Clinical Features of Type 1 Diabetes in Older Adults and the Impact of Intermittently Scanned Continuous Glucose Monitoring (isCGM): Association of British Clinical Diabetologists Study

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Abstract

Background and aims: The study evaluated the clinical features and impact of flash glucose monitoring in older adults with type 1 diabetes (T1D) across Young-Old, Middle-Old, and Old-Old Age Groups.

Materials and methods: Clinicians were invited to submit anonymised isCGM user data to a secure web-based tool within the National Health Service secure network. We collected baseline data before isCGM initiation, such as demographics, HbA1c values from the previous 12 months, Gold score and Diabetes Distress Scale (DDS2) score. For analysis, people with diabetes were classified as Young-Old (65-75y), Middle-Old(>75-85y) and Old-Old (>85y). We compared the baseline clinical characteristics across the age categories using a t-test. All the analyses were done in R 4.1.2.

Results: The study involved 1171 people with diabetes in the Young-Old group, 374 in the Middle-Old group, and 47 in the Old-Old group. There were no significant differences in baseline HbA1c and DDS2 among young-old, middle-old, and Old-Old age groups. However, Gold score, increased with age (3.20 (±1.91) in Young-Old vs 3.46 (±1.94) in Middle-Old vs 4.05 (±2.28) in Old-Old P-value<0.0001). This study showed reduced uptake of insulin pumps (P=0.005) and structured education (P=0.007) in Middle-Old and Old-Old populations compared to the Young-Old population with type 1 diabetes. With median isCGM use of 7 months, there was a significant improvement in HbA1c in the Young-Old(P<0.001) and Old-Old, but not in Middle-Old group. Diabetes-related distress score improved in all three age groups (P<0.001) and Gold score improved (P<0.001) in Young-Old and Old-Old people but not in the Middle-Old population. There was also a significant improvement in resource utilization across the three age categories following the use of isCGM.

Conclusion: This study demonstrated significant differences in hypoglycaemia awareness and insulin pump use across the older age groups of adults with type 1 diabetes. The implementation of isCGM demonstrated significant improvements in HbA1c, diabetes-related distress, hypoglycaemia unawareness, and resource utilization across in older adults with T1D.

Introduction

Type 1 diabetes (T1D) is a chronic autoimmune disease that affects individuals of all age groups, including older adults[1-4]. However, the clinical features and management of T1D in older adults can differ from younger age groups due to various physiological, cognitive, and psychosocial factors[3,5]. Older adults with T1D may experience unique challenges related to glycaemic control, hypoglycemia awareness, diabetes distress, and functional limitations[3]. Therefore, understanding the clinical features and management strategies for T1D in older adults is crucial for providing optimal care to this population.

In recent years, intermittently scanned continuous glucose monitoring (isCGM) has emerged as a valuable tool for glycaemic management in T1D[6-11]. IsCGM allows for real-time monitoring of glucose levels through a small sensor inserted under the skin, providing glucose readings at regular intervals without the need for frequent fingerstick blood glucose monitoring. IsCGM has been shown to improve glycemic control, reduce hypoglycemic events, and enhance the quality of life in individuals with T1D[6-9,11]. Nevertheless, research on the impact of isCGM in older adults with T1D, especially in distinct age groups within the older adult population, remains scarce.

Therefore, the aim of this study is to evaluate the clinical features of T1D in older adults and assess the impact of isCGM in different age groups, including Young-Old (65-75 years), Middle-Old(>75-85 years), and Old-Old (>85 years) individuals. By examining the clinical characteristics and outcomes of isCGM use in older adults, this study aims to contribute to the understanding of how isCGM can be utilised in managing type 1 diabetes in these populations.

Methods

In this observational study, data were used from the nationwide Association of British Clinical Diabetologists (ABCD) audit on FreeStyle Libre[6], which was initiated in November 2017. Data was collected through paper forms completed at baseline and follow-up clinic visits and entered into a secure online NHS tool. Baseline data included patient demographics, history of structured diabetes education, duration of diabetes, use of continuous subcutaneous insulin infusion (CSII), Body Mass Index (BMI), HbA1c values from the previous 12 months, Gold score, Diabetes Distress Scale (DDS2), severe hypoglycaemia events, paramedic callouts, and hospital admissions due to hypoglycaemia and diabetic ketoacidosis (DKA) in the previous 12 months. The Gold score[12] is a validated screening tool to assess awareness of hypoglycemia, rated on a 7-point Likert scale, with one indicating "always aware" and seven indicating "never aware". A score of ≥4 indicates impaired awareness of hypoglycaemia (IAH). Diabetes-related distress was measured using the two-item diabetes distress screening tool (DDS2)[13]. An average score of DDS1 and DDS2 was calculated, with a score of ≥3 classified as "moderate diabetes-related distress" and an average score of <3 considered as "low distress". Follow-up variables included Gold score, HbA1c, DDS2, BMI, severe hypoglycaemic events, paramedic callouts, and hospital admissions due to hypoglycaemia done as a part of routine follow-up in the UK.

