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# Could diabetes prevention programmes result in the widening of sociodemographic inequalities in type 2 diabetes? Comparison of survey and administrative data for England

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► Additional supplemental material is published online only. To view, please visit the journal online (<http://dx.doi.org/10.1136/jech-2022-219654>).

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Received 2 August 2022

Accepted 16 May 2023

## ABSTRACT

**Background** The NHS Diabetes Prevention Programme (DPP) in England is a behavioural intervention for preventing type 2 diabetes mellitus (T2DM) among people with non-diabetic hyperglycaemia (NDH). How this programme affects inequalities by age, sex, limiting illnesses or disability, ethnicity or deprivation is not known.

**Methods** We used multinomial and binary logistic regression models to compare whether the population with NDH at different stages of the programme are representative of the population with NDH: stages include (1) prevalence of NDH (using survey data from UK Household Longitudinal Study (n=794) and Health Survey for England (n=1383)); (2) identification in primary care and offer of programme (using administrative data from the National Diabetes Audit (n=1 267 350)) and (3) programme participation (using programme provider records (n=98 024)).

**Results** Predicted probabilities drawn from the regressions with demographics as each outcome and dataset identifier as predictors showed that younger adults (aged under 40) (4% of the population with NDH (95% CI 2.4% to 6.5%)) and older adults (aged 80 and above) (12% (95% CI 9.5% to 14.2%)) were slightly under-represented among programme participants (2% (95% CI 1.8% to 2.2%) and 8% (95% CI 7.8% to 8.2%) of programme participants, respectively). People living in deprived areas were under-represented in eight sessions (14% (95% CI 13.7% to 14.4%) vs 20% (95% CI 16.4% to 23.6%) in the general population). Ethnic minorities were over-represented among offers (35% (95% CI 35.1% to 35.6%) vs 13% (95% CI 9.1% to 16.4%) in general population), though the proportion dropped at the programme completion stage (19% (95% CI 18.5% to 19.5%)).

**Conclusion** The DPP has the potential to reduce ethnic inequalities, but may widen socioeconomic, age and limiting illness or disability-related inequalities in T2DM. While ethnic minority groups are over-represented at the identification and offer stages, efforts are required to support completion of the programme. Programme providers should target under-represented groups to ensure equitable access and narrow inequalities in T2DM.

## WHAT IS ALREADY KNOWN ON THIS TOPIC

- ⇒ There are large sociodemographic inequalities in the prevalence of type 2 diabetes mellitus (T2DM). Diabetes prevention programmes can reduce the risk of onset of T2DM through behavioural interventions that target people with non-diabetic hyperglycaemia (NDH).
- ⇒ What we do not know is whether sociodemographic inequalities in T2DM reduce as a result of diabetes prevention programmes.

## WHAT THIS STUDY ADDS

- ⇒ Based on data analysis in the period between March 2018 and April 2019, we now know that sociodemographic inequalities in T2DM have the potential to widen as a result of the National Diabetes Prevention Programme (NHS DPP) in England, because people with limiting illnesses or disabilities who have NDH are less likely to be offered the programme, and because people with NDH who are aged below 50 and over 80 years, from minority ethnic groups and living in the most deprived areas are more likely to stop participating in the programme.

## HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

- ⇒ Based on our analysis of NHS DPP data in the period between March 2018 and April 2019, data indicate targeting of under-represented groups such as the youngest and oldest old age groups, people with limiting illness or disabilities, and those living in deprived areas needs to be specially considered from the outset to ensure equitable access and completion.
- ⇒ The NHS DPP England has the potential to reduce ethnic inequalities, but continued efforts are required from future diabetes prevention programmes to support the completion of the programme by minority ethnic groups.

## INTRODUCTION

Type 2 diabetes mellitus (T2DM) in the UK is an increasingly important public health concern.<sup>1</sup> Non-diabetic hyperglycaemia (NDH), described



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**To cite:** Chatzi G, Whittaker W, Chandola T, et al. *J Epidemiol Community Health* Epub ahead of print: [please include Day Month Year]. doi:10.1136/jech-2022-219654

as pre-diabetes, is an indicator of when HbA1c blood levels are higher than normal but not high enough for a diagnosis of T2DM. In the UK, NDH is defined as 42–47 mmol/mol (6.0%–6.4%).<sup>2</sup> People with HbA1c within this range are at greater risk of developing T2DM.<sup>3,4</sup>

There are well-established sociodemographic inequalities in the onset of T2DM<sup>5–7</sup> and in the transitions from the NDH to T2DM.<sup>8–10</sup> Ethnic minority groups have an earlier onset of T2DM, and equally socioeconomic disadvantaged groups have an earlier onset of T2DM and higher likelihood to transition from NDH to T2DM. While programmes such as the Diabetes Prevention Programme (DPP) seek to reduce transitions to T2DM, there is a risk that such programmes attract and retain subgroups of the target population who are healthier, wealthier and without disability, potentially widening sociodemographic inequalities.

