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DIABETIC Medicine

REVIEW

Developing services to support the delivery of care to people with early-onset type 2 diabetes

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Abstract

Early-onset type 2 diabetes occurring in childhood or early adulthood carries a significant excess burden of microvascular diabetes complications, cardiovascular disease and premature death, compared to later onset type 2 diabetes along with adverse pregnancy outcomes in women of child-bearing age. National audit data in England reveal that 122,780 individuals under the age of 40 years are currently living with type 2 diabetes, with an over-representation of people from minority ethnicities and those in the most socioeconomically deprived quintiles. A diagnosis of type 2 diabetes earlier in life poses some unique challenges to healthcare providers that are not routinely encountered when type 2 diabetes presents later. These include; (1) the need to ensure correct diabetes classification in an age group that carries a higher probability of other types of diabetes, (2) overcoming difficulties in engaging with individuals who are of working age or in full-time education, (3) appreciating and addressing the lower attainment of diabetes treatment targets and (4) proactively supporting women of child-bearing age to optimise their future pregnancy outcomes through better preparation for pregnancy, including achieving optimum glycaemic control at the time of conception. Meanwhile, approaches to prevent type 2 diabetes in younger age groups are challenged by difficulties in identifying those at highest risk, by poorer attendance at lifestyle interventions to prevent or delay the onset of type 2 diabetes and by attenuation of associated weight loss in those that do attend. In this article, we discuss the importance of recognising and addressing the distinct challenges in delivering healthcare to those with early-onset type 2 diabetes, the greater challenges in preventing type 2 diabetes at younger ages, and key components of strategies that might address these challenges to drive improvements in pregnancy outcomes, microvascular and cardiovascular outcomes.

KEYWORDS
deprivation, ethnic minority, pregnancy, service provision, type 2 diabetes, young adults

1 | INTRODUCTION

There has been a concerning rise in cases of early-onset type 2 diabetes globally and the UK is no exception.[1-5] Early onset type 2 diabetes has a significant impact on the risk of mortality[6,7] with an average of 11 years of life lost in those diagnosed <20 years and 7 years of life lost in those diagnosed between 20 and 39 years compared to those without diabetes.[8] Early-onset type 2 diabetes is associated with a more aggressive diabetes phenotype than older-onset[9,10] with a more rapid deterioration in glycaemic control warranting early insulin treatment,[11] a worse cardiometabolic risk factor profile[11-13] and higher proportions affected with diabetes-related microvascular and macrovascular complications.[12,14,15,16,17,18]

Early-onset type 2 diabetes has been noted in youth or adolescents aged below 18 years but the diagnosis also extends beyond the age of 18 years into early adulthood. Whilst there is no consistent agreement on what age limits constitute a diagnosis of early-onset type 2 diabetes, clear distinctions are necessary as adolescents and young adults with type 2 diabetes have distinct requirements for support from healthcare services and variable access to licenced medications for glucose-lowering. The paucity of evidence regarding the optimal management for adults with early-onset type 2 diabetes,[19] has resulted in clinical guidelines with no distinct targets or recommendations for younger adults living with type 2 diabetes, despite their higher risk of adverse cardiovascular and microvascular outcomes, although consensus guidelines do exist for the management of paediatric type 2 diabetes.

Current models of diabetes care were developed when early-onset type 2 diabetes in adolescents and young adults was sporadic. Now, there are larger numbers of people with the diagnosis who have distinct characteristics that may make the delivery of routine care a challenge, including being in full-time education, being of working age and incorporating women of child-bearing age who maybe planning a pregnancy. There is therefore a pressing need to consider how services are organised to support these individuals currently and to prevent the high rates of future multimorbidity that will pose a burden to the individuals themselves, as well as to healthcare services. We discuss key aspects of early-onset type 2 diabetes to consider when developing models of care to support these individuals, the unique challenges and we outline potential solutions.

What's new?

- A diagnosis of type 2 diabetes under 40 years is associated with premature death and worse microvascular and cardiovascular outcomes, compared to a diagnosis later in life. With increasing numbers of individuals, healthcare organisations must consider how services can provide support to improve these outcomes. However, the considerations in delivering care to young people with type 2 diabetes have not been carefully reviewed previously.
- We discuss the importance of recognising and addressing the distinct challenges in delivering healthcare to those with early-onset type 2 diabetes, including diagnostic uncertainty, engagement with those of working age and supporting women of child-bearing age to achieve better pregnancy outcomes. We discuss how services might be modelled to support improvement in outcomes.

