were included. Baseline and 2 year follow-up data measurements were analysed; for patients whose follow-up data were not available (Fig. 2), data imputation using last observation carried forward (LOCF) was used. This was an interim value measured after one year, for around 50% of cases, or the baseline value. Analyses using the same final models were performed using only subjects with complete data and using only patients who had not died; whilst estimates of effect differed slightly, results and their interpretation were essentially the same.

Detailed data on staff salaries, travel and subsistence, equipment costs, payment to practices, and prescribing were collected to estimate the net intervention cost over a 2 year period. Changes in Quality Adjusted Life Years (QALY) between intervention and control groups were measured using EQ5D questionnaire[21].

Authors with access to data for analysis were NR, SB, PO'H, AHB, AS, and AG. The decision to submit the manuscript was made by all authors and the UKADS Study group.

Results:

Patient demographics and baseline risk factors

1486 patients of South Asian ethnicity, with established type 2 diabetes, consented to take part and were included in the study; 500 (33.7%) from Coventry and 986 (66.3%) from Birmingham.

Baseline risk factor profile, comparing the intervention and control groups, is shown in Table 1. Mean age for the whole group was 57.0 years, standard deviation (SD) 11.9. Differences observed between groups for gender, age, duration of diabetes and diabetes treatment modalities were not statistically significant. Current smoking prevalence (15%) was similar in both groups, but more control patients were ex-smokers. There were no differences in weight, body mass index (BMI) or waist circumference measurements. Significantly more intervention than control patients were treated with statins (Table 1).

At baseline, 268 (18%) patients had evidence of existing CHD or prior cardiovascular events; angina, myocardial infarction, cardiovascular accident, coronary artery bypass graft or other heart problems, comprising 150 (17%) intervention and 118 (19 %) control patients.

Urinary albumin:creatinine ratio was measured for 1389 (93%) patients and micro-albuminuria (defined as a ratio >2.5 in males and >3.5 in females) was present in 268 (19%) patients. Significant proteinuria, defined as albumin:creatinine ratio of >25.0 was detected in 114 patients (8%). The prevalence of combined microalbuminuria or proteinuria was 28% , with no difference between intervention and control groups.

Using the Framingham equation, mean (s.d) 10 year CHD risk score was 10.6 (8.8) with no difference between treatment groups (Table 1).

Effect of intensive control for 2 years

During 2 years of follow-up, 48 (3%) patients died, 24 (3%) intervention and 24 (4%) control. New cardiovascular events were recorded for 97 (7%) patients, 62 (7%) intervention and 35 (6%) controls. None of these small differences between intervention and control groups were significant. Patients with CHD at baseline were more likely to die; 18 (7%) vs. 30 (2%), or to experience CHD events during follow-up 34 (13%) vs. 63 (5%) irrespective of treatment group. No significant adverse events related to intervention were recorded during the study period.

Results for comparison of outcomes between intervention and control groups are presented in Table 2; unadjusted differences compared with a t-test, plus results from multiple linear and mixed regression modelling are shown. Comparing treatment groups, after two years there was a reduction of 5.1 mmHg in Systolic Blood Pressure (SBP) and 4.5 mmHg in Diastolic Blood Pressure (DBP) for intervention vs. 4.7 mmHg and 2.9 mmHg respectively in the control group. T-tests showed significant differences in favour of the intervention group for diastolic BP and HbA1c. After adjustment for potential confounders DBP and Mean Arterial Pressure (MAP) showed significant advantages for the intervention group. In final models taking clustering effects into account, significant effects persisted for the intervention group for both MAP and DBP (Table 2). BMI was significantly increased in the intervention group. Other differences in primary and secondary outcomes; HbA1c, total cholesterol, waist circumference and CHD risk scores were small and not statistically significant after adjustment for confounding and clustering (Table 2).

The percentage of patients with microalbuminuria or proteinuria increased from 28% at baseline to 32% after 2 years with no significant difference between the intervention and control groups. Patients at high renal risk, defined by plasma creatinine >120 for females

and >150 for males increased from 3% at baseline to 4% after 2 years, with no difference between treatment groups.