Behavioural interventions that support weight loss and encourage adopting a healthy diet, and increasing physical activity can prevent or delay the onset of T2DM for people with NDH.<sup>11–15</sup> In England, the ‘Healthier You: NHS Diabetes Prevention Programme’, was rolled out across England from 2016. The NHS DPP aims to prevent or delay the onset of T2DM for people diagnosed with NDH (HbA1c 42–47 mmol/mol (6.0%–6.4%) or fasting plasma glucose (FPG) 5.5–6.9 mmol/L).<sup>16</sup> Those at high risk for developing T2DM are referred into the DPP to participate in a behavioural education programme focused on healthy eating, changes in lifestyle and weight loss, and increasing physical activity.

There is some evidence with regards to how and why health interventions and programmes can widen health inequalities within populations, highlighting the need to investigate the differential effects and impact of such interventions by socio-demographic characteristics.<sup>17–19</sup> Access to care and services is a multifaceted construct with the use of services depending on availability, awareness, accessibility and affordability—such factors may differ across groups of the population.<sup>20–22</sup>

To date, assessments of sociodemographic inequities in DPPs have focused on comparisons of sociodemographic characteristics at different stages of completion of these programmes among participants only.<sup>16,23</sup> This is a partial picture that fails to identify whether patients in the programme are representative of the general population with NDH, and if not, where inequities may arise. Understanding who is not accessing interventions such as the DPP is important for assessing its population-level inequality impacts and informing targeted approaches to redress any imbalance.

This study is the first to explore whether DPP participants at various stages of the programme (from identification to completion) were representative of the population with NDH in England. We used a range of data including population surveys, primary care records and prevention programme administrative records from March 2018 to April 2019. We examined differences in the distribution of sociodemographic characteristics using logistic regression analyses.

## METHODS

### Data

We explored the extent to which participants in the DPP become less representative of those with NDH in the general population, and how this varied at different stages of the DPP process; prevalence, identification and offer, and participation. This required data on the population with NDH from several data sources, including: the surveyed population with NDH, those identified

with NDH and offered the DPP in healthcare records, and those involved in various stages of the programme (defined in detail in online supplemental table S1, online supplemental file A). Across data sets, individuals whose blood test indicated HbA1c levels within the range 42–47 mmol/mol inclusive or 6.0%–6.4% inclusive were categorised as NDH. Our final analytical sample comprised of 1 417 044 observations.

### The population with NDH

The population with NDH were identified from two population surveys. Two surveys were used to partially mitigate against any potential concerns of unrepresentativeness of the surveys. The first survey was the UK Household Longitudinal Study (UKHLS), an annual longitudinal survey of over 40 000 households; 56 198 men and women over 16 years of age participated in the main interview in waves 2 and 3 of UKHLS in 2010–2012<sup>24</sup>; 10 065 respondents lived in England and had an HbA1c measurement. Out of these participants, 794 (8%) had NDH. Further details about the UKHLS data, final sample specification and survey weights to account for selection into the final sample are provided in online supplemental file A.

The second survey was the Health Survey for England (HSE): an annual, cross-sectional survey based on a random probability sample of households. We used data from 2015 to 2018 surveys which included HbA1c measures.<sup>25–28</sup> Out of the 32 220 (aged 16+) who were eligible for an interview, 15 453 (48%) had a blood sample. Of those participants, 1383 (8.9%) participants had NDH. Further details about the HSE data, final sample specification and survey weights to account for selection into the final sample are provided in online supplemental file A.

### The population with NDH identified in healthcare records and the population offered the DPP

Identification of the population eligible for the DPP was usually performed using data from NHS Health Checks, during consultations or retrospectively in patient records.<sup>29</sup> The population with NDH in healthcare records were sourced from the National Diabetes Audit (NDA). The NDA was established in 2004 to monitor diabetes management and outcomes. Since 2017, 98% General Practitioners (GPs) submit patients’ data to the NDA.<sup>30</sup> We included participants with NDH diagnosis between January 2017 until December 2019 (n=1 109 930) and participants with NDH who have been coded as having been offered the DPP between April 2018 until March 2019 (n=157 420). Our analytical sample from this dataset was 1 267 350 participants. Further details about the NDA data and sample are provided in online supplemental file A.