2 | CURRENT EVIDENCE IN EARLY-ONSET TYPE 2 DIABATES

2.1 | Recognition that early-onset type 2 diabetes is a 'high-risk' diagnosis

In the last decade, several large systematic population studies have illustrated the high-risk state of an early diagnosis of type 2 diabetes.[5,8,13,16,18] The 'high risk' label relates to earlier cardiovascular-related death, faster progression to microvascular and macrovascular complications, poorer pregnancy outcomes,[20] and, also, to surrogate outcomes such as lower proportions achieving desired treatment targets (for example based on HbA_{1c}, blood pressure and cholesterol levels[21]) or a more accelerated progression to needing insulin.[22]

Prospective studies have predominantly examined childhood-onset type 2 diabetes with two large north American cohorts (TODAY and SEARCH) leading the way.[23,24] The TODAY cohort has highlighted the accelerated progression to microvascular complications; after a mean duration of 13 years a cohort of 500 individuals all diagnosed with type 2 diabetes under 20 years of age, had a cumulative incidence of diabetic kidney disease of 55%, retinopathy of 51% and neuropathy of 32%. Hypertension was noted in 68% at the end of follow-up and dyslipidaemia

in 52%.[18] Such prospective studies of early-onset type 2 diabetes in adults do not exist but population studies have demonstrated that the high risk observed in youth-onset type 2 diabetes, extends into early adulthood, as outlined above.

It is not completely clear whether the poor cardiovascular outcomes and a high proportion of microvascular complications in those with early-onset type 2 diabetes relate to inadequate management (due to healthcare factors or patient factors) or due to intrinsic differences in the disease process itself that lead to rapid progression.[4] It is clear, however, that the effect of longer duration in isolation is not the cause, as several studies have shown the higher risk at lower age-of-onset occurs independently of duration.[10,25] The presence of multiple cardiometabolic risk factors presenting together with a long duration of exposure due to the earlier presentation are likely to be key combinatorial factors.[13] These risk factors include a much higher body mass index than for people with later-onset type 2 diabetes or for those with type 1 diabetes, a more atherogenic lipid profile and higher HbA_{1c} at presentation.[11] In a UK study of data from Clinical Practice Research Datalink, people with early onset type 2 diabetes had significantly more cardiovascular risk factors compared to age-matched controls. However, the difference was attenuated for Asian and Black individuals with type 2 diabetes.[13]

The impact of early-onset type 2 diabetes is seen most acutely in the pregnancy outcomes of women with pre-existing type 2 diabetes. In an analysis of population data over 5 years, the English national diabetes in pregnancy audit showed women with pre-existing type 2 diabetes had higher rates of neonatal deaths and higher rates of perinatal deaths (neonatal deaths and stillbirths combined) across all HbA_{1c} categories, in comparison to women with type 1 diabetes.[20] Women with type 2 diabetes were also less likely to be on folic acid preconception. In one study, there was a 90% increase in pregnancies affected with pre-gestational type 2 diabetes between 1998 and 2012.[26] In even younger women followed-up in the TODAY study (mean age 21.5 years with mean diabetes duration of 8 years) pregnancy loss was observed in 25% and pre-term birth in 33% of 260 pregnancies.[27] Women of child-bearing age with type 2 diabetes, therefore, represent an important subset of the early-onset type 2 diabetes population.

2.2 | Defining 'early-onset' of type 2 diabetes

The definition of early onset adult type 2 diabetes is variably described with multiple age cut-offs in published studies (see Table 1).[28] A systematic review and metanalysis has not have shown that the higher risk of mortality

TABLE 1 Similarities and differences between early-onset type 2 diabetes in youth and adults

	Type 2 diabetes in youth	Type 2 diabetes in early adulthood
Age	<18 years	18–39 years
Nomenclature	Variably defined in the literature as youth-onset type 2 diabetes, paediatric onset type 2 diabetes and adolescent-onset type 2 diabetes.	Early-onset type 2 diabetes in adults
Risk of adverse outcomes	Extremely high	Extremely high
Individual Characteristics	In full-time education Likely parental involvement in care provision	higher education oremployment Women of child-bearing age who may be planning pregnancy
Current location of care	Highly variable in paediatric specialist services or primary care	Highly variable in adult specialist services or primary care
Licenced medications	Metformin Insulin Liraglutide	Full array of type 2 diabetes medications
Access to remission and weight loss programmes	No	Yes, in some parts of England

and complications associated with early-onset type 2 diabetes occurs continuously and incrementally per 1-year decrease in age at diagnosis.[29] The application of an age cut-off to a continuum of risk may be considered arbitrary, however, to deliver targeted services a criterion for selecting those at the highest risk is important.

We propose a definition of early-onset type 2 diabetes as a diagnosis of type 2 diabetes under 40 years of age. This age range can be justified because, (1) there is strong evidence highlighting the higher risk of complications and cardiovascular outcomes in studies of people below this age cut-off, independent of duration,[8,25] (2) this age cut-off adequately captures higher proportions of early-onset type 2 diabetes across most ethnicities, which is important given the preponderance for earlier-presentations in some but not all ethnic groups and (3) diabetes diagnostic uncertainty is likely to be greatest below this age group, therefore, careful consideration as to the need for diagnostic testing for alternative forms of diabetes may be required, which is currently not standard practice for a diagnosis of type 2 diabetes later in life.

