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REVIEW

Narrative Review: Continuous Glucose Monitoring (CGM) in Older Adults with Diabetes

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ABSTRACT

Introduction: Continuous glucose monitoring (CGM) has revolutionised diabetes care, with proven effect on glycaemic control, adverse diabetic events (such as hypoglycaemia and diabetic ketoacidosis) and hospitalisations in the general population. However, the evidence for CGM in older people is less robust.
Method: We conducted a narrative review of trials reporting data comparing standard blood glucose monitoring (SBGM) and CGM in adults over 65 with type 1 or type 2 diabetes who were treated with insulin published between 1999 and 2024.
Results: Seventeen studies were identified, including eight retrospective cohort studies and five randomised controlled trials (RCTs). Sixteen of the 17 papers were based in Europe or North America. The studies were highly heterogeneous; however, they provided clear evidence supporting the use of CGM in reducing hypoglycemia in older adults, with potential benefits for overall wellbeing and quality of life..
Conclusions: Current approaches to diabetes care in older adults may over-rely on HbA1c (haemoglobin A1c) as a measurement of control given accuracy may be reduced in older adults and propensity for hypoglycaemia. Although goals should be personalised, avoidance of hypoglycaemia is a key goal for many older people with diabetes. There is good evidence that CGM can improve time-in-range and reduce hypoglycaemia and glucose variability in older adults. CGM should be considered for older adults as a means of reducing hypoglycaemia and associated potential harm.

Keywords: CGM; Older adults; Libre; Diabetes

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Key Summary Points
An over-reliance on HbA1c (haemoglobin A1c) in older adults may lead to over-treatment and associated harm.
Treatment goals for older adults with diabetes should be personalised, with a focus on preventing hypoglycaemia and associated harm, especially in frailer patients.
Continuous glucose monitoring (CGM) has proven benefits in reducing hypoglycaemia and improving variability in older adults.
CGM may help to reduce HbA1c in some patients, however this may not be desirable in patients at high risk of hypoglycaemia.
CGM has the potential to improve diabetes care for older adults, especially in reducing hypoglycaemia and they should not be excluded from new technologies based on their age.

INTRODUCTION

Around 4.5 million people in the UK are currently living with diabetes, with half of these over 65 years old [1, 2]. Despite posing a significant disease burden for older adults, this group is unfortunately frequently excluded from larger diabetes trials, leading to less robust evidence for older adults. One of the key advances in diabetes care in recent years is the explosion of continuous glucose monitoring (CGM) as a tool for improving glycaemic control and reducing adverse diabetic events [3]. Although CGM use has undoubtedly increased in recent years, studies have shown that uptake is consistently lowest among older adults, representing a potential untapped opportunity to revolutionise diabetes care for older adults [4–6].

Evidence for CGM in Diabetes (General Population)

Crucial potential benefits of CGM include improved glycaemic control (HbA1C/time in range), reduction in hypoglycaemia and adverse diabetic events and hospital admissions [7–11]. An international meta-analysis of 15 randomised controlled trials of CGM in type 1 and type 2 diabetes demonstrated a 2 mmol/mol reduction in HbA1c ($p=0.003$) and a significant reduction in hypoglycaemia ($p<0.001$) [8]. Furthermore, several large-scale cohort studies in the USA and Europe have shown significant reductions in adverse diabetic events such as hypoglycaemia and diabetic ketoacidosis (DKA) and hospital admissions following initiation of CGM monitoring [9, 10]. A number of the initial large-scale studies produced limited data regarding CGM outcomes in older adults or did not show a clear benefit in this group. For instance, one of the first RCTs of CGM in insulin-treated adults with type 2 diabetes (Multicentre European REPLACE RCT) showed a significant reduction in HbA1c for adults < 65 years old with CGM, however, this was not shown in the > 65 group [10]. More recently, studies have been published specifically evaluating CGM in older adults which will be the primary focus of this review.

What Does 'Good' Diabetes Control Look Like in Older Adults?