### Participants in the DPP

Information on participation was collected in a Minimum Data Set (MDS) by the four providers of the DPP at this time. Following referral to the programme, participants attend an initial assessment (IA) session. Age, sex, area deprivation and HbA1c measurement were provided at the point of referral and disability and ethnicity were recorded at the IA. We used data at three different participation stages of the programme: IA, and after 8 and 11 sessions; 8 and 11 sessions were used to measure completion. Completion of the programme was defined as attendance of at least 60% of sessions.<sup>31</sup> The volume of sessions varied by provider, with some offering 16 sessions, to capture a minimum of 60% sessions for all participants we identified completion as attending a minimum of 11 sessions.

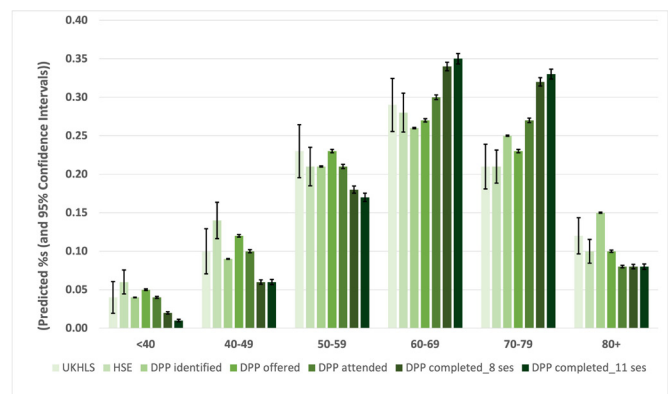
The DPP was rolled out in different areas of the country in three waves, with full national coverage from wave three only (starting in April 2018). The first wave included participants who were referred from June 2016 covering 27 sites and 110 Clinical Commissioning Groups (CCGs). The second wave included referred participants from April 2017 covering 13 sites and incorporating 48 CCGs and the last wave had full coverage across England and included participants who were referred from April 2018. The staged rollout means that only referrals from April 2018 to March 2019 were an appropriate comparator to the other datasets covering the whole of England. Final sample sizes included 98 024 observations in the IA, 29 577 who attended 8 sessions and 19 916 who attended 11 sessions.

### Participant characteristics

We analysed as many as possible of the characteristics listed as protected by the Equality Act 2010.<sup>32</sup> This required sociodemographic measures that were identical across the datasets. Age was categorised into groups of <40, 40–49, 50–59, 60–69, 70–79 and 80+ years. Sex was measured as a binary measure for male or female. Disability was reported inconsistently across the data. Limiting illness or disability variable was described consistently in the survey populations of UKHLS and HSE as longstanding and limiting longstanding illness. In the MDS population, disability was described as limiting longstanding illness, progressive conditions and chronic illnesses such as cancer, multiple sclerosis and HIV infection according to the Equality Act 2010,<sup>32</sup> see link for details <https://www.gov.uk/definition-of-disability-under-equality-act-2010>. For the NDA and DPP offered populations, only the measure of learning disability was available in the dataset. Ethnicity was dichotomised into white-British and ethnic minorities due to small sample sizes from the survey datasets. Area deprivation (Index of Multiple Deprivation—IMD 2010 for UKHLS and NDA data, and 2015 for HSE and MDS) was grouped into quintiles.

### Data analyses

The data from the UKHLS, HSE, NDA and MDS were pooled into a single data file but linkage at individual level was not possible. Summary statistics present the proportion of each sociodemographic characteristics at each stage. Separate logistic regressions were estimated for each sociodemographic characteristic (multinomial regressions for age and deprivation, and binary regressions for sex, limiting illness or disability, and ethnicity). The explanatory variables were a set of dummy variables for the different datasets to indicate different stages: (1) general population (UKHLS and HSE), (2) DPP identified (NDA diagnosed), (3) DPP offered (DPP offered), (4) DPP attended (MDS IA) and the last (5) and (6) included the DPP completed (MDS 8 sessions and 11 sessions, respectively). The predicted probabilities from the regression provide the share of participants with that specific sociodemographic characteristic in each of the stages. Differences in the estimates for the stage indicators may signal inequity. For example, a higher share of a specific sociodemographic characteristic (eg, limiting illness or disability) for participants in the UKHLS or HSE compared with the DPP attended stage dataset would indicate that there are more participants with limiting illness or disability with NDH in the general population compared with those in the DPP. If characteristics are similar across each stage, then the indicators for stages would not be significantly different from the reference category. This approach enables identification of where in the pathway patients are unrepresentative.



**Figure 1** Predicted probabilities of the general population (UKHLS and HSE) and various DPP stages for age groups. More information on the regression model in online supplemental table S3. Note: predicted %s (probabilities) and predicted 95% CIs were drawn from regression models by age groups for general population and administrative data (online supplemental table S4). DPP, Diabetes Prevention Programme; HSE, Health Survey for England; UKHLS, UK Household Longitudinal Study.