Combining all patients from intervention and control groups after two years, there was an overall decrease of 4.9 (4.0 to 5.9) mmHg in SBP (P<0.001), 3.8 (3.2 to 4.4) mmHg in DBP (P<0.001) and 4.2 (3.6 to 4.8) mmHg in MAP (P<0.001). Total cholesterol decreased by 0.45 (0.40 to 0.51) mmol/L (P<0.001). A very small and statistically non significant increase was observed for HbA1c; 0.04% (-0.04 to 0.13), P=0.2902.

Prescribing changes and targets achieved

After two years follow-up, proportions of patients treated with anti-hypertensives had increased to 75% overall, with no difference between groups. Treatment with statins had increased and the difference between treatment groups disappeared, with 540 (64%) intervention vs. 389 (65%) controls treated. The use of ACE inhibitors or Angiotensin Receptor Blockers increased substantially from 37% to 65% in the intervention and 40% to 62% in the control group; no significant difference between groups.

Similar proportions of patients were treated with insulin at baseline; 161 (19%) intervention and 129 (21%) control. After 2 years, more intervention than control patients had started insulin therapy, 47 (8%) vs. 23 (5%), but this was not statistically significant, relative risk (RR) 1.44 (0.89 to 2.34).

The proportion of patients achieving the study targets were; blood pressure (35% v 30%), cholesterol (48% v 51%) and HbA1c (32% v 27%) for intervention and control groups respectively. Corresponding proportion of patients achieving the QOF targets for blood pressure of < 145/85 mmHg was (66% v 55%), cholesterol <5 mmol/L (81% v 82%) and HbA1c <7.5% (44% v 39%).

Cost of intervention and quality of life

A detailed cost breakdown is presented in Table 5. Over two years, the cost of intervention per patient was £434 (£406 net service and £28 net prescribing costs). Overall quality of life in the studied subjects deteriorated over 2 years. In spite of that, the resultant net change in quality of life in the intervention over control group was positive, although small. The incremental cost-effectiveness ratio is calculated to be £28,933 per QALY gained.

Discussion:

The achievement of targets set by national and international advisory bodies in general practices in inner city areas with a high prevalence of socially diverse ethnic groups poses a major challenge[12-14, 22]. At baseline, a large majority of our patients had HbA_{1c} >7% (70%), BP >130/80 (76%) and Total Cholesterol >4 mmol/l (70%); above targets recommended by international standards for diabetes care. After two years in which secular changes included the pay for performance initiative there were significant improvements in blood pressure and total cholesterol across the whole study population, but no change in HbA1c. SBP decreased by 4.9mmHg, DBP by 3.8mmHg and mean cholesterol by 0.45 mmol/L. These reductions are both statistically and clinically highly significant. A reduction in blood pressure has been associated with rapid reduction in cardiovascular risk in many studies[23-25]. The relationship between blood pressure and cardiovascular risk is such that a reduction of 5 mmHg, if sustained would confer substantial protection from cardiovascular events[26]. The improvements in blood pressure and cholesterol in our study were associated with increased prescribing of anti hypertensive agents and statins and are consistent with improvements reported by several others following introduction of the QOF initiatives [27].

The mortality observed during the study (3%) together with the baseline (18%) and follow-up (7%) frequency of cardiovascular events confirm that the South Asian group we studied have a high cardiovascular risk and that substantial benefits could be obtained by aggressive risk factor reduction. The failure to prevent the increase in microalbuminuria despite a 5mmHg reduction in blood pressure is surprising and suggests that lower targets may be needed for this group.

Comparing intervention and control groups after two years, significant differences were observed for diastolic blood pressure and mean arterial pressure after adjustment for confounding and clustering. SBP was lower in the intervention group but this was not statistically significant. The reductions seen in DBP were comparable to those observed in our pilot study but the reduction in SBP was less than previously achieved. It is possible that the relatively young age of onset and ethnicity may be a factor in this observation and it is interesting that a more pronounced diastolic effect has been reported in some other studies[28] .