Diabetes control is often measured using HbA1c clinically and in research trials, however, a number of studies have shown that HbA1c rises with age, independent of glucose levels, insulin resistance and body mass index (BMI) [12, 13]. A population-based study in Germany found that the normal reference value for HbA1c was significantly higher in adults over 60 compared to 20 to 39-year-olds (47.8 mmol/l compared to 42.1 mmol/l) [13]. A similar study in China showed that the diagnostic efficiency of HbA1c decreased with age, suggesting that it may not be as accurate in diagnosing diabetes in the older population [14]. Moreover, a number of other factors can result in falsely elevated or reduced HbA1c, such as chronic kidney disease (CKD) and anaemia, which are more prevalent in the older population [15, 16]. These findings illustrate that HbA1c may not be the optimal marker of diabetes control in older adults. Furthermore, as HbA1c is effectively an average of

glucose levels, someone with significant episodes of hypo- or hyperglycaemia may appear to have a satisfactory HbA1c level [15]. This is especially pertinent to older adults who are at higher risk of hypoglycaemia as HbA1c alone may not reflect this. In the era of CGM, time in range (TIR) has been established as a strong predictor of microvascular complications and of all-cause and cardiovascular mortality [17, 18]. Furthermore, TIR may provide more information regarding a patient's glycaemic patterns [17]. Of interest, a single-centre US reported that in their cohort of older CGM users, high glucose variability was associated with greater time in hypoglycaemia ($p<0.001$), despite no significant difference in HbA1c between the group [19]. This may suggest that CGM metrics such as glucose variability and time below range may allow for better identification of patients at risk of hypoglycaemia. More research is required to establish the most accurate and helpful methods of monitoring diabetes in older adults and whether HbA1c should play a role.

In considering new advances for older people living with diabetes, it is essential to consider our goals in each patient, and indeed in specific patient groups such as frail/elderly adults. The International Diabetes Federation (IDF) guideline for older adults recommends balancing the potential risks and benefits for each patient, advocating for a pragmatic approach [20]. This mirrors the approach recommended by the National Institute for Health and Care Excellence (NICE), which advises balancing the risks of long-term diabetes complications versus the risk of hypoglycaemia in this group [21]. The IDF recommends varying HbA1c targets for older adults depending on their functional status, allowing for more relaxed diabetes control in frailer older adults who are at greater risk of hypoglycaemia [20].

Older adults with diabetes tend to have more frequent and more severe episodes of hypoglycaemia which can be life-threatening [22]. In addition, several sequelae may be associated with hypoglycaemia in this group, including falls, frailty and cognitive impairment [3, 22]. Aiming to reduce hypoglycaemia is therefore a crucial aspect of diabetes management in older adults.

METHODS

A literature search was performed in PubMed, COCHRANE and Scopus for the search terms 'Continuous Glucose Monitoring', 'Flash Glucose Monitoring', 'CGM' or 'Libre' and 'older' or 'elderly'. We focussed on studies in adults over 65 with type 1 or type 2 diabetes who were treated with insulin published between 1999 and 2024. Our initial scoping study suggested considerable heterogeneity across the studies, so a narrative review approach was chosen.

Studies including only patients on continuous subcutaneous insulin infusion (CSII) were excluded from our review. Studies using continuous glucose monitoring (real-time) and intermittent 'flash' glucose monitoring were included and referred to as 'CGM' for this review.

This article is based on previously conducted studies and contains no new studies with human participants or animals performed by any of the authors.

RESULTS

The literature search as performed above identified 17 key papers, which are summarised in Table 1 [9–11, 23–36]. There were eight retrospective cohort studies, five randomised controlled trials (RCTs) (four original, one extension), three prospective cohort studies and one cohort-control study. Nine studies were based in the USA and/or Canada, seven studies based in Europe and one in Brazil. Thirteen of the 17 studies were funded by Abbott Diabetes Care or Dexcom Inc.

DISCUSSION

Impact of CGM on Diabetes Control: Older Adults

As discussed, large studies examining the benefits of CGM in Diabetes have, until recently, provided limited or inconclusive data regarding the glycaemic benefits of CGM in older people.