The model for each sociodemographic model also included the remaining sociodemographic characteristics to account for the correlations between them. Observations from the general population surveys were weighted to account for selection probabilities, attrition and non-response using the blood sample weights provided in the surveys. All models were estimated in Stata/MP V.16.1 (StataCorp).

## RESULTS

### Descriptive and multivariable analyses

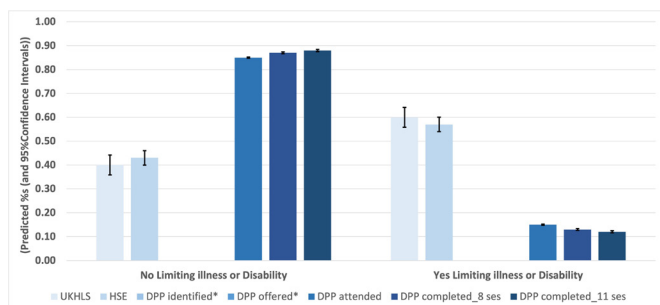
Online supplemental table S2 contains summary statistics for adults with NDH from the various datasets. Online supplemental tables S3–S12 provide the full set of estimates (ORs and 95% CIs) and predicted probabilities from multinomial and binary logistic regressions for each sociodemographic characteristic (age, sex, limiting illnesses or disability, ethnicity and area deprivation). ORs in multinomial logistic regression analysis are also referred as Relative Risk Ratio and/or Multinomial OR.

**Figure 1** (online supplemental tables S3 and S4) plots the predicted probabilities (shares) for each age group over each dataset. The share of younger adults (aged under 40 years) was greater in the general population (UKHLS (4% (95% CI 2.4% to 6.5%)), HSE (6% (95% CI 3.5% to 7.5%))) than in those attending 8 (2% (95% CI 1.8% to 2.2%)) or 11 sessions (1% (95% CI 0.8% to 1.2%)) of the DPP.

There was evidence of under-representation of the oldest adults aged 80 years or over in the DPP attended and completed stages, relative to the general population (12% share in UKHLS (95% CI 9.5% to 14.2%)) and DPP identified and offered stages (15% (95% CI 14.9% to 15.1%)), with a 7% point gap between the DPP identified and the DPP attended stage (8% (95% CI 7.8% to 8.2%)).

While there were some sex differences (online supplemental figure S1, online supplemental tables S5 and S6), these were not statistically significant. There was a consistent pattern of more women at all stages compared with men.

Participants in the general population had a higher probability of having limiting illness or disability (60% (95% CI 53.8% to 64.2%)) compared with the DPP attended stage (15% (95% CI 14.8% to 15.2%)) sample and estimates were even lower after

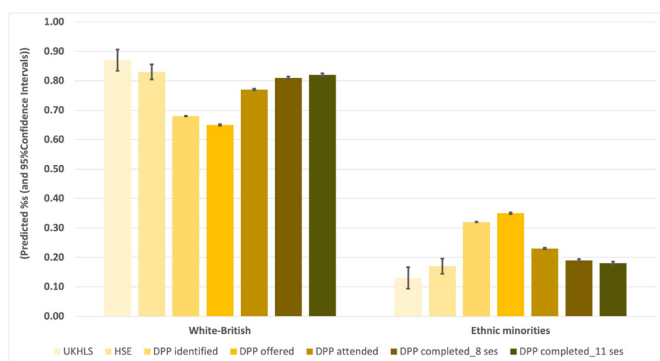


**Figure 2** Predicted probabilities of the general population (UKHLS and HSE) and various DPP stages for limiting illness or disability. More information on the regression model in online supplemental table S7. Notes: predicted %s (probabilities) and predicted 95% CIs were drawn from regression models by limiting illness or disability for general population and administrative data. \*Comparable disability measures were not available in the DPP identified and offered stages (online supplemental table S8). DPP, Diabetes Prevention Programme; HSE, Health Survey for England; UKHLS, UK Household Longitudinal Study.

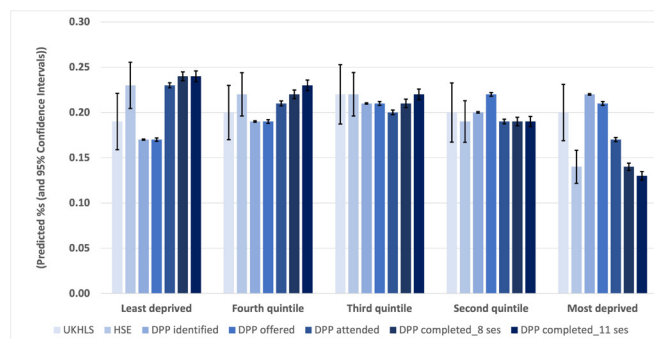
8 (13% (95% CI 12.6% to 13.4%)) and 11 sessions of DPP completion stages (12% (95% CI 11.6% to 12.4%)) (figure 2 and online supplemental tables S7 and S8).