There are also legitimate reasons to segregate early onset *adult* type 2 diabetes from youth onset type 2 diabetes (diagnosed <18 years) when considering the provision of care to these individuals. As evidenced from experience in the care of people with type 1 diabetes, social, educational, and familial circumstances are disparate between the two age categories.[30] Additionally, the medical management of type 2 diabetes between youth-onset and early onset adult type 2 diabetes is significantly different with the repertoire of licenced medication for youth onset type 2 diabetes, relatively limited (to metformin, insulin and liraglutide at this point, although licencing of additional medications such as SGLT-2 inhibitors is likely as relevant trials are undertaken and reach completion), in comparison to early adulthood when the full repertoire of diabetes medications are licenced.

2.3 | An expanding, ethnically diverse and socioeconomically deprived caseload

In a retrospective UK study of the incidence of type 2 diabetes diagnosed <40 years, the standardised incidence ratio per 100 000 population increased from 217 in 1996–2000 to 598 in 2006–10.[1] Prevalence estimates from Clinical Practice Research Datalink (CPRD) show a rise from 3.21% to 5.26% between 2004 and 2014 of people with type 2 diabetes <40 years out of all those coded with type 2 diabetes[31] and this rise has been replicated in other cohorts.[32,33] The National Diabetes Audit in England, which records type 2 diabetes registrations by current age demonstrates a rise in those aged<40 years from 3.6% of registrations in 2013 to 3.9% in 2019.[34]

At a population level, the number of cases presenting in early adulthood (aged 18–39 years) accounts for a significantly larger proportion of the 'early-onset' group than those under 18 years. In NDA data; of 122,780 individuals in England with type 2 diabetes currently aged <40 years, 650 (0.5%) were children under 16 years of age, 910 (0.7%) adolescents aged between 16 and 18 years, 8245 (6.7%) young adults between 19 and 25 years-of-age and 112,980 (92%) adults aged between 26 and 39 years.[35]

In nearly all descriptions of cohorts of early-onset type 2 diabetes, Asian and black individuals are overrepresented.[28,33,36,37] In English national data, for example, Asian ethnicity was recorded for 38% (245/650) of those under 16 years, 31% (280/910) of those aged 16–18 years and 31% (1865/8245) of those aged 26–39 years. In contrast, people of Asian ethnicity accounted for 20% (192,805/945,090) of type 2 diabetes in those aged 40–59 years and only 11% (180,355/1,574,585) of those aged 60–79 years.[35] Black individuals also showed higher proportions in those aged <16 years 13% (85/650) and aged 16–18 years 10% (95/910) compared to later years—7% (68,760/945,090) of those aged 40–49 years and 4% (56,710/1,574,585) of those aged 50–79 years.

Similarly, national data also reveals an overrepresentation of individuals from the most socioeconomically deprived quintile (measured using quintiles of Index of Multiple Deprivation associated with the Lower Super Output Area derived from participant postcode): 42% (270/750) of those aged <16 years, 38% (345/910) of adolescents aged 16–18 years, 35% (2890/8245) of 19–25 years and 35% (38,985/112,980) of 26–39 years, compared to 25% of those aged 40–79 years.

3 | ARE SPECIFIC GUIDELINES FOR EARLY-ONSET TYPE 2 DIABETES NEEDED?

Despite such an adverse risk profile for early-onset type 2 diabetes, current guidelines for the management of type 2 diabetes *in adults*, make no age-related treatment recommendations.[21] There are guidelines for the management of type 2 diabetes in paediatric populations but these are broadly consensus-based and currently limited in drug choice by licensing of available medications.[38,39] With the exception of a few small studies that have specifically investigated treatment response in paediatric populations,[23,40] there is a paucity of data providing sufficient granularity regarding the most effective medications at this age or indeed, if existing treatments show differences in efficacy based on age-at-onset[19,41] although this may change as further studies of

glucose-lowering therapies in children report outcomes. For adults, deriving signals from existing drug trials is also problematic as, in most large randomised controlled cardiovascular outcome trials, the median age of recruitment is in the 5th or 6th decade.[19,41] The aspiration to provide age-specific medication guidelines is, therefore, not currently achievable.

Data from the National Diabetes Audit for England and Wales (NDA) does, however, highlight areas for improvement. Each year, eight care processes on every individual coded with diabetes in GP records are submitted for audit; HbA_{1c}, blood pressure, cholesterol, creatinine, urine albumin to creatinine ratio, BMI, smoking and a foot check (the ninth important care process, retinal screening, was only recently included, due to prior problems of data flow in England). Greater achievement of care processes has further been associated with a reduction in mortality in people with type 2 diabetes.[42] An analysis of the 2019–2020 dataset demonstrates that 33% of people with type 2 diabetes currently aged <40 years receiving all 8 care processes, in contrast to 47% of those aged 40–59 years and 59% of those aged 60–79 years[35,43,44]. In the absence of evidence supporting broader medication choices for younger people, more targeted approaches[13,45,46] that address lifestyle choices, psychological well-being and engagement with healthcare providers are likely to be beneficial given the over-representation of those from socioeconomically deprived and from minority ethnic groups, to support greater completion of these care processes.