Table 1 Summary of key papers: CGM in older adults on insulin

Paper author/trial title	Type of study	Country	Funding	No patients	Insulin type	Diabetes type	Age	Impact on diabetes control	Impact on hypoglycaemia	Impact on ADEs	Other findings	Limitations
Argento et al., 2014 [23]	Retrospective cohort	USA	Dexcom, Inc	38	Intensive	T1	> 65	– 0.5% reduction HbA1c ($p < .0001$)	Significant reduction severe hypo (0.37 to 0.12 per year, $p = .0007$)	–	–	Small cohort (only 25 patients had paired HbA1c data)
Polonsky et al., 2016 [24]	Cohort-control study	USA	Dexcom, Inc	210 CGM, 75 controls	Any	T1 = 260 T2 = 25	> 65	–	Significant reduction in reported hypos vs controls ($p < 0.01$)	Significant reduction ED/paramedic attendance for hypoglycaemia ($p < 0.01$)	Improved QoL and wellbeing, reduced 'hypo fear' and 'diabetes distress' vs controls ($p < 0.05$)	Lack of HbA1c/TIR data No randomisation
Litchman et al., 2017 [25]	Prospective cohort	USA	Declared none	11 rt-CGM, 11 SBGM	MDI	T1 only	> 65	–	Reduction in reported episodes of hypoglycaemia with CGM vs SBGM ($p = 0.02$)	–	Improved feeling of wellbeing and safety (cited reduced hypoglycaemia as reason)	Small cohort Lack of HbA1c/TIR data
Ruedy et al., 2017 [26] (DIAMOND)	RCT	USA	Dexcom, Inc. (additional interests declared)	116	Intensive (1) (MDI)	T1 = 34 T2 = 82	> 60	Adj. mean difference HbA1c – 0.4% to – 0.1%, reduced glycaemic variability ($p = 0.02$)	–	–		Relatively small cohort Lack of TIR data or effect on hypoglycaemia
Haak et al., 2017 [11] (REPLACE)	RCT	Multi-centre Europe	Abbott Diabetes Care	> 200 total	Intensive	T2 only	All—< 65 vs > 65	Reduction in HbA1c in CGM vs controls in < 65 ($p = 0.03$), for adults > 65, larger HbA1c reduction in controls vs CGM ($p = 0.008$). No difference TIR whole cohort	Sig reduction across age groups, more marked in > 65s (56% reduction in TBR compared to controls ($p = 0.0083$)	–	–	Actual number of patients > 65 in sub-group analysis unclear
Kroger et al., 2019 [27]	Retrospective cohort study	Multi-centre Europe	Abbott Diabetes Care	363 total	Intensive	T2 only	> 65 vs < 65	HbA1c reduced following CGM initiation (– 9.7 mmol/mol, $p < 0.0001$), no significant difference in HbA1c reduction < 65 vs > 65 ($p = 0.28$)	–	–	–	Unrandomised No control Lack of TIR/hypoglycaemia data

Table 1 continued

Paper author/trial title	Type of study	Country	Funding	No patients	Insulin type	Diabetes type	Age	Impact on diabetes control	Impact on hypoglycaemia	Impact on ADEs	Other findings	Limitations
Volčanšek et al., 2019 [28]	Prospective cohort study	Slovenia	None declared	25	MDI	T1 & T2	> 65	Increased TIR and variability on initiation of CGM ($p < 0.001$)	Reduced TBR on initiation of CGM (9.6% vs 5.2%, $p = 0.041$)	–	Patient reported high satisfaction, improved feeling of security and sleep quality	Small cohort Unrandomised No control
Pratley et al., 2020 (WISDM study) [29]	RCT	USA	Jaeb Centre for Health Research	203	MDI or CSII ($n = 106$ and 108)	T1 only	> 60	– 0.3% adjusted HbA1c effect of CGM vs SBGM on HbA1c after 26-week follow-up ($p < 0.001$)	Adjusted treatment benefit TBR – 27 min ($p < 0.001$) and severe hypos	No significant effect on hospitalisations ($p = 0.30$)	–	Included patients on CSII and MDI
Roussel et al., 2021 [9] (RELIEF study)	Retrospective cohort study	France	Abbott Diabetes Care (additional interests declared)	Sub-group ~ 20,000 > 65 on Libre	Intensive (BB)	T1 & T2	Sub-group > 65	–	–	45.7% reduction in hospitalisations for ADEs in whole cohort	Benefit greater in young people, potentially due to reduced DKA hospitalisations	Unrandomised No control Lack of HbA1c/TIR data
Bergenstal et al., 2021 [10]	Retrospective cohort	USA	Abbott Diabetes Care (additional interests declared)	2463 total	Intensive	T2 only	< 50 vs > 50	–	–	Reduction in ADEs (HR 0.38, $p < 0.001$) and hosp (HR 0.68, $p < 0.001$), no sig difference < 50 vs > 50	–	Unrandomised No control Lack of HbA1c/TIR data
Miller et al., 2022 [30] (WISDM study extension)	RCT	USA	Juvenile Diabetes Research Fund and the Leona M. and Harry B. Helmsley Charitable Trust	> 200	Intensive	T1 only	> 65	Reduction baseline HbA1c ($p = 0.01$), increased TIR with CGM at 1 year (56% vs 64%, $p < 0.001$)	Median TBR 5.0% at baseline vs 2.8% at 1 year ($p < 0.001$)	–	–	Lack of data on effect of reducing hypoglycaemia on ADEs/hospitalisations