The general population with NDH had the lowest probability of belonging to a minority ethnic group (13% (95% CI 9.1% to 16.7%)), while the DPP offered population had the highest share (35% (95% CI 35.1% to 35.6%)). In figure 3 (online supplemental tables S9 and S10), the predicted probabilities show that there were more adults from ethnic minorities in the DPP identified and offered stages. The share for the DPP completed stages was smaller (19% (95% CI 18.5% to 19.5%)) for 8 sessions and 11 sessions (18% (95% CI 17% to 18.1%)). This may suggest that while recruiters appear to over-represent minority ethnic groups, ethnic minorities were less likely to attend and complete the DPP.

There were clear differences between the stages in terms of the proportions living in the most deprived areas (figure 4—online supplemental tables S11 and S12). Participants in the DPP attended stage were less likely (17% (95% CI 16.7% to 17.2%)) to live in the most deprived areas compared with the general



**Figure 3** Predicted probabilities of the general population (UKHLS and HSE) and various DPP stages for ethnicity. More information on the regression model in online supplemental table S9. Predicted %s (probabilities) and predicted 95% CIs were drawn from regression models by ethnicity for general population and administrative data (online supplemental table S10). DPP, Diabetes Prevention Programme; HSE, Health Survey for England; UKHLS, UK Household Longitudinal Study.



**Figure 4** Predicted probabilities the general population (UKHLS and HSE) and various DPP stages for index of multiple deprivation. More information on the regression model in online supplemental table S11. Predicted %s (probabilities) and predicted 95% CIs were drawn from regression models by Index of Multiple Deprivation for general population and administrative data (online supplemental table S12). DPP, Diabetes Prevention Programme; HSE, Health Survey for England; UKHLS, UK Household Longitudinal Study.

population (20% (95% CI 16.4% to 23.6%)). Moreover, the predicted probabilities of belonging to the most deprived areas were lower after the DPP completed stage of sessions 8 (14% (95% CI 13.7% to 14.4%)) and 11 (13% (95% CI 12.4% to 13.4%)). The probabilities showed that participants in the DPP identified (22% (95% CI 21.9% to 22.1%)) and offered (21% (95% CI 20.9% to 21.1%)) stages were more likely to live in the most deprived areas compared with participants at any stage other stage of the DPP.

## DISCUSSION

We examined whether participants, between April 2018 until March 2019, at various stages of a diabetes prevention programme were representative of the population with NDH in England. We compared the characteristics of participants in the programme with those identified as having NDH in general population surveys and primary care records (the primary source for identifying referrals). Our results demonstrate that there were substantial differences in the sociodemographic characteristics at different stages of the programme. There was a consistent pattern of greater proportions of younger adults aged under 50 and the oldest adults aged 80+ in the general population and DPP identified and offered participants compared with any of the stages of the DPP.

There was clear evidence that adults with disabilities as well as those living in the most deprived areas were under-represented in the DPP compared with survey populations. The high share for no disability in the DPP identified and offered participants reflects the different measure of disability in those datasets. Minority ethnic groups were over-represented in the DPP identified and offered stage, but these percentages dropped by around 9%–16% points during the DPP completion stages. Furthermore, those in the most deprived groups were under-represented at the later stages of the DPP intervention compared with the general population and other stages. The 5% point gap in the proportion of adults living in the most deprived areas between the DPP early stages and DPP attended stage increased to a 7% point gap after 11 sessions.

Older people were less likely to be present in DPP attended stage and as the intervention progressed. Older people with comorbidities, poor physical functioning and cognitive problems face challenges in undertaking research on health promotion<sup>33</sup>

and therefore are less likely to be take part or continuing in intervention studies.<sup>34 35</sup> Further, clinical judgement may inhibit participation on the grounds of safety (eg, for those with frailty).

