

# The impact of socioeconomic factors, social determinants, and ethnicity on the utilization of glucose sensor technology among persons with diabetes mellitus: a narrative review

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*Ther Adv Endocrinol Metab*

2024, Vol. 15: 1–13

DOI: 10.1177/  
20420188241236289

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**Abstract:** Continuous glucose monitoring (CGM) usage has been shown to improve disease outcomes in people living with diabetes by facilitating better glycemic management. However, previous research has suggested that access to these devices can be influenced by nonmedical factors such as socioeconomic status and ethnicity. It is critical that equitable access to CGM devices is ensured as people from those groups experience poorer diabetes-related health outcomes. In this narrative review, we provide an overview of the various healthcare systems worldwide and how socioeconomic status, social context, and ethnicity shape device usage and the associated health outcomes. In general, we found that having a lower socioeconomic status and belonging to an ethnic minority group negatively impact CGM usage. While financial means proved to be an important mediator in this process, it was not the sole driver as disparities persisted even after adjustment for factors such as income and insurance status. Recommendations to increase CGM usage for people of a lower socioeconomic status and ethnic minorities include increasing the availability of financial, administrative, and educational support, for both patients and healthcare providers. However, recommendations will vary due to local country-specific circumstances, such as reimbursement criteria and healthcare ecosystems.

## Plain language summary

### The effects of income, education, social factors and ethnicity on the use of glucose sensors by people with diabetes mellitus: a narrative review

Over the recent years, glucose sensors have transformed the monitoring of glucose levels in people with diabetes. However, access to these devices has been determined by the healthcare systems and the associated rules and regulations, as well as perceptions from providers and patients about who would benefit most from these devices. In this narrative review, we performed an expansive literature search into what is known about factors that negatively impact the access to glucose sensors, and how these factors might be addressed. From this, we learn that, depending on the healthcare system, financial means form a major driver behind the disparities in glucose sensor use. However, factors such as ethnicity and provider and patient perceptions also can negatively affect one's chances to obtain a glucose sensor. Furthermore, we found that a successful program aimed at resolving the found disparities in glucose sensor use must be multi-faceted, and must include measures aimed at financial support, the use of objective and simple criteria for sensor eligibility, as well as educational support for both patients and providers.

**Keywords:** CGM, ethnicity, socioeconomic status

Received: 19 June 2023; revised manuscript accepted: 8 February 2024.

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## Introduction

Over the past decades, technological innovations have dramatically altered the available treatment options for diabetes.<sup>1,2</sup> Continuous subcutaneous insulin infusion (CSII) has emerged as a viable alternative to multiple daily injections (MDI),<sup>3</sup> and the availability of continuous glucose monitoring (CGM) devices has done the same for capillary measurements.<sup>4</sup> In combination with glucose stabilizing algorithms, these technologies have led to the development of hybrid closed-loop systems, which utilize the continuous stream of data of the monitoring devices to titrate the continuous administration of insulin.<sup>5</sup> These CGM devices have been proven to be beneficial for both people with type 1<sup>6,7</sup> and type 2 diabetes.<sup>8</sup> In addition, it has been found that those with higher baseline HbA1c gain greater reductions of HbA1c once started on CGM technology.<sup>9</sup>

However, with the increase in options comes the question of who has access to them. It is known that access to diabetes care<sup>10</sup> and technology in general<sup>11</sup> is affected by factors such as socioeconomic status (SES) and ethnicity. SES is defined as a measure of one's combined economic and social standing,<sup>12</sup> and it is part of the social determinants of health (SDOH), which also include factors such as social context and physical environment.<sup>10</sup> There are multiple methods to quantify SES in research,<sup>13</sup> which typically include measures of income, education, and occupational social class. Lower SES has been associated with reduced access to healthcare<sup>14</sup> and greater mortality in general,<sup>15</sup> as well as for lower diabetes quality of care specifically.<sup>10</sup> The prevalence of type 2 diabetes is higher among persons with lower SES.<sup>10</sup> In addition, these people with diabetes and with lower SES suffer from lower attainment of treatment goals<sup>16–18</sup> and higher morbidity<sup>19,20</sup> and mortality.<sup>21–23</sup>

Ethnicity could also be a factor that further influences access to care as ethnic minorities have reported greater barriers to care,<sup>24</sup> and experience poorer health outcomes compared to the ethnic majority.<sup>19</sup> However, ethnic minorities can often also be of a lower SES, which may play a mediating role in the effects found.<sup>25,26</sup> Disentangling the confounding effects of SES on the relationship between SES and healthcare usage and outcomes can be a difficult process.<sup>27</sup> However, even if such adjustment takes place, disparities in access to diabetes treatment and outcomes

persist.<sup>16</sup> This shows it to be an independent factor, meriting specific attention.