Table 1 continued

Paper author/trial title	Type of study	Country	Funding	No patients	Insulin type	Diabetes type	Age	Impact on diabetes control	Impact on hypoglycaemia	Impact on ADEs	Other findings	Limitations
Bao et al., 2022 [31] (Subgroup analysis MOBILE RCT)	RCT	USA	Dexcom Inc. (additional interests declared)	42 > 65 years vs 133 aged 33–64	Basal only	T2 only	65–79	Adjusted HbA1c mean difference = − 0.65% in > 65, − 0.35% in < 65, TIR adjusted difference = 19% in > 65 ($p = 0.01$) and 12% in < 65 ($p = 0.003$)	Low both groups → no significant difference	–	–	Relatively small cohort (42 patients over 65) Lack of data on effect of reducing hypoglycaemia on ADEs/hospitalisations
Carlson et al., 2022 [32]	Retrospective cohort study	Multi-centre North America	Abbott Diabetes Care (additional interests declared)	191 total	Basal-only	T2 only	> 65 vs < 65	A1c adjusted difference after ~ 3 months = − 1.4% ($p < 0.0001$). No sig difference > 65 vs < 65 ($p = 0.09$)	–	–	–	Lack of data on hypoglycaemia/HbA1c/TIR
Eeg-Oloffson et al., 2023 [33]	Retrospective cohort study	Sweden	Abbott Diabetes Care	711	79% on insulin	T2 only	> 65 vs < 65	6 month reductions in A1c: 25–65 (− 0.72; $p < 0.0001$), 66–74 (− 0.34%, $p < 0.0001$), > 74 (− 0.01, $p = 0.934$)	–	–	–	Lack of data on hypoglycaemia/HbA1c/TIR/ADEs
Leite et al., 2023 [34]	Prospective study	Brazil	Abbott Diabetes Care	66	Any insulin	T2 only	> 65	Stable TIR (63.5% at baseline, 65.5% at 6 weeks, $p = 0.19$), sig lower glycaemic variability ($p < 0.001$)	TBR reduction at 6 weeks of CGM (5.8% vs 3.8%, $p = 0.008$)	–	–	Small cohort Lack of data on effect of reducing hypoglycaemia on ADEs/hospitalisations
Guerci et al., 2023 [35]	Retrospective study	France	Abbott Diabetes Care (additional interests declared)	> 38,000 starting CGM – hosp pre vs post	Intensive or CSII	T2 only	> 65	–	–	34% and 40% reduction in admissions at 12 and 24 months, respectively (hypo & DKA)	–	Lack of data on HbA1c/TIR

Table 1 continued

Paper author/ trial title	Type of study	Country	Funding	No patients	Insulin type	Diabetes type	Age	Impact on diabetes control	Impact on hypoglycaemia	Impact on ADEs	Other findings	Limitations
Deshmukh et al., 2024 [36]	Retrospective cohort	UK	Abbott	1171 (paired data for 723)	Intensive	T1 only	> 65	Significantly lower HbA1c in 65–75 years and > 80 years, not in 75–80	–	–	Significantly reduced diabetes distress score (DDS2) across all groups and Gold score (hypo awareness) in 65–75 and > 80 groups	Lack of data on HbA1c/TIR Not randomised No controls

ADEs acute diabetic events, *BB* basal-bolus, *CGM* continuous glucose monitoring, *CSII* continuous subcutaneous insulin infusion, *DKA* diabetic ketoacidosis, *HbA1c* haemoglobin A1C/glycated haemoglobin, *HR* hazard ratio, *MDI* multiple daily injections, *RCT* randomised controlled trial, *SBGM* standard blood glucose monitoring, *TBR* time below range, *TIR* time In range

Indeed, a number of the studies identified in this work are limited by small cohort size. In recent years, there have been several studies published focussing particularly on CGM in older adults which generally suggest that CGM may lead to reduced HbA1c in older adults. It is important to be aware of the caveat that although HbA1c is the primary outcome measure in a number of these trials, a reduction in HbA1c does not necessarily equate to better glycaemic control in older adults for the reasons discussed above.