A small but statistically significant increase in BMI was noted in the intervention group. One likely reason for this could be the increased use of insulin in the intervention group but other factors such as poor adherence to lifestyle advice may have contributed.

The lack of improvement in HbA1c may be due, at least in part, to the natural disease progression commonly seen in type 2 diabetes[29]; in the control group HbA1c tended to rise while in the intervention group it remained stable over two years.. It is disappointing, given the healthcare resources provided, that neither the QOF incentives nor our culturally sensitive enhanced care package impacted significantly on glycaemic control.

Despite clear evidence of failure to reach target levels of HbA1c via diet and oral anti-diabetic therapy, only a small increase in the percentage of patients treated with insulin was observed in both groups (8% vs. 5% for intervention and control groups). Even

though the intervention included support from specialist diabetes nurses with experience of insulin initiation and enhanced time for patient education, this appears to have had only a limited effect in terms of behavioural change or patient acceptance of insulin.

Initiating insulin in primary care in the UK is relatively new and building up confidence of both the health care team and South Asian patients may be as important as any financial incentives paid to the former. Changing patient behaviour through motivation and patient education might take longer than the two years follow-up in this study. Alternative methods of motivation, including structured patient education[30] and more aggressive insulin initiation, may be needed.

Significant improvements in performance indicators were observed across the UK general practice following the introduction of the QOF initiatives and it is likely that even the control practices in our study benefited from these changes. Considerably fewer patients achieved the study targets compared to those meeting the QOF targets suggesting adherence to treatment protocols was poor in both groups. Despite additional nursing resources there were small improvements in the intervention group. This may be due to reluctance on the part of health professionals and on behalf of patients in their motivation to intensify treatments and achieve tighter targets beyond those already set in the QOF initiative. Such factors will not be exclusive to South Asians in the UK primary care and may be relevant to other racial groups and healthcare settings.

The economic analysis shows that the financial investment required over two years (£434 per patient) did not produce sufficient health related quality of life gain to make such a nurse-led intervention clearly cost-effective. At £28,933 per QALY gained, compared to

an indicative norm of £30,000 per QALY[31], wide scale implementation is not indicated without improvement in effectiveness.

In our analyses we used LOCF, which we acknowledge has its weaknesses. However, analysing complete data only, produced very similar results. A further limitation of our study is the inability to assess the relative contributions of individual components of the intervention; such difficulties are inherent to evaluation of complex interventions.

Considerable difficulties in recruiting and retaining individuals of South Asian ethnicity have been reported previously by several investigators[32, 33] which may account for the lack of large scale studies in this area[34]. However, our experience indicates that recruitment and retention is possible in this hard to reach group. Our results suggest that small but sustained improvements in blood pressure can be achieved through the introduction of a culturally sensitive enhanced care package for South Asian patients in addition to improvements from the QOF financial incentives. Improving glycaemic control remains a major challenge and further work to enhance effectiveness of healthcare delivery in general practice and to improve motivation is clearly needed for this group if healthcare inequalities are to be reduced. Whilst progress has been made there remains a substantial challenge in achieving the more stringent targets recommended by national and international expert advisory bodies.

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Table 1 – Baseline characteristics, Intervention (N=868) vs. Control (N=618) group

Baseline measure:	**Intervention:**	**Control:**	**Total:**
	n *(%)*	**n *(%)***	**n *(%)***
Gender:			
Female	396 *(46)*	313 *(51)*	709 *(48)*
Male	472 *(54)*	304 *(49)*	776 *(52)*
Age group:			
<45 years	131 *(15)*	84 *(14)*	215 *(14)*
45-64	467 *(54)*	363 *(59)*	830 *(56)*
65+	270 *(31)*	171 *(28)*	441 *(30)*
Duration of diabetes:			
0-4 years	367 *(42)*	222 *(36)*	589 *(40)*
5-9	230 *(27)*	189 *(31)*	419 *(28)*
10-19	197 *(23)*	161 *(26)*	358 *(24)*
20+	72 *(8)*	41 *(7)*	113 *(8)*
Treatment:			
Insulin	161 *(19)*	129 *(21)*	290 *(20)*
Oral	591 *(68)*	429 *(69)*	1020 *(69)*
Diet only	116 *(13)*	60 *(10)*	176 *(12)*
Smoking status:*			
Current smoker	135 *(16)*	86 *(14)*	221 *(15)*
Ex smoker	59 *(7)*	69 *(11)*	128 *(9)*
Non smoker	673 *(78)*	462 *(75)*	1135 *(76)*