4 | ENSURING CORRECT DIAGNOSIS

Whilst, at an older age of onset of diabetes, the prior probability of types of diabetes other than type 2 is lower, people presenting at a younger age have a higher likelihood of an alternative type of diabetes, for example, type 1 diabetes or maturity-onset diabetes of the young (MODY), a monogenic form of diabetes (see Figure 1). There are no specific diagnostic tests for type 2 diabetes and the diagnosis is usually made on clinical grounds with older age-at-onset and obesity traditionally favouring a diagnosis. There is, however, evidence that the diabetes subtype may sometimes be misclassified from several studies.[47-51] Indeed, in the UKPDS study, people diagnosed under 35 years of age were far more likely to be positive for one or more pancreatic autoantibodies.[52]

The changing characteristics of the population have meant that traditional factors such as BMI or age, may not sufficiently discriminate diabetes subtype in all cases. Incident cases of clinician-assigned type 1 diabetes, for example, had a median body mass index of 26 kg/m^2[53] and this has been confirmed in other cross-sectional cohorts defining type 1 diabetes using biomarkers.[51] This in turn means that the presence of obesity at a young age, should not necessarily be assumed to be indicative of a diagnosis of type 2 diabetes given that type 1 diabetes can occur at any body mass index.

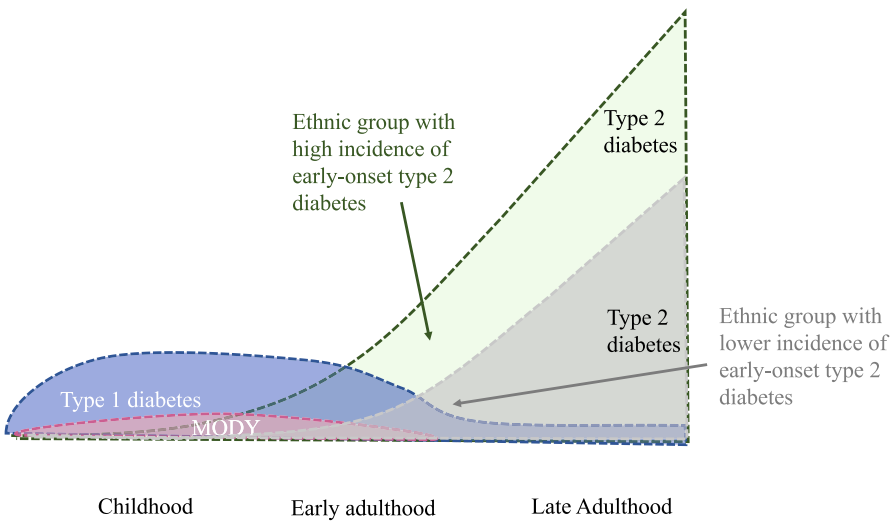

FIGURE 1 A schematic diagram illustrating different subtypes of diabetes and their relative likelihood according to age at diagnosis. In childhood type 1 diabetes presentations (shaded blue) predominate and MODY (shaded pink) is relatively easy to identify as it is primarily being differentiated from type 1 diabetes. In adolescents and young adults, the rising prevalence of early-onset type 2 diabetes (shaded green or grey), obscures the identification of MODY as the presentation is broadly similar, but also type 1 diabetes if the presentation is not typical. The rise in type 2 diabetes cases, the age of onset and the number of cases, varies by ethnic group, thus in an ethnic group with a high prevalence of early-onset type 2 diabetes (shaded green), the detection of other forms may be masked to a greater extent in early adulthood, compared to an ethnic group with lower prevalence (shaded grey). MODY, maturity-onset diabetes of the young.

Type 2 diabetes also presents at lower BMI in some ethnic groups, for example, south Asian people who are relatively leaner at diagnosis,[54,55] although significant obesity appears to accompany a diagnosis of early-onset type 2 diabetes in most cases coded by practitioners.[13] Thus, a relatively 'normal' BMI does not exclude type 2 diabetes and indeed south Asian people appear to have an 'obese' metabolic phenotype at a lower BMI.[56] Taken together these data suggest the need to consider a diagnosis of type 1 diabetes in many, if not the majority, of early-onset diabetes presentations.

Hidden within early onset diabetes presentations are cases of MODY.[57] Recognition is important as the treatment is different to the standard care for type 1 or type 2 diabetes and depends on the affected gene.[58] Whilst biomarkers, for example, pancreatic autoantibodies and C-peptide levels may provide some discriminatory value in distinguishing MODY from type 1 diabetes, they have less value in separating type 2 diabetes from MODY[59,60] as both MODY and early-onset type 2 diabetes cases would be expected to show evidence of persistent beta-cell function and negative pancreatic autoimmunity. Careful history taking is needed as many individuals with early-onset type 2 diabetes have one or both parents also affected with type 2 diabetes, so the presence of a family history does not neatly segregate MODY from type 2 diabetes earlier in life.