Men were under-represented in the DPP intervention stages compared with general population and this may be because men visit health services less often or seek health information and advice less frequently compared with women<sup>36 37</sup> and therefore they are less likely to take part in health-enhancing interventions.<sup>38 39</sup>

People with limiting illnesses or disabilities were under-represented in the intervention programme compared with the general population and this finding is consistent with the literature which suggests that people with disabilities experience direct or indirect discrimination in healthcare and health promotion.<sup>40</sup>

People from ethnic minorities were under-represented in the DPP intervention compared with DPP identified and offered stages, and over-represented in comparison with the general population. There is some evidence that minority ethnic groups were more likely to be offered the programme when identified in GP practices. Early findings from the DPP, comparing DPP offered and attended stages suggested that adults from minority ethnic groups were more likely to attend the DPP than white Europeans.<sup>16</sup>

Participants living in deprived areas were under-represented as the intervention progressed compared with those living in the wealthiest areas and compared with general population. This finding could be related to evidence that socially advantaged people seek healthcare at the earlier stages of disease and consume more preventive care.<sup>41</sup>

This study has several strengths. First, we used data from the UKHLS and HSE which are representative of the English population for participants 16 years and over. Both surveys provide sociodemographic and biomarker information to examine disparities in sociodemographic characteristics between datasets. The use of both surveys provided reassurances of representativeness with the general population, with both providing broadly similar sociodemographic characteristics for those with NDH, with the choice of not materially influencing the findings of this study. Moreover, we were able to add in the underlying administrative data from the NDA. We therefore had two sources of underlying population data—the surveys as well as the administrative datasets. Second, we were able to compare the sociodemographic characteristics of the survey and administrative populations with the DPP participants' sociodemographic information collected at the referral and in the initial assessment alongside biomarker data enabling patient-level and survey data comparisons.

Important limitations of this study are the small samples from minority ethnic groups in survey populations and the inconsistency in the reporting of limiting illness or disability in the administrative dataset. Minority ethnic groups are under-represented in the surveys<sup>42</sup> and therefore the interpretations of our results should be made with caution, however, we were able to compensate for this limitation by adding in the administrative data from the NDA and including sample weights to account for non-response, selection probabilities and attrition. While the measurement of disability was not comparable in primary care records, this does not detract from the large differences seen between the surveys and the programme records. The analyses of administrative data may be hampered by inaccurate coding and record keeping.

## CONCLUSION

Intervention like the DPP may result in a widening of socio-economic and limiting illnesses or disability-related inequalities among people with NDH as the programme recruited fewer adults living in deprived areas and with a disability than expected in the general population. The DPPs have the potential

to reduce ethnic inequalities, with identification and offer over-representing this group, but continued efforts are required to support the completion of the programme by minority ethnic groups. The complex nature of access to the intervention suggests this may be due to the way the DPP is provided both in terms of accessibility and availability of the programme; but also, from the patient perspective in terms of whether the format and content are acceptable to patients. Identifying these issues may help inform how providers of the programme may target people in younger and older age groups, people with disabilities and people living in deprived areas.

The programme continues to adapt, with initiatives to support retention of ethnic minorities and socioeconomically deprived populations and the roll out of digital options which may support younger populations. Future research could explore the impacts these have on the findings presented here.

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**Acknowledgements** The authors would like to thank the NHS DPP national management team at NHSE for their support with access to the NHS DPP Minimum Dataset. We thank Elizabeth Howarth, Sarah Cotterill and Emma McManus for cleaning and preparing the National Diabetes Audit and Minimum Data Set data for analyses. Furthermore, we thank the DIPLOMA team for providing important feedback throughout the course of this study.

**Contributors** WW, TC and GC participated in the study conceptualisation. GC conducted the analyses and drafted the manuscript. WW, TC, TM, CS-R, MS and PB contributed to the design of the work, data interpretation, writing the manuscript and critically revised the manuscript for important intellectual content. All authors have read and approved the final manuscript. GC and WW have full access to the data and GC takes responsibility for the integrity of the data and accuracy of the data analyses. GC acts as guarantor and accepts full responsibility for the work and/or the conduct of the study, had access to the data, and controlled the decision to publish.

**Funding** Research funded by the National Institute for Health and Care Research (The Health and Social Care Delivery Research (HSDR) Programme, 16/48/07—Evaluating the NHS Diabetes Prevention Programme (NHS DPP): the DIPLOMA research programme (Diabetes Prevention—Long Term Multimethod Assessment)).

**Disclaimer** The views and opinions are those of the authors and not necessarily reflect those of the National Institute for Health and Care Research or the Department of Health and Social Care.