Given the increasing use of CGM technology and the potential benefits for persons with DM,<sup>6,8,9,28</sup> understanding the factors that could hamper its widespread use is of importance. Considering that the evidence suggests that people with lower SES and/or belonging to an ethnic minority are disproportionately affected more by diabetes,<sup>10,16–22,29</sup> it would be logical to assume that this population would have a higher usage of CGM technology. Yet, access to CGM technology is lower for these groups<sup>10,11</sup> and as such, the population that stands to gain the most from CGM technology uses it the least. The first step to approaching this issue is identifying the underlying mechanism(s) and therefore, this review aims to provide an overview of the available literature and how these device-related inequalities might be addressed.

## Methods

A literature search of the PubMed and Embase databases was performed using the search strategy described in Supplemental Appendix A. The resulting studies were then reviewed for eligibility based on the following criteria:

- The study should mainly concern the access to, the use of, and/or the efficacy of CGM devices as affected by SES and/or ethnicity. Consequently, studies that focused mainly on the effects of insulin pumps, smart pens, and/or telehealth were excluded.
- Studies should be published after 2000, after the emergence of CGM technology.
- Studies should be written in English.

Where applicable, the reference lists of included studies were reviewed and included as per the above criteria. Furthermore, Google Scholar was used to find additional sources using the same search terms and restrictions indicated above.

Of the 1750 PubMed and 89 Embase results, 199 (193 PubMed and 6 Embase) remained after removing any duplicates and from the title and abstract screening. The remaining 64 results were selected for full-text review, and of which, 44 were selected for inclusion. A review of references revealed an additional eight studies suitable for inclusion. Data were extracted from these articles

and grouped per domain of SES (financial/occupational and education), social factors, and/or ethnicity. For the full results of this data extraction, please see Supplemental Appendix B.

### Current situation

Currently, the healthcare systems of most Western nations have adopted CGMs into their diabetes care. However, the regulations and protocols surrounding the prescription of these devices differ among them. These differences affect which parts of the population gain and maintain access to these devices upon introduction of these devices to the market, which will be discussed below.

#### United States of America

The United States of America (USA) utilizes a mixed healthcare insurance system, with publicly financed insurance in the form of Medicare (generally targeted at those > 65), Medicaid (targeted at those with limited incomes), and private insurance providers, which is often provided through employers.<sup>30</sup> Medicare reimburses CGM technology for patients with type 1 or type 2 diabetes with a need for frequent measurements of blood glucose levels and routine in-clinic visits.<sup>31</sup> Medicaid coverage is state dependent, with some offering no reimbursements or restricting them to specific patient populations.<sup>32</sup> If reimbursements are granted by either, deductibles and co-pay do still apply, with costs estimated at 50 dollars per month.<sup>33</sup> Coverage by private insurers varies per package but is estimated to cost between 10 and 75 dollars per month, in addition to normal insurance costs.<sup>34</sup> This interplay of requirements and costs has shaped the distribution of CGMs to patients, with those having lower SES being less likely to receive CGM treatment [odds ratio (OR) 0.48 between low *versus* high incomes<sup>35</sup>]. In addition, minorities, such as non-Hispanic Black and Hispanic patients, are less likely to receive CGMs (OR 0.40, OR 0.73 *versus* non-Hispanic White patients, respectively).<sup>35</sup>

#### Europe

CGM usage statistics have been documented in a variety of European countries. For instance, in Germany, the DPV registry was used to track CGM and insulin pump usage in a nationwide cohort.<sup>36</sup> Disparities in CGM usage were noted in 2016 [OR 1.85 (1.63–2.10), Q1 *versus* Q5 of

deprivation, according to the German Index of Multiple Deprivation 2016]. However, this disparity gradually decreased over the years and was no longer significant in 2019 [OR 0.97 (0.88–1.08)]. This was mainly due to a sharper increase in CGM usage in the lower SES quintiles than in the higher ones, which was attributed to the inclusion of various CGM devices in statutory health insurance plans. These plans fully reimburse the devices for those needing intensive treatment with insulin.<sup>37</sup> The contents of these plans are decided upon by the German government and cover 90% of the population.<sup>38</sup> The remainder are covered *via* private insurance that had reimbursed intermittent scanning continuous glucose monitor (is-CGM) devices ahead of national reimbursements.<sup>39</sup>