Paediatric consensus guidelines do advocate routine testing of pancreatic autoantibodies in all presentations and consideration of genetic testing for MODY, if negative. Adult guidelines however, vary, with pancreatic antibodies only advocated in people with suspected type 1 diabetes.

Whilst there is insufficient evidence to recommend routine genetic testing of adults with type 2 diabetes for MODY, careful consideration is required. Early-onset adult type 2 diabetes could be a diagnosis of exclusion after a clear history and, if warranted, biomarker measurements are undertaken. This is particularly important in adults from black and ethnic minority backgrounds where the presentation and prevalence of type 1 diabetes and MODY are not fully understood.

5 | VARIABILITY IN TRANSITION SERVICES

Adolescents with a diagnosis of type 2 diabetes may or may not be under specialist paediatric services. In some cases, once alternative diagnoses have been excluded, adolescents may be variably transitioned to the care of their GP, remain under paediatric teams until the transition to adult specialist services, or in most cases transition to general practice at 18 years.

The experience of care received may therefore be substantially different between services and from one locality to the next. In view of the high risk of complications in youth onset type 2 diabetes, harmonising the approach in a given locality would be beneficial, ensuring a standardised level of input and, for example, a medication review that explores the need for additional (now licenced) medications at 18 years.

6 | IS THE CURRENT MODEL OF CARE WORKING?

It is possible that current models of care in operation work less well for early-onset type 2 diabetes than for later-onset cases given the age-related changes identified in the delivery of care processes and achievement of HbA_{1c} targets from NDA audit data.[35]

An ideal guideline might include age-specific recommendations regarding HbA_{1c} and blood pressure targets, for example, or explicit recommendations around the order of initiation of glucose-lowering therapies. However, the scientific evidence base to guide such recommendations is currently sparse, therefore, investing in care models that might drive higher achievement of treatment targets and delivery of care process completion would seem to offer the best opportunity for improvement at present.

It is unclear whether the differences in proportions of those achieving treatment targets between earlier- and later-onset type 2 diabetes reflects the disease process itself or patient factors for example higher levels of diabetes distress contributing to lack of engagement with self-management. Indeed, the rapid progression to beta cell failure and insulin requirement may also contribute to the high proportion of individuals not achieving HbA_{1c} targets. Whilst the pathogenesis and environmental drivers of type 2 diabetes are vastly different to type 1 diabetes, the vulnerabilities of the young-adult population in receiving the life-changing diagnosis of chronic disease are likely to be similar.[46] That the type 2 diabetes diagnosis carries significant stigma around weight[61] and lifestyle choices, may further dissociate engagement of an already susceptible group.[45] In addition, the current models of care do not address the expanding caseload, the role of remission programmes, accessibility/appropriateness of bariatric surgery or the need for expertise in medical management.

6.1 | A suggested strategy

A sustainable, age focussed, integrated care partnership between primary care and specialist services is likely to be the most productive approach to addressing the needs

of those with early-onset type 2 diabetes. In England, this is in keeping with the NHS Long Term[62] Plan and there will be a need for policy-makers, internationally, to understand how this partnership can manifest in their own healthcare settings.

Globally, the prevalence of early-onset type 2 diabetes is variable with cases in some low and middle-income countries[22] exceeding high-income countries. National strategies will need to be tailored to the needs of the population, the organisation of healthcare and the resources available.

A variety of approaches are likely to be needed, as a single service model is unlikely to fulfil the needs of all communities or geographical locations. These models must take into consideration variability in local geographical caseload, ethnic diversity of affected individuals, local resources, and the availability of relevant expertise across the sector. See Figure 2 for a schematic outlining the key components. Furthermore, it is inevitable that not all initiatives will be successful so it is important that each is accompanied by ongoing monitoring and evaluation using the NDA and local data.

Irrespective of the model of care most appropriate for a given geographical location, it is likely to require the following key components:

6.2 | A clearly defined local strategy for early-onset type 2 diabetes

Each locality delivering care should have a strategy in place to identify cases of early-onset type 2 diabetes and to develop pathways that help address their higher risk of complications from the point of diagnosis. The decision on how best to model this should be made according to local factors and resources but may be strategised, for example in England, at a Primary Care Network Level or within an Integrated Care System,[62] with input from relevant stakeholders.

The aims of this strategy should be to (1) prioritise the identification of those with existing diagnoses and those at high risk of developing early-onset type 2 diabetes and (2) to have a clear pathway in place for new cases in order to support the assignment of correct diagnoses and (3) to also identify groups at particularly high risk of early consequences—for example, women of child-bearing age. The strategy should also explore methods to drive improvements in the proportions of people meeting the three treatment targets and receiving the eight/nine care processes, using, for example, peer comparison methods that highlight patients using database searches and consider proportions achieving the three treatment targets as a specific local indicator on diabetes dashboards.