	Mean *(s.d.)*	**Mean *(s.d.)***	**Mean *(s.d.)***
Weight (kg)	76.2 *(14.6)*	75.2 *(14.6)*	75.8 *(14.5)*
Waist (cm)	102.0 *(11.5))*	101.3 *(12.3)*	101.7 *(11.8)*
BMI	28.5 *(4.8)*	28.6 *(4.9)*	28.5 *(4.9)*
Framingham 10 years CHD risk score	10.5 (8.8)	10.6 (8.8)	10.6 (8.8)
Risk factors profile:			
Mean Arterial Pressure (MAP)	101.7 *(12.9)*	102.9 *(12.9)*	102.2 *(12.9)*
Systolic BP	139.4 *(21.1)*	141.1 *(20.3)*	140.1 *(20.8)*
Diastolic BP	82.9 *(11.0)*	83.8 *(11.1)*	83.3 *(11.0)*
Total cholesterol	4.7 *(1.1)*	4.7 *(1.1)*	4.7 *(1.1)*
HbA1c	8.2 *(1.9)*	8.2 *(1.8)*	8.2 *(1.9)*
Prescribing:			
All anti-hypertensives	475 *(55)*	342 *(55)*	817 *(55)*
ACE/ARB	321 *(37)*	246 *(40)*	567 *(38)*
Statins*	438 *(50)*	273 *(44)*	711 *(48)*

Missing data: duration of diabetes 7, smoking status 2, weight 2, waist circumference 5, BMI 10, total cholesterol 2, HbA1c 13 patients**.**

*** Statistically significant difference between groups at 5% level**

Smoking status χ^2 =9.01, P=0.01, Statins χ^2 =5.72, P=0.02,

Table 2. Outcomes, differences (95% confidence intervals) adjusted for potential confounding and for clustering:

Outcomes:	(A) Difference between means (P value)	(B) Differences least squares means (P value)	(C) Differences least squares means (P value)
Primary:			
MAP	-1.23 (-2.52 to 0.05) (0.0606)	-2.00 (-3.08 to -0.92) (0.0003)	-1.36 (-2.49 to -0.23) (0.0180)
Systolic BP	-0.43 (-2.33 to 1.48) (0.6591)	-1.42 (-3.02 to 0.18) (0.0817)	-0.33 (-2.41 to 1.75) (0.7577)
Diastolic BP	-1.63 (-2.80 to -0.46) (0.0065)	-2.29 (-3.28 to -1.30) (<0.0001)	-1.91 (-2.88 to -0.94) (0.0001)
Total cholesterol	0.01 (-0.11 to 0.12) (0.8783)	0.02 (-0.07 to 0.12) (0.6433)	0.03 (-0.04 to 0.11) (0.3684)
HbA1c	-0.18 (-0.34 to -0.01) (0.0371)	-0.13 (-0.28 to 0.02) (0.0796)	-0.15 (-0.33 to 0.03) (0.1111)
Secondary:			
CHD risk (Fram) (n=1376)*	0.06 (-0.56 to 0.68) (0.8495)	-0.08 (-0.62 to 0.46) (0.7700)	0.01 (-0.57 to 0.59) (0.9736)
Waist (cm)	-0.25 (-0.99 to 0.50) (0.5162)	-0.06 (-0.76, 0.64) (0.8627)	-0.24 (-1.32, 0.85) (0.6657)
BMI	0.38 (0.20 to 0.55) (<0.0001)	0.40 (0.22, 0.57) (<0.0001)	0.40 (0.20, 0.60) (<0.0001)

* Note:- Framingham CHD risk only estimated for patients aged 30 to 74 yrs at baseline.