The REPLACE RCT randomised 224 adults from 26 European diabetes centres with insulin-treated T2DM to CGM or standard blood glucose monitoring (SBGM), analysing HbA1c at 6 months as their primary outcome, with pre-specified sub-group analysis of patients < 65 and > 65 years old [11]. CGM produced a significant reduction in HbA1C versus control in under 65s, however in patients over 65, HbA1c reduction was greater in the control group [11]. Nevertheless, there was a 56% reduction in hypoglycaemia for CGM users over 65 compared to the control group ($p = 0.0083$) [11]. However, a key limitation of this study is the fact that the actual number of patients included in the > 65 sub-group is not clear. A smaller study of older adults with insulin-treated T2DM in Brazil found similar results as the REPLACE trial, with no significant impact of CGM on time-in-range, however a significant reduction in hypoglycaemia was demonstrated [34]. These studies illustrate that even if the effect on glycaemic management is minimal, there could be key benefits in this group in terms of reducing hypoglycaemia [11].

Real-world analysis of the Swedish Diabetes Register showed that in this cohort, there was no significant difference in HbA1c for adults > 74 using CGM [33]. However, there was a significant reduction in HbA1c for adults aged 66–74 (– 0.35%, $p < 0.0001$), albeit more modest than in the 25–65 age group (– 0.72%, $p < 0.0001$) [34]. This study raises the question of whether CGM may have reduced effect in reducing HbA1c in the 'very elderly' group who are likely to be more frail and co-morbid. However, it may be that in this group, stable or increased HbA1c may be desirable if the primary goal is to prevent hypoglycaemia. Therefore, it could be argued

that effect on HbA1c is not the best metric to assess the utility of CGM in this population.

There are several studies which support the effect of CGM in reducing HbA1c in older patients both with type 1 and type 2 insulin-controlled diabetes. For instance, the WISDM RCT of 203 older adults (>60) with T1DM showed an adjusted HbA1c difference between the CGM and standard BCGM groups of – 0.3%, $p<0.001$ (in addition to a significant reduction in Time Below Range/ TBR) [29]. These findings held in the extension study, reporting increased TIR with CGM at 1 year after initiation of CGM (56% vs 64%, $p<0.001$) [30]. More importantly, in the WISDM trial, there was an adjusted treatment benefit of 27 min per day less in hypoglycaemia/below range in CGM ($p<0.001$), indicating strong evidence in reducing time in hypoglycaemia in older adults [29]. Moreover, these findings are significant as it is one of only two RCT of those identified which was not funded by a CGM manufacturer. A significant reduction in HbA1c has also been reported in real-world data of patients with T2DM, in addition to no significant difference between patients < 65 and > 65 in the context of both basal-bolus and basal-only insulin regimens [27, 31, 32]. In summary, CGM may have some benefit in reducing HbA1c, however a personalised approach should be taken for each patient to be supported to reach their management goals.

Despite identifying a number of well-designed larger trials in this area, it is essential to acknowledge that 13 of the 17 studies identified were funded by Dexcom or Abbott Diabetes Care, introducing a possible bias in results. Moreover, there may be an element of publication bias, with some companies less likely to publish studies which do not show convincing evidence for their product. It is important for this potential to be considered when critically appraising the data. Another potential limitation of the evidence is that the majority of trials were retrospective in nature, and patients did not undergo randomisation. However, of five RCTs, four showed a reduction in HbA1c, and three studies showed reduced TBR or increased TIR (one showed no significant difference and the other was not reported). Larger RCTs of CGM in older adults focusing on hypoglycaemia and related adverse events may aid in strengthening evidence for its wider application.