Ethical approval

The ABCD nationwide audit program has Caldicott Guardian approval. Anonymised data were collected during routine clinical care at participating centres.

Statistical analysis

We categorised the study participants into Young-Old (65-75 years), Middle-Old (>75-85 years), and Old-Old (>85 years) categories[14,15]. The χ^2 test of association was used to compare categorical data, the Mann-Whitney U test for non-parametric continuous data and the independent t-test for continuous parametric data. Paired t-test was used for paired data. Statistical analysis was conducted using R 4.3.1 (https://www.r-project.org/)

Results

Table 1 shows the demographic characteristics of the study population across the three age categories. The study consisted of 1171 people with T1D in the Young-Old category, 324 people in the Middle-Old category, and 47 people with type 1 diabetes in the Old-Old category. There were no significant differences in HbA1c and diabetes-related distress across the three age categories at baseline. The mean Gold score increased significantly with age categories ($P<0.0001$), with the lowest in the Young-Old group at 3.20 (±1.91) followed by 3.46 (±1.94) in the Middle-Old group and highest in the Old-Old group at 4.05 (±2.28). BMI, on the other hand, decreased significantly with age categories ($P<0.0001$), with the highest in the Young-Old group at 26.2 (±5.91) followed by 25.1 (±5.44) in the Middle-Old group and lowest in the Old-Old group at 24.7 (3.28). The use of an insulin pump decreased with increasing age ($P=0.005$), with highest use in the Young-Old population (12%), followed by the Middle-Old (6%) and then Old-Old population (4%). Similarly, the uptake of DAFNE education was highest in Young-Old population (31%), followed by Middle-Old (25%) and Old-Old population (14%) ($P=0.007$).

With the use of isCGM, the time in range achieved was similar across the three age categories, 50.7 (±19.6) vs 46.7 (±22.4) vs 57.1(±17.4) with a similar mean number of isCGM scans per day (n=12 in Young-Old and Middle-Old and n=13 in Old-Old).

Table 2 compares glycaemic control, Gold score and diabetes-related distress across the three age categories in those with paired baseline and follow-up data. Follow-up data were available for 47.7% in Young-Old , 43.8% in Middle-Old and 47.8% in Old-Old population with T1D.

The mean duration of follow-up following the initiation of isCGM was seven months. There was a significant improvement in the HbA1c in the Young-Old group (64.9 (±13.5) vs 61.0 (±11.7) mmol/mol P<0.0001) and Old-Old population (65.6 (±15.6) vs 59.2 (±9.6) mmol/mol P=0.03); however, there were no significant changes in the HbA1c in the Middle-Old population ((65.2 (±13.3) vs 64.2 (±13.3) mmol/mol P=0.45). There was an improvement in DDS2 in all groups: Young-Old (2.55 (±1.24) vs 1.91 (±0.95) P<0.0001), Middle-Old(2.56 (±1.24) vs 2.03 (±1.05), P<0.001) and Old-Old (2.43 (±1.25) vs 1.75 (±0.68), P=0.01). There was also a significant reduction in the proportion of people with moderate-to-severe diabetes related distress at follow-up in the Young-Old (32% vs 13% P<0.001), Middle-Old (37% vs 18% P<0.001), and Old-Old populations (27% vs 4% P<0.01) **(Figure 1)**. Furthermore there was a significant improvement in the Gold score in Young-Old(3.20 (±1.91) vs 2.62 (±1.70) P<0001), and Old-Old (4.05 (±2.28) vs 2.67 (±1.71) P=0.01) but not in Middle-Old(3.46 (±1.94) vs 3.05 (1.99) P=0.06) population (or group) with . This therefore translates into a significant reduction in impaired awareness of hypoglycaemia in young- old (40% vs 25%) and Middle-Old (50% vs 35%) and Old-Old (40% vs 30%) people living with T1D **(Figure 1).** During the seven-month follow-up period, as compared to the baseline data from a 12-month period, there was reduction in the occurrence of severe hypoglycemia in both the Young-Old (1.34 (±5.25) vs. 0.19 (±1.84), P<0.0001) and middle-old (2.78 (±12) vs. 0.11 (±0.50), P<0.0001) individuals with T1D. However, no significant improvement was observed in the Old-Old population with T1D.

Figure 2 shows the effect of isCGM on hypoglycaemia and hyperglycaemia-related admissions and paramedic out-calls. The figure compares resource utilisation one year prior to the initiation of isCGM with seven months after the initiation of isCGM. With the initiation of isCGM there was a reduction in hypoglycaemia-related admissions, hyperglycaemia/DKA-related admissions and paramedic outcalls in the young-old, Middle-Old and Old-Old populations.