In England, the National Institute for Health and Care Excellence (NICE) evaluates the economics of reimbursing healthcare practices.<sup>39</sup> These evaluations are then formulated into guidelines, which are then implemented by the Integrated Care Systems.<sup>40</sup> Prior to reimbursement of is-CGMs, usage thereof was primarily restricted to the affluent, with 60.2% of users belonging to the least-deprived quintile, compared to 4.1% of the most deprived.<sup>41</sup> These disparities have lessened over the years but remain present.<sup>42,43</sup> Currently, real-time continuous glucose monitors (rt-CGMs) are reimbursed for type 1 patients and those with type 2 requiring intensive monitoring.<sup>44,45</sup>

In France, 99% of the population is covered *via* statutory health insurance, with is-CGMs being reimbursed as of 2017 for all insulin-dependent patients. A study running from 2017 to 2018 found no association of deprivation with CGM utilization, concluded to be due to the pervasiveness of the health insurance system.<sup>46</sup>

#### Australia

Australia introduced coverage of CGM devices into their universal Medicare insurance in 2017. This publicly funded governmental insurance scheme forms the basis of the healthcare system in Australia, which can be further augmented *via* private insurance.<sup>47</sup> A study comparing the situation prior to its introduction to 2 years thereafter found that CGM uptake had increased from 5% to 79%, which coincided with improved odds of attaining optimal glycemic regulation (HbA1c < 7.0%/53.0 mmol/mol, OR 2.5,  $p < 0.001$ ).<sup>48</sup> Factors regarding SES and ethnicity were not included in the study but assumed

to be of no relevance due to the universal nature of the reimbursements.

#### *Canada*

In Canada, CGM devices can be acquired *via* certain private-payer insurance, but publicly funded programs exist for certain patient populations on a province-by-province basis.<sup>49</sup> A study from Toronto found that rt-CGM utilization in the area differed significantly per deprivation quintile.<sup>50</sup> Those least deprived used rt-CGM significantly more than those most deprived (20.8% *versus* 12.9%). This difference was not found among is-CGM users, which was theorized to be due to the is-CGM being included in the regional public insurance scheme, whereas the rt-CGM was not. Rt-CGM had to then be acquired *via* either private insurance or self-funding, allowing for disparities in wealth to affect access.

#### **The influences of SES, social context, and ethnicity**

The effects of SES and ethnicity on healthcare access, and access to CGMs in particular, have become a topic of global interest. Several studies, mostly employing large, registry-based databases, clearly show the impact of SES on CGM utilization.<sup>51,52</sup> A transatlantic comparison study comparing the USA and the German registries for type 1 diabetes showed a clear gradient of CGM utilization across the SES quintiles, with the less affluent using fewer devices.<sup>53</sup> The gradient was more pronounced in the USA (slope 0.460,  $p < 0.001$ ) than in Germany (slope 0.068,  $p < 0.001$ ), most likely due to differences in healthcare systems and culture. Of note, the disparities in HbA1c, once corrected for technology usage, were less severe. This indicates that diabetes technology, such as CGMs, is a driver behind the disparities in treatment outcomes. This has been corroborated by other studies.<sup>35,54–57</sup> Another study calculated that 16.4% of the disparities in HbA1c between non-Hispanic Black and non-Hispanic White patients were due to differences in diabetes technology use (which includes CSII in addition to CGM) and 37.6% was due to SES factors.<sup>18</sup> Similarly, in Canada, it was reported that differences in rt-CGM utilization between SES quintiles accounted for 12% of the differences in HbA1c, after correction for age, gender, and disease duration.<sup>50</sup> Notably, the efficacy of CGM technology does not seem to be

affected by SES,<sup>43</sup> indicating that low SES is not a valid reason to withhold CGM technology.

In the above-mentioned studies, SES is often evaluated as a composite structure. This, by nature, obfuscates the impact of each subdomain of SES, that is, income, occupational, and educational domains, as well as the social context. Moreover, ethnicity is a factor of considerable importance, which is deeply intertwined with SES and SDOH.<sup>25</sup> As such, it will be discussed separately.