Notes

(A) crude differences based on t-test comparison, no adjustment.

(B) differences based on fixed effects model, adjusted for confounding.

(C) differences based on mixed model, adjusted for confounding and clustering.

Table 3. Intervention costs and incremental cost-effectiveness over 2 years

Intervention costs (*incremental cost between intervention & control*)	
1. Staff salaries*	£224,774
2. Payment to practices*(incremental cost between intervention and control practices)***	£50,000
3. Travel and subsistence	£17,720
4. Clinical equipment	£11,060
Total enhanced diabetes care service over 2 years	£303,554
Per patient enhanced service cost over 2 years	£406
Prescribing cost (*incremental cost between intervention & control*)	
Per patient net prescribing cost for non-diabetic drugs over 2 years	£16
Per patient net prescribing cost for diabetic drugs over 2 years	£12
Per patient net prescribing cost over 2 years	£28
Total per patient incremental net cost of intervention over 2 years	£434
Per patient quality adjusted life year (QALY) gain over 2 years	0.015
Incremental cost per QALY gained	£28,933

* Staff salaries covered two specialist nurses and five link workers clinical time. The salaries included national insurance and pension contributions.

** It is the net amount paid to nine intervention practices to implement the intervention over two years.

Figure 1: Graphic representation of the complex intervention trial.

Timeline	Intervention	Control
Month 0 Randomisation of practices	F C	F C
Months 1-8 Recruitment of patients and Baseline data collection	B, C, D E	B, C, E
2 monthly research clinic appointments	B, C, D A F	A, F
Research Monitoring meetings (2-3 months apart)	G, C, D	G, C, D
Months 12-20 Outcomes assessed	B, C, D E	B, C, D E

A Prescribing algorithms - algorithms for blood pressure, blood glucose and lipid control (Appendix 1)

B Practice Nurse (works in a GP Surgery as a part of primary health care team)- protected time to run research diabetes clinic in intervention practices. Dietary advice and implementation of protocols. Practice nurses were formally trained in Diabetes and had 1:1 observed sessions with Diabetes Specialist Nurse

C Diabetes Specialist Nurse (Nurse with specialist knowledge of management of Diabetes; usually works in a hospital setting) - clinical input including insulin initiation and educational role. Attendance at some, but not necessarily all research clinics. Two specialist nurses were responsible for all 21 practices in the trial, one based in Coventry and one in Birmingham.