Reducing Hypoglycaemia and Adverse Events

The high prevalence and risk associated with hypoglycaemia in the elderly population is widely recognised in the literature, including the potential for increased risk of falls, cognitive impairment and reduced quality-of-life [3, 22]. Furthermore, episodes of hypoglycaemia overnight are common in this group, meaning that patients may not be able to respond appropriately to elevate their blood sugar [37]. CGM data of 134 patients from the HYPOAGE trial showed that despite only 40% of patients appearing to be over-treated based on their HbA1c, almost all patients exceeded the recommended time-below-range, suggesting that a large proportion of these patients may be over-treated based on our current model of care [38]. In addition to the significant risk of mortality in older adults presenting with severe hypoglycaemia, it has been associated with cognitive decline, frailty and poorer quality-of-life [3, 22, 39, 40]. Due to these potential acute and chronic effects of hypoglycaemia in this group, reducing hypoglycaemia remains a key aspect of diabetes care in older adults.

The evidence for CGM in reducing hypoglycaemia in older adults is compelling, with no studies to our knowledge showing a detrimental effect. A 2016 study comparing adults > 65 with type 1 or 2 diabetes on insulin showed a reduction in reported episodes of hypoglycaemia in adults initiated on CGM [24]. Furthermore, both the WISDM and REPLACE randomised controlled trial showed a significant reduction in hypoglycaemia/ 'time below range' at 6 and 12 months following CGM initiation, respectively [11, 30]. Of interest, the reduction in 'time below range' for the > 65 group in the REPLACE study was more marked than in < 65s (56% reduction compared to 35%)[9]. This may suggest that the utility of CGM in preventing severe hypoglycaemia in older adults could be even greater than in the general population.

In addition to reported and recorded hypoglycaemia, the literature suggests that CGM in older adults reduces hospital admissions related to acute diabetes-related events. A French study of over 38,000 people explored the potential benefit of CGM in adults over 65 with type 2 diabetes on intensive insulin therapy and showed a 34–40% reduction in admissions for adverse diabetic events in the year and two years following CGM initiation [35]. This was driven by a reduction in admissions for DKA at 1 year and severe hypoglycaemia at 2 years, illustrating a significant reduction in severe hypoglycaemia [35]. Furthermore, several large cohort studies in adults with diabetes have shown a benefit in reducing adverse diabetes-related events and hospitalisations with CGM which persists even in the older age group [10, 32]. These studies illustrate the utility of CGM in reducing diabetes-associated harm in older adults, and the importance of ensuring that they are not excluded from new advances in technology.

Quality-of-Life

Prior to the widespread use of CGM, the impact of regular blood glucose monitoring in patients with type 2 diabetes not on insulin was not clear, with one meta-analysis of 24 RCTs showing no overall long-term reduction HbA1c with standard blood glucose monitoring compared to a control group [41]. In addition to this, some studies suggested that regular blood glucose monitoring may lead to increased feelings of anxiety for patients [42, 43]. However, initial studies involving CGM suggest that it may actually improve quality-of-life and patient satisfaction and reduce anxiety around hypoglycaemia [9, 24]. A sub-group analysis of older adults with type 2 diabetes within a prospective multi-centre study showed that CGM was associated with increased patient satisfaction and reduction in perceived episodes of hypoglycaemia [9]. In a small prospective cohort study, older adults reported feeling safer while using CGM, and better sleep quality [28]. Improved sleep is of particular interest, given the emphasis on adequate sleep as a factor which may improve health outcomes and insulin sensitivity in the 2022 consensus on Type 2 Diabetes from the American Diabetes Association and the European Association for the Study of Diabetes [44, 45]. This illustrates the wider benefits that CGM may have for older people's physical and mental wellbeing and overall quality-of-life.

CGM in Older Adults on Basal-Only Insulin or Oral Hypoglycaemics

Although the majority of studies identified focused on older patients with diabetes on basal-bolus insulin, it is important to consider that there may be benefits for patients on basal-only insulin, or oral hypoglycaemic agents. A retrospective study and meta-analysis in North America demonstrated an improvement in HbA1c for adults with type 2 diabetes on basal insulin, which held across the age groups [46]. Furthermore, the MOBILE randomised controlled trials showed improved HbA1c and more importantly, time in range for adults using basal insulin [47]. Sub-group analysis of this trial confirmed that the glycaemic benefit held in adults over 65, and that the benefit in this group was at least as substantial as adults under 65 [31]. Of course, depending on the individual, a reduction in HbA1c may or may not be desirable. These findings suggest that CGM may benefit older adults on basal insulin, however, more research within this sub-group is required to confirm this.