#### *Income and occupation*

A relationship between income, which is closely related to occupational status, and CGM use has often been reported, from the introduction of CGM devices,<sup>56</sup> to the present day,<sup>58</sup> in which those in high-income groups (>\$100,000 annually) are twice as likely to use a CGM than those in low-income groups (<\$25,000 annually). Similar patterns have been found across all ages<sup>59</sup> and cost is the most often cited barrier to the use of CGMs, by both patients<sup>60</sup> and providers,<sup>61</sup> in the USA and abroad.<sup>62</sup> An important factor regarding cost is the insurance status, with private insurance being a significant predictor of consistent CGM usage.<sup>63</sup> This was found to be in part mediated by prescription biases, as found by one study in a pediatric provider cohort<sup>64</sup> and another in both the pediatric and adult provider cohorts.<sup>65</sup> Both studies employed vignettes that differed in either public or private insurance status, and both found their cohort to be biased against public insurance (84.6% and 61% of the cohort, respectively). Both studies also found that longer practice duration resulted in a higher likelihood of bias. This was theorized to be due to an increasing number of past encounters with the cumbersome nature of acquiring coverage for individuals with public insurance, and as such, the practice-shaping effects of such restrictions. In Germany, France, and Australia, the inclusion of CGMs in universal healthcare plans correlated with large increases in usage, predominantly among those of lower SES.<sup>34,44,46</sup> In California, generous is-CGM reimbursement practices for their Medicaid recipients impacted disparities to such a degree that no significant differences in CGM utilization were found among the various ethnicities.<sup>66</sup>

#### *Education*

Higher levels of educational attainment are positively correlated with the odds of acquiring CGM

technology, independent of income and ethnicity.<sup>35,56,67,68</sup> This is attributed to the increased awareness of the various options regarding glucose management, heightened knowledge about their disease, and their knowledge of how to successfully navigate the bureaucratic landscape of insurance requirements. As part of elucidating the effects of educational attainment on CGM use, a focus group study revealed that biases on the part of endocrinologists (as reported by the recipients) were a significant mediator in this process.<sup>69</sup> The study targeted either recipients who were hospitalized for diabetic ketoacidosis in the previous year or had HbA1c > 9% (75 mmol/mol) and were recorded as having two or more consecutive 'no-shows' for endocrinology visits or received their primary care at a Federally Qualified Health Center, which provides care regardless of insurance status. Focus groups were led by trained faculty members with expertise in qualitative research, assisted by graduate assistants. Focus groups were conducted according to a semi-structured format, using a standard protocol script with open-ended questions regarding their diabetes technology use and resources. The found biases most often involved statements regarding the suitability of the participants for the use of CGM, stating that the technology would be too difficult for them to use, or that their glycemic regulation was too poor. This is reflected in another study, which found a marked discrepancy in barriers reported by endocrinologists and patients.<sup>70</sup> Whereas 40%–46% of endocrinologists endorsed the notion that the information provided by CGMs would be too difficult to understand, only 4.5% of patients agreed. If a provider perceives more barriers, they are naturally less inclined to prescribe CGMs.<sup>71</sup>

### *Social context*

While the effects of social context have been widely studied as a determinant of diabetes prevalence and outcomes,<sup>10</sup> it has been less studied regarding CGM adoption. Most CGM-focused studies have been based on SES. One part of the social context is elucidated in a study that found that among Hispanic patients, English speakers were less likely to use CGM and had higher HbA1c than their Spanish-speaking counterparts [33% *versus* 62%,  $p=0.002$ ,  $9.69\% \pm 2.22\%$  ( $82.4 \pm 24.3$  mmol/mol) *versus*  $8.49\% \pm 1.94\%$  ( $69.3 \pm 21.2$  mmol/mol),  $p=0.003$ , respectively].<sup>72</sup> These differences were theorized to be

because Spanish-speaking patients were often served by Spanish-speaking providers, eliminating the language barrier. Moreover, Spanish-speaking Hispanic people are more likely to have a stronger family support network and oversight. This highlights both the importance of a strong social structure and the role of the language barrier.