Discussion

To the best of our knowledge, this is the first study looking at glycaemic control, diabetes-related distress, hypoglycaemia awareness across the Young-Old, Middle-Old, and Old-Old populations living with type 1 diabetes and the effect of isCGM in these subgroups. This study in older people with type 1 diabetes demonstrates improvements in glycaemic control, hypoglycaemia awareness and diabetes-related distress in Young-Old and Old-Old populations with type 1 diabetes. In the Middle -Old group there was a significant improvement in diabetes-related distress with a non-significant trend to improvements in HbA1c and Gold score. Overall, the adoption of isCGM was associated with notable improvements in glycaemic control, diabetes-related distress and hypoglycaemia awareness across all old-age categories.

In this study, our baseline data shows that glycaemic control and diabetes-related distress were comparable in the Young-Old, Middle-Old, and Old-Old people living with diabetes. It is likely that older individuals with diabetes have gained more experience in managing their condition over time and developed effective self-management skills leading to better adaptation and coping strategies. Additionally, it is worth considering that the observed comparability in glycaemic control and diabetes-related distress among the young-old, middle-old, and Old-Old populations living with diabetes might be influenced by survivor bias. It is plausible that individuals who were more susceptible to higher HbA1c levels may not have survived to reach the age of 65 years, and consequently, are under-represented in this study. The prevalence of diabetes-related distress was similar across the three age categories. However, up to one-third of people in these age categories had moderate to severe diabetes-related distress; the prevalence of diabetes-related distress more than halved following isCGM initiation.

Technology uptake is typically lower in older adults[16] ; however, our data suggest they derive similar benefits to younger cohorts. Age should be no barrier to technology access in people living with Type 1 diabetes.

In our study investigating hypoglycaemia unawareness in older adults with T1D we observed that the mean Gold score (a measure used to assess hypoglycaemia unawareness) was higher in Middle-Old and Old-Old adults when compared to Young-Old adults. We show that approximately 45 to 52% of people with type 1 diabetes in the Middle-Old and Old-Old age groups had impaired awareness of hypoglycaemia. This is higher than previously reported incidence of impaired awareness of hypoglycaemia in people with T1D[6,9,17]. This is likely because individuals in the Middle-Old and Old-Old age categories with T1D often have long-standing type 1 diabetes, a recognised risk factor for impaired awareness of hypoglycaemia. Older adults with type 1 diabetes can be more susceptible to falls, incontinence, frailty, cognitive impairment, and depressive symptoms[18], and the presence of impaired awareness of hypoglycaemia can potentially contribute to these issues[19]. Understanding the link between hypoglycaemia unawareness and these geriatric conditions is crucial for providing better care to older adults with type 1 diabetes.

In this study, we assessed the impact of isCGM on older adults with Type 1 diabetes. Encouragingly, our findings reveal that participants within the young-old, middle-old, and Old-Old subgroups displayed effective engagement with isCGM, as evidenced by a comparable number of scans conducted per day and achieved similar time in range. Our findings align with our previous work[6-9] and corroborate existing literature[20,21] , indicating that the implementation of isCGM is associated with enhanced glycaemic control in individuals with Type 1 diabetes. Nonetheless, our analyses demonstrate that the improvement in glycaemic control within these age categories was modest. This observation is likely attributable to the lower baseline (pre-isCGM) HbA1c levels observed in older adults, a critical determinant influencing the extent of

HbA1c reduction with isCGM usage[6]. Furthermore, we substantiate the favourable impact of isCGM on addressing hypoglycaemia unawareness and diabetes-related distress across all subgroups of older adults with Type 1 diabetes, except for Gold score in the Old-Old population, where no significant improvement was noted.

Another finding of this study was the limited uptake of insulin pumps and structured education in people living with type 1 diabetes in Middle-Old and Old-Old populations with type 1 diabetes as compared to the Young-Old population. It is possible that older adults with type 1 diabetes face challenges[16] in adapting to and using insulin pump technology due to limited experience with digital devices, unfamiliarity with new technology, comorbidities affecting eyesight, dexterity, cognitive function and possibly healthcare professional bias. Given the potential glycaemic and psychosocial benefits, healthcare professionals need to work to ensure equitable access to all diabetes technologies.