The accuracy of documentation, coding and confirmation of age-at-diagnosis should also be considered an essential variable to document during consultations, to improve data integrity.

6.3 | A diagnostic hub service

Each locality should identify how best to deliver specialist tests (and their interpretation) to support accurate diagnoses in those with a putative diagnosis of early-onset type 2 diabetes. Many guidelines already advocate the use of pancreatic autoantibody testing in specific populations where type 1 diabetes is suspected[63] and it is recognised that the use of clinical features, for example, BMI, is not adequate to segregate a diagnosis of type 2 diabetes from type 1 diabetes. Pancreatic autoantibody testing is best undertaken at diagnosis, whereas the use of C-peptide has more value in discriminating subtypes, years after diagnosis. In line with international paediatric guidelines for youth-onset type 2 diabetes and adult guidelines for type 1 diabetes, routine autoantibody testing in adults presenting with diabetes <40 years is could be recommended for preventing misdiagnosis of type 1 diabetes.

Tests for type 1 diabetes and MODY genetic testing are usually routinely available, but the pathway to access these tests may not be clear at a practice level and there may be additional challenges, for example, the need to transport C-peptide samples on ice or the need for genetic counselling. The concept of a diagnostic hub within an Integrated Care System or Primary Care Network could be a useful concept, such that general practitioners are supported to (1) determine when these tests are appropriate, (2) have a streamlined pathway for accessibility and (3) have the availability of relevant specialists, when required. A suitably qualified clinician, a diabetes consultant working in the community setting or indeed a laboratory specialist could be in a position to support this if they have relevant expertise.

6.4 | Consideration of patient engagement

Consideration should be given to the development of non-traditional ways to engage with people that have early-onset type 2 diabetes. Several studies outline that younger people with type 1 diabetes are less likely to engage with healthcare services and there is evidence this may also apply to those with early-onset type 2 diabetes. This may partially be related to education and employment pressures or feelings of distress around chronic disease management. Novel approaches are important to encourage