Negative perceptions also play a role in the adoption of CGM technology. It was found that non-Hispanic Black parents experienced that their children were treated differently for wearing CGM devices and being bullied for it.<sup>73</sup> In addition, non-Hispanic Black parents reported higher levels of shame regarding the diagnosis of diabetes and being judged for having a child with the disease. It would be said that the disease, T1D in this case, was the consequence of a faulty lifestyle, even if this belief is untrue. This combination of factors makes non-Hispanic Black parents more likely to want to cover up the fact that their child has diabetes, thus avoiding any outward signs thereof, such as CGMs.

### *Ethnicity*

In the USA, after correction for SES and diabetes care factors, CGM utilization differed according to ethnicity, with non-Hispanic Black persons utilizing fewer CGMs than non-Hispanic White and Hispanic persons (31% *versus* 53% *versus* 58%).<sup>18</sup> Similar results were found by other studies, in the USA,<sup>57,58,67,74–76</sup> and abroad.<sup>42</sup> In Germany, after the inclusion of CGM devices in the statutory healthcare plans, the effect of a migration background (a proxy for ethnicity) on CGM utilization decreased but did not disappear (OR 1.79 prior, OR 1.30 after).<sup>36</sup> This indicates that cultural and language barriers do remain and should be addressed separately. These ethnic disparities might be mediated by prescriber biases. One study found that non-Hispanic Black persons were less likely to have documented discussions about CGM initiation (OR 0.41, 0.29–0.90) and CGM prescriptions (OR 0.61, 0.41–0.93), even after adjustment for SES and clinic attendance.<sup>77</sup> A similar pattern was found in another study.<sup>78</sup> In addition, they also found higher rates of discontinuation among non-Hispanic Black children. After correction for insurance type, age at diagnosis, and sex, non-Hispanic White children were 3.9 (2.2–6.9) times as likely to continue CGM use 1 year after diagnosis. As such, not only are ethnic minorities less likely to be initiated on CGMs but they are also

less likely to continue it once attained. The lower prescription rate could be indicative of the use of subjective criteria and the presence of implicit biases in offering CGMs to ethnic minorities, which was also found by Howe *et al.*<sup>73</sup> They found that the argument of needing to have stable blood glucose levels prior to initiation was often used in communication with non-Hispanic Black parents, whereas it was not with non-Hispanic White parents. In addition, Agarwal *et al.*<sup>79</sup> found that providers often played the role of gatekeeper, with some participants (either non-Hispanic Black or Hispanic) only learning about the existence of these technologies once participating in the study. Other participants stated the same experiences as those found by Howe *et al.*<sup>73</sup> The lower continuation rate could be due to issues with the support systems surrounding CGM use or due to changes in reimbursement eligibility. The presence of implicit bias was further investigated in a vignette study, in which the patients had different names, which demonstrated the presence of ethnic bias in 34% of the provider cohort.<sup>65</sup> This needs to be addressed to ensure equitable access to optimal care.

### Recommendations

All the included studies demonstrate that the effects of SES, social context, and ethnicity on the utilization of CGMs are multi-faceted. As such, any attempt at remedying these disparities must be equally multi-faceted. It appears that the main driver behind the disparities in CGM utilization is household income, either measured directly or *via* proxy (such as insurance status).<sup>55,57,58,67</sup> These disparities differed in degree between countries, depending on the construction of their healthcare system. It was present even in those countries with socialized healthcare, with the impact being lessened in those with more generous reimbursement practices. Expanding reimbursement coverage has then been argued to decrease disparities in CGM access.<sup>80</sup> In practice, addressing this aspect has been found to significantly increase CGM utilization in the lower SES quintiles. In Germany<sup>36</sup> and Australia,<sup>48</sup> this has been achieved *via* the inclusion of the CGMs into the preexisting universal healthcare structures. In California, USA, a similar structure was introduced, which provided is-CGM devices with a \$0 co-pay for all Medicaid recipients.<sup>66</sup> This was found to have equalized CGM uptake among ethnicities; however, large 95% CI intervals remained. This could indicate that, while generous reimbursement practices could go a long

way in addressing disparities, it is possible that it may not wholly negate disparities.