There has been growing interest in use of CGM in non-insulin/oral hypoglycaemic agents. A meta-analysis of randomised controlled trials for patients with type 2 diabetes on non-insulin therapy concluded that CGM improved glycaemic control compared to standard glucose monitoring [37]. However, specific studies or sub-group analysis has not been performed for older adults on non-insulin therapy, meaning that the potential effects in this group are not yet known.

Cost-Effectiveness

There are a number of studies across Europe and North America which support the cost-effectiveness of CGM in adults on intensive insulin therapy in the general population [48–52]. This appears to be driven largely by a reduction in symptomatic DKA and hypoglycaemia, and

admissions for the same [52]. There is a paucity of evidence specifically on the cost-effectiveness of GCM in older people with diabetes, with only one study to our knowledge reported [53]. Munshi and colleagues (2024) report a further RCT of CGM in older adults which showed no impact on A1c but significant reduction in hypoglycaemia, reporting just a $3 cost per hypoglycaemic episode avoided [53]. This study was not included in our comparison of studies due to being unable to access the full article, however does begin to demonstrate cost-effectiveness in this group. More widely, the evidence suggests that CGM can lead to a reduction in hospitalisations for older adults with diabetes (especially for hypoglycaemia), which may further support the argument for cost-effectiveness, however more robust evidence is needed to confirm this [35].

Possible Barriers to CGM Use in Older Adults

There are several possible barriers for older people accessing CGM, including inequalities, familiarity/usability, cognitive co-morbidities and potential bias from healthcare professionals [54]. More generally, there are a number of possible challenges in widespread implementation of CGM, for example healthcare professional awareness/training, information technology systems and infrastructure and cost [55]. Indeed, these challenges may be more pronounced in resource-limited settings. Although the majority of CGM trials in the general population have been carried out in high-income countries, there is evidence for improving glycaemic control, adverse diabetic events and quality-of-life [56]. There are a number of possible challenges for low-to-middle-income countries in adopting CGM, including availability of healthcare staff, cost, technological literacy, access to the internet and in some instances, sociocultural beliefs regarding wearable technologies [57]. Aiming to overcome these challenges is a crucial area of work given that inequal access to diabetes technologies could further widen international healthcare inequalities if not addressed sufficiently.

A study of over 13,000 patients with type 1 diabetes in Germany found that CGM use was 28.2% among those over 80, compared to 75.3% among 18- to 25-year-olds [5]. Interestingly, they showed that several factors may increase CGM use, including female sex, those without a migration status and a variable relationship with deprivation [5]. Another study in England found that patients from the least deprived quintile were more likely to use CGM (67% vs 45%, $p<0.001$) and those of white or mixed ethnicity compared to black ethnicity (60% vs 40%, $p<0.001$) [58]. Furthermore, ethnicity and deprivation may play a crucial role in older adults' internet use for health information, with the least deprived white older adults at least 10 times more likely than the most deprived non-white older adults to use technology to access health information [59]. This illustrates that there may be a number of intersecting inequalities which may compound inequal access to diabetes technologies for older adults.

Some older adults may be less familiar with newer technologies, however we should not assume this to be the case, nor allow it to preclude older adults from accessing new technologies such as CGM. A mixed-methods study of 30 older adults with diabetes found CGM to be acceptable and usable with a compliance rate of 81% [38]. It has been suggested that targeted education for older adults may allow those who are less familiar with technology to access CGM [54, 60]. Interestingly, a small virtual study in the USA found that older adults achieved greater TIR following enhanced CGM education, however those > 65 years old required an average of 41 min appointment duration compared to those < 40 years old ($p<0.001$) [61]. This may suggest that appropriate understanding and education is possible in older adults, however, on a larger scale, more time and funding may be required to allow for older adults to fully access the benefits of CGM.

CGM in Cognitive Impairment

A large proportion of older adults with diabetes may have physical or mental co-morbidities such as visual or cognitive impairment which

could impact on their ability to self-manage their diabetes [62]. Diabetes is a well-recognised risk factor for developing cognitive impairment and up to 20% of patients with cognitive impairment also have diabetes [63]. In addition, this sub-group of older adults are at increased risk of severe hypoglycaemia, meaning that it is even more crucial to optimise therapy [21, 22]. An early feasibility study of older adults with diabetes using CGM showed that it was an acceptable intervention for them and/or their carers [64]. It is important to appreciate that CGM may allow for carers to 'monitor' the patient's blood glucose while allowing them to retain some autonomy over managing their condition [65]. However, there remains a paucity of high-quality, large-scale evidence on CGM use in cognitive impairment which is needed to improve patient care.