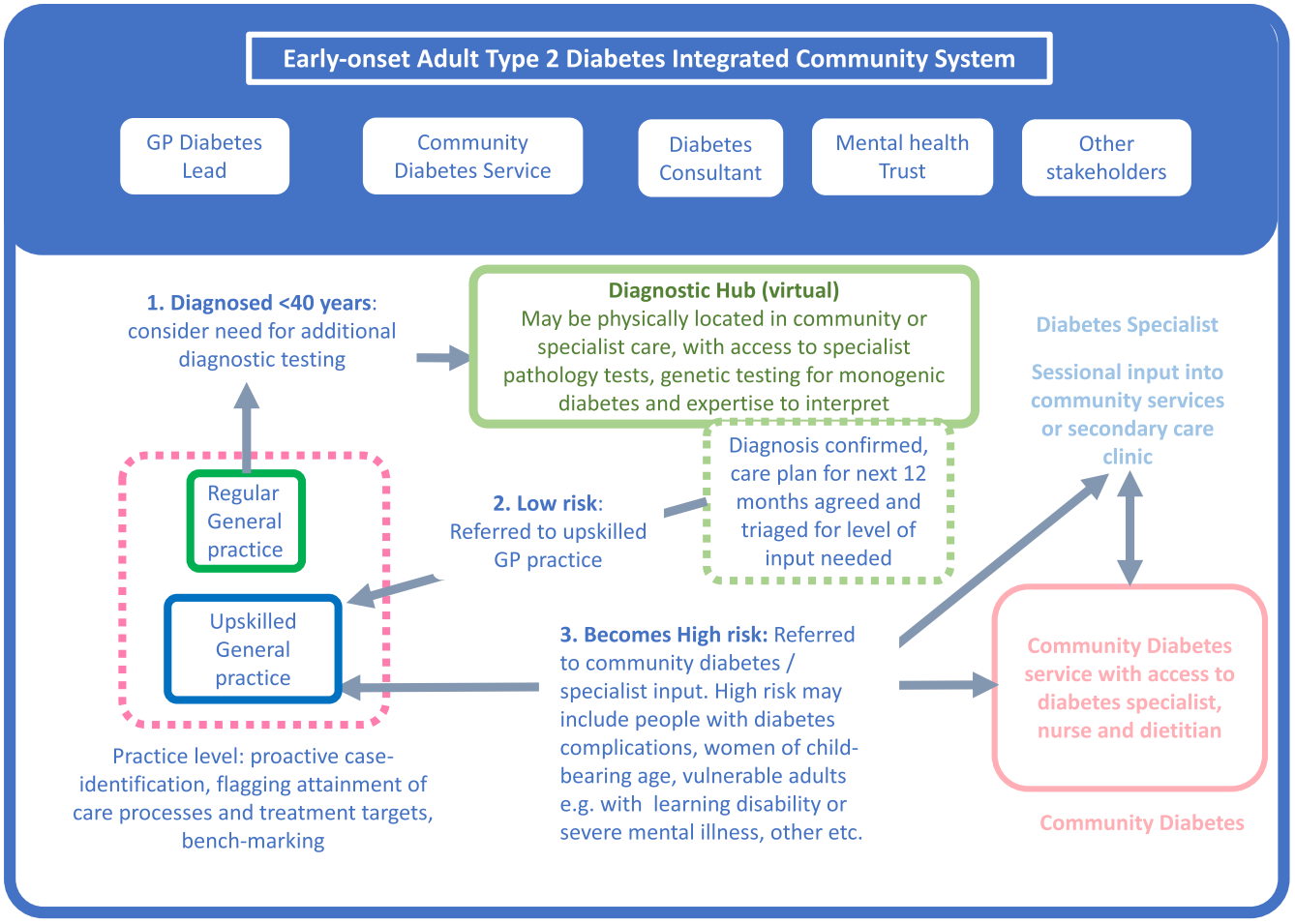

FIGURE 2 A schematic representation of key aspects of a model of care for those with early-onset type 2 diabetes. A diagnosis of type 2 diabetes below 40 years could (1) prompt the consideration of specialist tests of atypical features present. Following confirmation of subtype, (2) a 'low risk' patient (most would be at diagnosis) could be referred to a GP with a special interest in early-onset type 2 diabetes who has developed relevant skills. If an individual became 'higher risk' at any time (3) they could be referred to a community diabetes clinic with specialist input or access to a multi-disciplinary team with further referral to secondary care services when needed. An overarching theme of this integrated community system would be a data-driven approach with knowledge of numbers of the affected individuals in a geography, proportions meeting the three treatment targets and receiving the eight/nine care processes and other demographic characteristics that may warrant approaches that drive better engagement.

participation in weight loss programmes and medication reviews. Consideration should also be given to participation in local remission programmes.[64] Digital platforms are likely to have appeal in this younger age group both for consultation purposes but also in relation to behaviour change,[65] however, alternatives for those with barriers to accessing digital solutions, should also be provided.

6.5 | Skills development

To support large and increasing numbers of individuals with early-onset type 2 diabetes relevant skills development for healthcare providers warrants discussion. For early-onset type 2 diabetes, the necessary components would likely include (1) that healthcare providers have or develop skills to support consultations with younger individuals with obesity and diabetes, (2) are trained to recognise diabetes distress related to stigma or the burden of chronic disease and refer for support as needed, (3) are supported to develop digital methods to engage with younger people living with type 2 diabetes and (4) feel skilled and confident in the use of all type 2 diabetes medications including the initiation of injectables, blood pressure and cholesterol-lowering medications, recognising that initiation in a 20-year-old patient versus a 39-year-old patient or woman of child-bearing age has different risks and considerations.

The care of people with type 2 diabetes in England has moved predominantly to general practice, with the management of complications when they arise, often under specialist services.

Understanding where specialist services can add the greatest value for those with early-onset type 2 diabetes is important; for example, it may lie in managing

complications, ensuring correct diagnoses and supporting more intensive management in women planning pregnancy. The level of specialist input is likely to vary according to the expertise within general practice within a given geography. It is likely that a consultant diabetologist or a general practitioner with a special interest in this condition could operate a hub service for affected individuals within a given locality or in a community diabetes clinic.

6.6 | Type 2 diabetes prevention in younger cohorts

Although in this article we focus on the delivery of care to people with existing diagnoses, it is clear that an important component of any strategy to tackle early-onset type 2 diabetes should be the opportunity for prevention. Living with overweight or obesity are the major modifiable risk factors for a diagnosis of early-onset type 2 diabetes. Therefore, population-level interventions targeting obesity and the obesogenic environment are likely to be effective components in the prevention of type 2 diabetes in adolescents and early adulthood.

The NHS Diabetes Prevention Programme (NHS DPP) provides behavioural interventions that support weight loss, increased physical activity, and better quality nutrition in those already identified to be at high risk with non-diabetic hyperglycaemia.[66] Eligible individuals are identified through routine clinical care, and through the NHS Health Check Programme (NHS Health Check-NHS (www.nhs.uk)). However, the lower age threshold of eligibility for the NHS DPP is age 18 years, for an NHS Health Check is age 40 years, and additionally, it is likely that the time spent in the "pre-diabetes" or non-diabetic hyperglycaemic category is shorter at younger ages, again making identification of those at risk and eligible for evidence-based interventions to prevent or delay the onset of type 2 diabetes more challenging.

Data from the NHS DPP does show participation in behavioural interventions in those <40 years but of all age groups, those <40 years achieved the smallest weight reduction; in the NHS DPP early outcome data, 5% of referrals (n = 17,797) were in people aged <40 years and in those who completed the intervention, mean weight reduction was 2.4 kg,[66] but this was the smallest weight reduction of all age categories.