Other studies have also found a reduction in disparities but not total negation after expanding reimbursement practices.<sup>36</sup> Supporting this, other studies have found evidence of prescription biases that extend beyond that of insurance eligibility. One such study found that non-Hispanic Black children were less likely to use CGMs compared to non-Hispanic White children in both the publicly and commercially insured populations.<sup>81</sup> In addition, not all cost-related barriers are necessarily related to the reimbursement of the devices to the patients. They also manifest as opportunity costs, for instance as a lack of training resources and staff and the allotted time for reviewing CGM data being inadequate, as reported by both Kompala *et al.*<sup>61</sup> and Rosenfeld *et al.*<sup>82</sup> In addition, improvements in 'CGM infrastructure' are also needed, as the time between the prescription of CGMs and receiving them is long, namely 152 days on average when prescribed through a commercial provider.<sup>83</sup> This is reported to be mostly due to the administrative burden and the need to resubmit documentation for the eligibility of the CGMs.<sup>84</sup>

Behavioral barriers also need to be addressed. For instance, the provider could suffer from implicit biases against ethnic minorities or those of lower SES.<sup>64,65</sup> This could be addressed *via* bias prevention training but it might be more effective to further enforce the use of objective criteria, circumventing subjective bias entirely. Such criteria could also be embedded within the previously mentioned streamlining of the prescription process.

The higher rate of discontinuations can be addressed by offering specialized programs, which can be fine-tuned to the needs of the population.<sup>78</sup> One instance of this was the CGM Time-In-Range program in California, which, prior to the reimbursement changes, provided additional aid for navigating the insurance system and CGM usage.<sup>85</sup> In all six reported cases, this resulted in improved glycemic regulation and sustained, effective use of CGMs. This is further a study that reported that offering CGM education prior to prescription impressively increases the odds of CGM initiation (OR 12.29, 95% CI 5.57–27.10).<sup>83</sup> Another successful showcase is reported on by Schmitt *et al.*<sup>86</sup> They used stakeholder interviews to identify problem areas and then implemented measures to

address these issues. These were summarized and addressed as follows:

1. Increasing provider awareness of CGM coverage, benefits, and disparities in access.
  - a. Solution 1: Providing summary documents of CGM devices and insurance criteria, supported *via* education during meetings as needed.
  - b. Solution 2: Providing providers with weekly analysis of their scheduled T1D patient contacts, assessing them for T1D high-risk status (HbA1c > 9%/74.9 mmol/mol) and CGM access (at least one document instance of CGM use, past or present). Subsequent updates also provided statistics concerning their patient's CGM access relative to the clinic average.
  - c. Solution 3: Providing patients questionnaires aimed at identifying strong and weak points regarding their diabetes regulation, as well as possible solutions.
2. Provide CGM sampling opportunities.
  - a. Solution: Having single-use professional and personal CGMs available at the clinic for distribution. These could immediately be provided to the patient as needed.
3. Advocate for CGM coverage criteria simplification of the publicly insured.
  - a. Solution: Contacted the Alabama Medicaid commissioner to remove the requirement of two documented episodes of hypoglycemia in a 4-week period. This was successful.

While the combined implementation of these measures prevents us from assessing which measure is the most effective, its combined effects cannot be understated. Overall CGM access increased from 50% to 82% over the 13-month period, with high-risk patients specifically increasing from 34% to 85%, non-Hispanic Black from 27% to 81% (for comparison, non-Hispanic White patients achieved 86%), and publicly insured from 25% to 78%. It can be argued that this is simply the result of natural progression, as some increase in access was already present before the introduction of these measures. However, strong and persistent stepwise increases in access were seen after each subsequent introduction of a measure, making it more likely that it was the measures that improved access. This program matches the barriers identified *via* group interviews.<sup>87</sup> In addition, the same study also found a

need for enhanced low-literacy and peer-to-peer support. A comparable program was implemented by Mathias *et al.*<sup>88</sup> This program included the formation of specialty clinics, the inclusion of social need-trained practice nurses in that clinic, additional CGM training for the staff, including bias training, and streamlining CGM prescription workflow. After implementation, CGM prescription rates increased from 15% to 69% over the 3-year period, which was more than national prescription rates, with all ethnicities enjoying equal increases.