**Competing interests** None declared.

**Patient consent for publication** Not applicable.

**Ethics approval** The University of Essex Ethics Committee has approved all data collection on Understanding Society main study and innovation panel waves. Approval for the collection of biosocial data by trained nurses in waves 2 and 3 of the main survey was obtained from the National Research Ethics Service (Understanding Society—UK Household Longitudinal Study: A Biosocial Component, Oxfordshire A REC, Reference: 10/H0604/2). Ethical approval for the 2015 Health Survey for England was obtained from the West London Research Ethics Committee (reference number 14/LO/0862). Ethical approval for the 2016 and 2018 survey was obtained from the East Midlands Nottingham 2 Research Ethics Committee (Reference no 15/EM/0254). Ethical approval for the 2017 survey was obtained from the East of England Research Ethics Committee (Reference no 15/EE/0229). Survey

data are available here <https://ukdataservice.ac.uk>. The National Diabetes Audit data used in this study were obtained upon application to NHS Digital (reference: DARS-NIC-196221-K4K3Y). The authors are not permitted to share this data. The use of this data is subject to various output rules, including rounding count values to the nearest 5. All other data used in this study are publicly available and referenced within the manuscript and supplementary material. The wider project protocol is available from: <https://fundingawards.nih.ac.uk/award/16/48/07> and ethical approval was received from the North-West - Greater Manchester East Research Ethics Committee (REC reference 17/NW/0426). The North-West Greater Manchester East NHS Research Ethics Committee (reference: 17/NW/0426, 1 August 2017) reviewed and approved the DIPLOMA programme of research of which this study is a part. The analysis was undertaken using anonymised routinely collected healthcare data and informed consent from individuals was not necessary.

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

**Data availability statement** Data are available in a public, open access repository. Data may be obtained from a third party and are not publicly available. UKHLS and HSE data used in this paper are available to researchers via the UK Data Service <https://ukdataservice.ac.uk>. National Diabetes Audit data was obtained via an application to NHS Digital, which required approval by their Independent Group Advising on the Release of Data (IGARD). <https://digital.nhs.uk/data-and-information/publications/statistical/national-diabetes-audit>. Minimum Data Set was made available to the authors by NHS England under a data processing agreement, and the authors are not permitted to share them beyond the study team.