The effectiveness of behavioural approaches in young adults and adolescents may therefore be attenuated both in terms of percentage uptake and efficacy of interventions.[66,67] These differences need to be taken into consideration when devising a local strategy—for example, digital interventions have been shown to have greater uptake in younger adults.[65]

Another high-risk group for progression to early-onset type 2 diabetes, is women of child-bearing age who have had a previous pregnancy complicated by gestational diabetes.[20,68] As of April 2021, women with previous gestational diabetes and currently normoglycaemic are eligible for referral into the NHS DPP; prior to this, eligibility had been limited only to those with non-diabetic hyperglycaemia. More active education and follow-up of these women would be of benefit.[69]

6.7 | Identifying people at risk of early-onset type 2 diabetes

Adults at high risk of type 2 diabetes are offered screening for type 2 diabetes through national health checks in many countries, however, the lower age limit for these programmes may not adequately capture youth or young adults. For example, in the UK, the NHS Health Check is undertaken in those aged 40 years or older and in the US, screening of overweight and obese individuals for type 2 diabetes is recommended above 35 years of age. The lack of incorporation of younger age groups in these population-level programmes predominantly stems from the inadequate evidence base for widespread screening to add benefit, given disease incidence is so low at younger ages. Youth identified through proactive screening of at-risk individuals had a lower HbA_{1c} at presentation, than those identified at diagnosis in one study[70] however, other studies demonstrate a fast progression to type 2 diabetes in at-risk youth[71] suggesting a very narrow time window in which screening may have benefit. These knowledge gaps have led paediatric guidelines to recommend targeted screening in youth with obesity and concurrent additional risk factors,[39,72] undertaken opportunistically at the time of assessment for obesity-related morbidities, which are proportionally more common than type 2 diabetes, as opposed to population-level screening of overweight and obese adolescents which is unlikely to be cost-effective.[72] It should be noted, however, that no such evidence base or guideline exists for routine screening of adults overweight or obese, aged 18–39 years.

Taken together, the data in favour of widespread screening of those overweight or obese in those below 40 years, is inconclusive. However, opportunistic screening for type 2 diabetes in those at highest risk (as shown in paediatric studies) may be of some benefit. Therefore, in each locality, part of the strategy to tackle early-onset type 2 diabetes, should involve a proactive review of people at a very high risk of early-onset type 2 diabetes, including; adolescents and young adults with obesity and additional risk factors[72] and women with a history of a pregnancy complicated by gestational diabetes.

7 | FILLING IN RESEARCH GAPS

It is clear that much research is needed to better understand how to manage people with early-onset type 2 diabetes including research on the most appropriate models of care. A priority area is to understand which drug classes might be better placed to treat early-onset type 2 diabetes. A basic unanswered question, for example, is whether earlier insulin treatment is advantageous. The role of newer drugs that support weight loss, or that have cardiovascular risk-benefit should also be explored. A second key question is whether the higher cardiovascular risk can be mitigated with the use of tighter blood pressure, cholesterol and HbA_{1c} targets, beyond those current recommended, or whether a primary focus on BMI and weight loss interventions may yield the most benefit.

The role of targeting remission in early-onset type 2 diabetes through lifestyle interventions or through bariatric surgery is unclear at this point, and the degree of sustainability is unknown. The drivers for change in lifestyle and psychological and motivational factors are also poorly studied in this group. Underpinning all of these unanswered questions is the need to understand the interaction with ethnicity given the over-representation of people with Asian and black heritage within this population cohort.

8 | CONCLUSION

Early-onset type 2 diabetes is an extremely high-risk condition with a rapidly rising caseload, that disproportionately affects people from black and minority ethnic groups in the UK. Type 2 diabetes care may benefit from a segmented focus on this younger group that incorporates people in full-time education, those of working age with potentially demanding employment and women of child-bearing age. Although many challenges exist, the development of local strategies that promote preventive care, actively case-find, accurately classify, and proactively address achievement of treatment targets and delivery of care processes, as well as benchmark outcomes with peers, are likely to drive improvements and are urgently needed. A model of care that integrates primary care and specialist workforces in networks of care, may best provide the skills to support and manage this rapidly growing group, in the most beneficial and holistic way. However, strategies will need to be tailored according to the needs of each population and the infrastructure available to support the delivery of healthcare.

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CONFLICT OF INTEREST

All authors are members of the clinical advisory groups to the National Diabetes Audit. PK, KK, BY and JV are members of the NDA research committee. BY is the clinical lead for the NDA and a trustee of Diabetes UK. KK has been a consultant and speaker for Novartis, Novo Nordisk, Sanofi-Aventis, Lilly, and Merck Sharp & Dohme; has received grants in support of investigator-initiated studies from Novartis, Novo Nordisk, Sanofi-Aventis, Lilly, Merck Sharp & Dohme, Pfizer, and Boehringer Ingelheim; has served on advisory boards for Novo Nordisk, Sanofi- Aventis, Lilly, and Merck Sharp & Dohme; and is Chair of the Ethnicity Subgroup of Scientific Advisory Group for Emergencies (SAGE) and member of SAGE. JV is National Clinical Director for Diabetes and Obesity at NHS England & NHS Improvement.

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