In summary, a successful CGM access program would need to contain multiple forms of support:

1. Financial support: Ensuring that all those who need CGMs can financially afford them. This can be achieved by eliminating factors such as co-pay.
2. Objective criteria: The utilization and enforcement of objective criteria, rather than subjective criteria, could further reduce SES and ethnic disparities. Ideally, those criteria should be based on measurements already collected as part of routine care, so as not to place any additional burdens on healthcare providers and to streamline auditing of those criteria. Galindo *et al.*<sup>89</sup> provide guidance on which criteria would be suitable, which are in line with statements from the American Diabetes Association<sup>90</sup> and the American Association of Clinical Endocrinology,<sup>91</sup> namely one of the following:
  - a. Diagnosed type 1 diabetes.
  - b. Diagnosed type 2 diabetes treated with any kind of insulin.
  - c. Diagnosed type 2 diabetes and problematic hypoglycemia, documented *via* either capillary blood glucose monitoring (BGM) professional CGM or self-reported incidence and severity, defined as either:
    - At least seven level 2 (moderate) hypoglycemic events (glucose  $\leq$  3.0 mmol/L or 54 mg/dL) over the prior 30-day period.
    - At least one level 3 (severe) hypoglycemic event (hypoglycemia requiring third-party intervention due to physical or mental dysfunction of the patient) over the prior 30-day period.
 In all cases, the initiation of CGM devices should both be preceded and

followed up upon with regular consultations from the prescribing provider (for instance, every 6 months), either in-person or *via* telemedicine, to ensure proper utilization of the device.

3. Bureaucratic support: The paperwork surrounding attaining CGMs is often reported as onerous, often based on the need to document a proven need for the devices, and efforts to streamline this process have proven effective. One method of doing this would be providing simple checklists based on the aforementioned criteria as sufficient proof. This could be further strengthened by providing support staffing and documentation.
4. Educational support (for providers): Improving familiarity with CGMs and associated practices will better enable providers to use them efficiently, thus increasing the likelihood of prescription and decreasing workload. In addition, the inclusion of anti-bias training could further reduce disparities. Examples of such programs are provided by Mathias *et al.*<sup>88</sup> and Schmitt *et al.*<sup>86</sup>
5. Educational support (for patients): Providing tailored education opportunities, incorporating cultural and language differences, can further enhance CGM attainment and retention. Including features such as CGM sampling opportunities, peer-to-peer support networks, trained social need specialists, and tools for handling diabetes stigma will be necessary for forming a robust training program.

A combination of the above could form the basis for successfully eliminating SDOH-related and ethnic disparities. Which combination of these suggestions is most suited for implementation is dependent upon the local circumstances and needs of the population of that country or region. For instance, in countries where the income of the patient is more impactful for the quality of care, such as those where people are predominantly privately insured, financial support would be of great importance. In countries with more socialized systems of healthcare, educational support could be more impactful.

It should be noted that the majority of the collected evidence in this review stems from research originating from the USA. This may restrict the relevance of the findings and recommendations provided in this review to countries beyond the

USA. Nevertheless, the results of studies conducted in Europe and Oceania, which are also incorporated into this review, underscore that the issues described are not exclusive to the USA. Furthermore, the comparison of various health systems in this article, and the fact that disparities persist across this system, shows that there is no 'silver bullet' for remedying disparities, but rather, that there is a need for a multi-faceted approach. Therefore, we argue that by tailoring CGM access programs to the specific requirements of each local population, there is a real opportunity to enhance the adoption of CGM technology and consequently enhance diabetes care in these diverse regions.

### Declarations

*Ethics approval and consent to participate*  
Not applicable.

*Consent for publication*  
Not applicable.

### Author contributions

**Riener A. Been:** Investigation; Methodology; Resources; Writing – original draft.

**Annel Lameijer:** Writing – review & editing.

**Reinold O. B. Gans:** Supervision; Writing – review & editing.

**André P. van Beek:** Supervision; Writing – review & editing.

**Andrew P. Kingsnorth:** Writing – review & editing.

**Pratik Choudhary:** Writing – review & editing.

**Peter R. van Dijk:** Conceptualization; Supervision; Writing – review & editing.

### Acknowledgements

The authors want to thank S. van der Werf, the librarian, for her help in formulating the search strategy.

### Funding

The authors disclosed receipt of the following financial support for the research, authorship, and/or publication of this article: P.C. and P.R.v.D. are funded by an unrestricted educational grant from the European Foundation for the Study of Diabetes (EFSD) mentorship program supported by AstraZeneca.



### Competing interests

The authors declare that there is no conflict of interest.

### Availability of data and materials

All data and materials are publicly available online.

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### Supplemental material

Supplemental material for this article is available online.

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