CGM Use in Long-Term Care

Around a quarter of care home residents are estimated to have diabetes, with diabetes being an independent risk factor for care home admission [2, 66]. In a blinded trial, CGM devices showed a very high prevalence of hypoglycaemia in care home residents, with 79% of patients with HbA1c > 8% experiencing at least one episode of hypoglycaemia [67]. This illustrates both the high prevalence of hypoglycaemia in this population but also the possible utility of CGM in early detection of hypoglycaemia and potentially avoiding more severe consequences such as falls, cognitive impairment and hypoglycaemic seizures. Nonetheless, it is important to appreciate that some staff in long-term care facilities may have limited knowledge or experience with diabetes and indeed with newer diabetes technologies. Further research is needed to fully delineate the safety and efficacy of CGM in the long-term care setting.

Guidelines and Recommendations

Current NICE guidance recommends considering CGM for all adults with type 1 diabetes and for selected adults with type 2 diabetes who are on more than one insulin injection per day [21]. NICE recommends CGM for adults with diabetes experiencing recurrent or severe hypoglycaemia, impaired hypoglycaemia awareness, disability meaning they are unable to self-monitor (including learning disability or cognitive impairment), or that they would be required to check their glucose over eight times per day [21]. The guidance does not yet cover all patients on basal-bolus insulin regimens, despite evidence for their benefit in improving HbA1c and reducing hypoglycaemia [8–11]. Health Technology Wales has recommended routine CGM for adults with diabetes who require insulin [68]. Although there are no specific recommendations for CGM in older people, they are in general at greater risk of hypoglycaemia than the general population which should be taken into account when applying the guidance, in addition to cognitive impairment/care requirements.

The American Association of Clinical Endocrinology recommends CGM for adults over 65 on intensive insulin due to the available evidence suggesting that it can reduce HbA1c, improve quality-of-life and reduce hypoglycaemia in older adults [69]. Furthermore, the American Diabetes Association recommends CGM for adults on basal-bolus or basal-only insulin, which more closely mirrors the benefits shown by the literature [70]. This extends to older adults, which they recommend CGM in patients with type 1 and 2 diabetes on insulin as a method of reducing hypoglycaemia [70]. The International Consensus on CGM recommends that CGM glycaemic metrics should be used in addition to HbA1c for patients on intensive insulin to help to achieve glycaemic targets, in particular for patients experiencing hypoglycaemia [71]. As discussed, the insights provided by CGM could act as a powerful tool in optimising diabetes care for older people, who are particularly prone to hypoglycaemia.

Key Research Priorities

- Determining the best measurement(s) for diabetes control in older adults and what role HbA1c should play in guiding therapy

- Setting realistic goals for older people with diabetes, including reduction of hypoglycaemia
- Utility of CGM for older adults on basal insulin/oral hypoglycaemics
- Potential use of CGM in long-term care facilities/by carers/in cognitive impairment

CONCLUSIONS

Treatment goals for older adults with diabetes should be personalised, with a focus on preventing hypoglycaemia and associated harm, especially in frailer patients. HbA1c accuracy may be reduced in older adults, in addition to the fact that a patient may have 'satisfactory' HbA1c with significant episodes of hypoglycaemia. CGM data from older adults has shown high TBR and significant hypoglycaemia, reflecting over-treatment in older adults with diabetes. HbA1c reduction should not always be seen as an improvement in glycaemic control and alternative measures of treatment success such as TIR should be considered. Arguably, the most important goal for older adults with diabetes is reducing hypoglycaemia, for which there is strong evidence for the use of CGM. There may also be wider benefits for overall wellbeing, sleep and quality-of-life. More research is needed to fully determine cost-effectiveness of CGM for older adults and its possible utility for older adults on basal insulin or oral hypoglycaemics. Given the strong evidence in reducing hypoglycaemia, CGM could prove to be a useful tool in reducing hypoglycaemia-associated harm in older adults.

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Declarations

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Ethical Approval. This article is based on previously conducted studies and contains no new studies with human participants or animals performed by any of the authors.

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