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#### REFERENCES

- Zghebi SS, Steinke DT, Carr MJ, *et al*. Examining trends in type 2 diabetes incidence, prevalence and mortality in the UK between 2004 and 2014. *Diabetes Obes Metab* 2017;19:1537–45.
- National Institute for Health and Care Excellence. *PH 38 preventing type 2 diabetes: risk identification and interventions of individuals at high risk*. London: NICE, 2012.
- Bansal N. Prediabetes diagnosis and treatment: a review. *World J Diabetes* 2015;6:296–303.
- Albright A. The National diabetes prevention program: from research to reality. *Diabetes Care Educ News* 2012;33:4–7.
- Espelt A, Borrell C, Palència L, *et al*. Socioeconomic inequalities in the incidence and prevalence of type 2 diabetes mellitus in Europe. *Gac Sanit* 2013;27:494–501.
- Thomas C, Hyppönen E, Power C. Diabetes risk in British adults in mid life: a national prevalence study of glycated haemoglobin. *Diabet Med* 2007;24:317–21.
- Kumari M, Head J, Marmot M. Prospective study of social and other risk factors for incidence of type 2 diabetes in the Whitehall II study. *Arch Intern Med* 2004;164:1873–80.
- Ravindrarajah R, Reeves D, Howarth E, *et al*. Epidemiology and determinants of non-diabetic hyperglycaemia and its conversion to type 2 diabetes mellitus, 2000–2015: cohort population study using UK electronic health records. *BMJ Open* 2020;10:e040201.
- Hong J-L, McNeill AM, He J, *et al*. Identification of impaired fasting glucose, healthcare utilization and progression to diabetes in the UK using the clinical practice research Datalink ( CPRD). *Pharmacoepidemiol Drug Saf* 2016;25:1375–86.
- Chatzi G, Mason T, Chandola T, *et al*. Sociodemographic disparities in non-diabetic hyperglycaemia and the transition to type 2 diabetes: evidence from the English longitudinal study of ageing. *Diabet Med* 2020;37:1536–44.
- Tuomilehto J, Lindström J, Eriksson JG, *et al*. Prevention of type 2 diabetes mellitus by changes in lifestyle among subjects with impaired glucose tolerance. *N Engl J Med* 2001;344:1343–50.
- Knowler WC, Barrett-Connor E, Fowler SE, *et al*. Reduction in the incidence of type 2 diabetes with lifestyle intervention or metformin. *N Engl J Med* 2002;346:393–403.
- Gong Q, Zhang P, Wang J, *et al*. Morbidity and mortality after lifestyle intervention for people with impaired glucose tolerance: 30-year results of the DA Qing diabetes prevention outcome study. *Lancet Diabetes Endocrinol* 2019;7:452–61.
- Ali MK, Echouffo-Tcheugui JB, Williamson DF. How effective were lifestyle interventions in real-world settings that were modeled on the diabetes prevention program. *Health Aff (Millwood)* 2012;31:67–75.
- Albright AL, Gregg EW. Preventing type 2 diabetes in communities across the U.S.: the National diabetes prevention program. *Am J Prev Med* 2013;44:S346–51.
- Barron E, Clark R, Hewings R, *et al*. Progress of the healthier you: NHS diabetes prevention programme: referrals, uptake and participant characteristics. *Diabet Med* 2018;35:513–8.
- McGill R, Anwar E, Orton L, *et al*. Erratum to: are interventions to promote healthy eating equally effective for all? Systematic review of socioeconomic inequalities in impact. *BMC Public Health* 2015;15:894.
- Capewell S, Graham H. Will cardiovascular disease prevention widen health inequalities? *PLoS Med* 2010;7:e1000320.
- White M, Adams J, Heywood P. How and why do interventions that increase health overall widen inequalities within populations. In: Babones SJ, ed. *Soc Inequal public health*. 1st ed. Bristol University Press, 2009: 65–82.
- Gulliford M, Figueroa-Munoz J, Morgan M, *et al*. What does "access to health care" mean? *J Health Serv Res Policy* 2002;7:186–8.
- McIntyre D, Thiede M, Birch S. Access as a policy-relevant concept in Low- and middle-income countries. *Health Econ Policy Law* 2009;4:179–93.
- Tudor Hart J. The inverse care law. *Lancet* 1971;297:405–12.
- Howarth E, Bower PJ, Kontopantelis E, *et al*. 'Going the distance': an independent cohort study of engagement and dropout among the first 100 000 referrals into a large-scale diabetes prevention program. *BMJ Open Diabetes Res Care* 2020;8:e001835.
- University of Essex, Institute for Social and Economic Research. *Understanding society: waves 2-3 nurse health assessment, 2010-2012*. 5th Edition. UK Data Service. SN:7251, 2023.
- NatCen Social Research, University College London, Department of Epidemiology and Public Health. *Health Survey for England 2015*. 2nd Edition. UK Data Service. SN:8280, 2019.
- NatCen Social Research, University College London, Department of Epidemiology and Public Health. *Health Survey for England 2016*. 3rd Edition. UK Data Service. SN:8334, 2019.
- University College London, Department of Epidemiology and Public Health, National Centre for Social Research (NatCen). *Health Survey for England 2017*. 2nd Edition. UK Data Service, 2021.
- NatCen Social Research, University College London, Department of Epidemiology and Public Health. *Health Survey for England 2018*. 2nd Edition. UK Data Service. SN:8649, 2022.
- NHS England. Diabetes prevention programme – information Governance and data flows framework 2019. Available: <https://www.england.nhs.uk/publication/diabetes-prevention-programme-information-governance-and-data-flows-framework/> [Accessed 20 May 2022].
- NHS Digit. National diabetes audit - report 1 care processes and treatment targets 2018-19, full report. 2020. Available: <https://digital.nhs.uk/data-and-information/publications/statistical/national-diabetes-audit/report-1-care-processes-and-treatment-targets-2018-19-full-report> [Accessed 20 May 2022].
- Valabhji J, Barron E, Bradley D, *et al*. Early outcomes from the English national health service diabetes prevention programme. *Diabetes Care* 2020;43:152–60.
- Equality act 2010. 2010. Available: <https://www.legislation.gov.uk/ukpga/2010/15/section/4>
- Jacelon CS. Older adults' participation in research. *Nurse Res* 2007;14:64–73.
- Gaertner B, Seitz I, Fuchs J, *et al*. Baseline participation in a health examination survey of the population 65 years and older: who is missed and why. *BMC Geriatr* 2016;16:21.
- McMurdo MET, Roberts H, Parker S, *et al*. Improving recruitment of older people to research through good practice. *Age Ageing* 2011;40:659–65.
- White A, De Sousa B, De Visser R, *et al*. Men's health in Europe. *Journal of Men's Health* 2011;8:192–201.
- Witty KR, White AK, Bagnall A-M, *et al*. Male frequent attenders of general practice and their help seeking preferences. *J Mens Health* 2011;8:21–6.
- Baker P. Current issues in men's health. *Trends in Urology & Men's Health* 2012;3:19–21.
- Evans J, Frank B, Oliffe JL, *et al*. Illness, men and masculinities (HIMM): a theoretical framework for understanding men and their health. *J Mens Health* 2011;8:7–15.
- Krahn GL, Walker DK, Correa-De-Araujo R. Persons with disabilities as an unrecognized health disparity population. *Am J Public Health* 2015;105 Suppl 2:S198–206.
- Cookson R, Propper C, Asaria M, *et al*. Socio-economic inequalities in health care in England. *Fiscal Studies* 2016;37:371–403.
- Tipping S, Hope S, Pickering K, *et al*. The effect of mode and context on survey results: analysis of data from the health survey for England 2006 and the boost survey for London. *BMC Med Res Methodol* 2010;10:84.