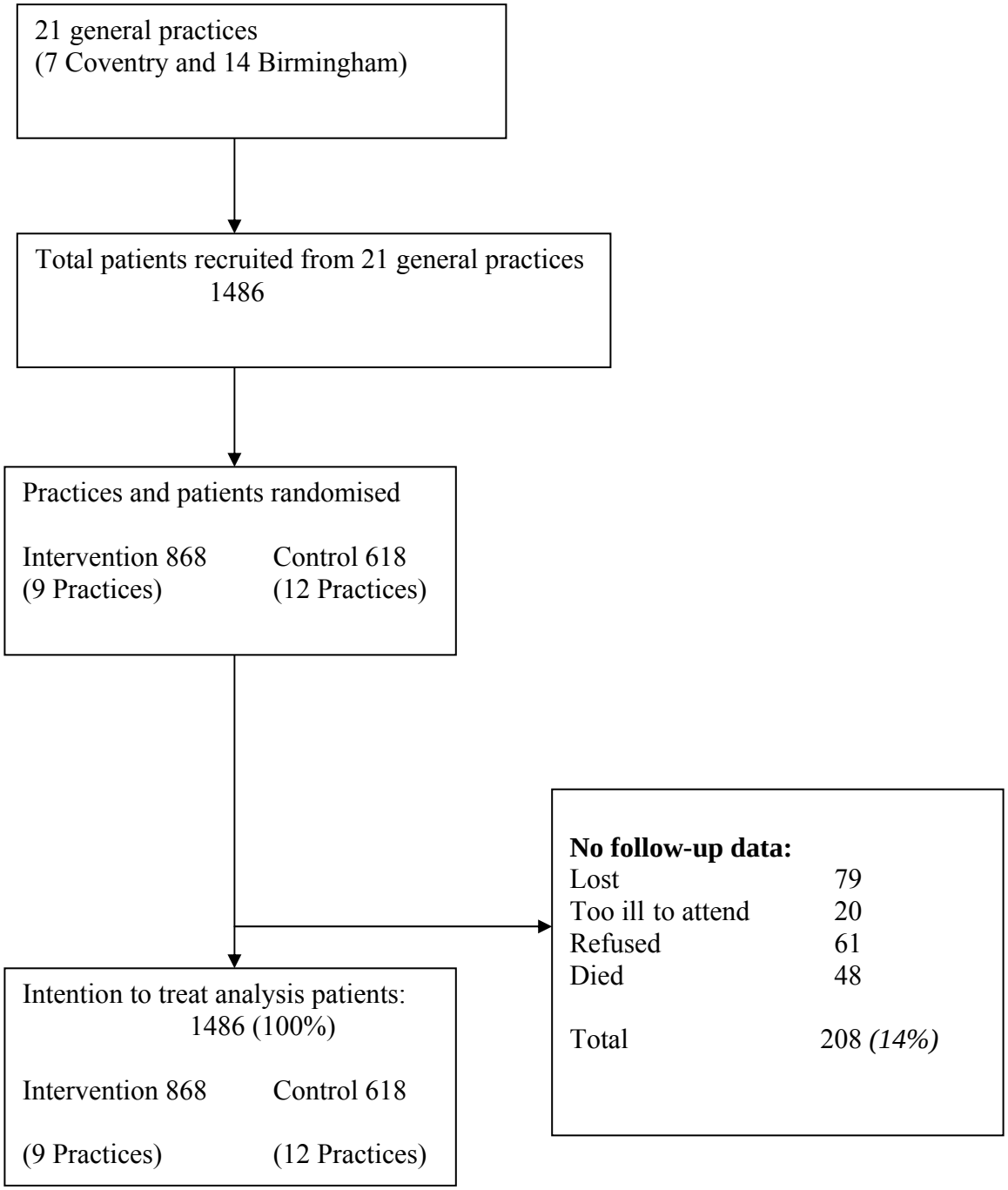
D Link Workers - educational, communication and facilitation role, promoting patients' understanding and concordance. Link Workers attended research clinics in intervention practices. A total of 5 Link Workers were employed, 3 in Birmingham (14 practices) and 2 in Coventry (7 Practices), with each responsible for 3 or more practices. All link workers attended a foundation course in Diabetes management (equivalent to diploma) in Diabetes Care.

E Questionnaires for patients – Quality of Life (EQ5D), and economic analysis data collection.

F General Practitioners - overall responsibility for implementation of the study protocol within their practice. This was mainly devolved to the responsible Practice Nurse. GPs were involved in changing prescribing processes.

G Research team - oversaw study processes. Meetings to monitor recruitment and data collection, to discuss and address issues of study conduct and management.

Figure 2 – Practice and patient recruitment and progress through the trial



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Conflict of interest

Dr. O'Hare, Professor S Kumar and Professor AH Barnett have received research grants and lecture fees from the companies mentioned in the acknowledgements.

Author's contributions

Dr. O'Hare and Professors Kumar and Barnett had the original idea for and designed the project. Mr N T Raymond contributed to study design and conducted /supervised statistical analysis. Dr S Bellary and Miss S Mughal were responsible for day to day running of the project, helping with data collection and analysis. Dr A Gumber undertook the analysis of economic data. Professor A Szczepura helped in data analysis and interpretation. All authors contributed to writing the paper and data interpretation.

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