We conducted a comprehensive investigation into the impact of isCGM on resource utilisation in older individuals with type 1 diabetes. Building upon prior studies, which have demonstrated a decrease in hypoglycaemia and hyperglycemia-related hospital admissions and paramedic out-calls with the implementation of isCGM, we sought to extend these findings to encompass the entire spectrum of older age groups. The beneficial effect on hypoglycaemia in older people with Type 1 diabetes is in agreement with a study in people with type 1 diabetes more than 60 years old, which showed that continuous glucose monitoring compared with standard blood glucose monitoring resulted in a significant improvement in hypoglycaemia over six months[22,23]. The findings of our study are also in agreement with the study involving a French national database which showed isCGM can reduce hospitalization for acute diabetes events, such as diabetic ketoacidosis, in an older population of adults (>65 years of age) with type 1 diabetes and older persons with type 2 diabetes on intensive insulin therapy[24] .

The strengths of our study are the insight into numerous, notable benefits observed across the young-old, middle-old, and Old-Old populations living with type 1 diabetes who are initiated on isCGM. By analysing resource utilisation patterns in these age groups, we provide valuable insights into the broader applicability and effectiveness of isCGM as a crucial tool in improving resource utilisation among older individuals. Our study had several limitations. Firstly, the lack of a control group for comparison makes it challenging to ascertain the specific impact of isCGM on hypoglycaemia awareness, diabetes distress and resource utilisation in older individuals with type 1 diabetes. Additionally, the cross-sectional design limits our ability to establish causality between isCGM use and the observed improvements in glycaemic control, diabetes-related distress, and hypoglycaemia awareness. A longitudinal study design would provide more robust evidence regarding the long-term effects of isCGM in this population. Furthermore, the sample size for each age category might not be large enough to detect more subtle differences between subgroups. Finally, our study had a median follow-up period of 7 months, and it remains to be seen if the beneficial effect of isCGM in older adults persists for a longer period. Despite these limitations, our study contributes valuable insights into the benefits of isCGM in older individuals with type 1 diabetes, highlighting the need for further research in this area to enhance diabetes management and overall patient outcomes.

To summarise, we show a high prevalence of impaired awareness of hypoglycaemia and diabetes-related distress in older adults living with diabetes, emphasising the need for targeted interventions in these age groups. We also show that adopting isCGM led to improvements in glycaemic control, diabetes-related distress, and hypoglycaemia awareness across the young-old, middle-old, and Old-Old populations. Further research with longitudinal designs and larger samples is necessary to validate these findings and explore long-term effects.

Table 1: Baseline demographic characteristics of people with Type 1 diabetes in the Young-Old, Middle-Old, and Old-Old subgroups

	Young-Old(N=1171)	Middle-Old(N=324)	Old-Old (N=47)	p-value
Duration of Diabetes (years)	34.5 (±17.2)	38.0 (±18.2)	43.6 (±18.3)	<0.0001
Gender (%Female)	515 (43%)	153 (47%)	15 (31%)	0.12
Ethnicity				
Caucasian	974 (83%)	277 (85%)	37 (78%)	0.22
Others	197 (175)	47 (15%)	10 (22%)	
Baseline HbA1c (mmol/mol)	64.9 (±13.5)	65.2 (±13.2)	65.6 (±15.6)	0.90
Baseline DDS2	2.55(±1.24)	2.56(±1.24)	2.43 (±1.25)	0.83
Baseline BMI (kg/m^2)	26.2 (±5.91)	25.1 (±5.44)	24.7 (±3.28)	0.01
Gold Score	3.20 (±1.91)	3.46 (±1.94)	4.05 (±2.28)	0.005
Insulin pump use (yes %)	147 (12%)	18 (6%)	2 (4%)	0.005
DAFNE	366 (31%)	81 (25%)	7 (14%)	0.007

DDS2: Diabetes Distress Score

Table 2: Effect of isCGM on HbA1c, hypoglycaemia unawareness and Diabetes-related distress across the young-old, Middle-Old and Old-Old people with type 1 diabetes

	Young-Old(n=559)			Middle-Old(n=142)			Old-Old (n=22)		
	Baseline	Follow-up	P-value	Baseline	Follow-up	P-value	Baseline	Follow-up	P-value
HbA1c (mmol/mol)	64.9 (±13.5)	61.0 (±11.7)	**<0.0001**	65.2 (±13.3)	64.2 (±13.3)	0.45	65.6 (±15.6)	59.2 (±9.6)	**0.03**
DDS2	2.55 (±1.24)	1.91 (±0.95)	**<0.0001**	2.56 (±1.24)	2.03 (±1.05)	**<0.0001**	2.43 (±1.25)	1.75 (±0.68)	**0.01**
Gold score	3.20 (±1.91)	2.62 (±1.70)	**<0.0001**	3.46 (±1.94)	3.05 (1.99)	0.06	4.05 (±2.28)	2.67 (1.71)	**0.01**

DDS2: Diabetes-related distress scoring scale; Gold score: Score to measure hypoglycaemia unawareness

Figure 1: Gold score and DDS2 pre and post isCGM in people with type 1 diabetes

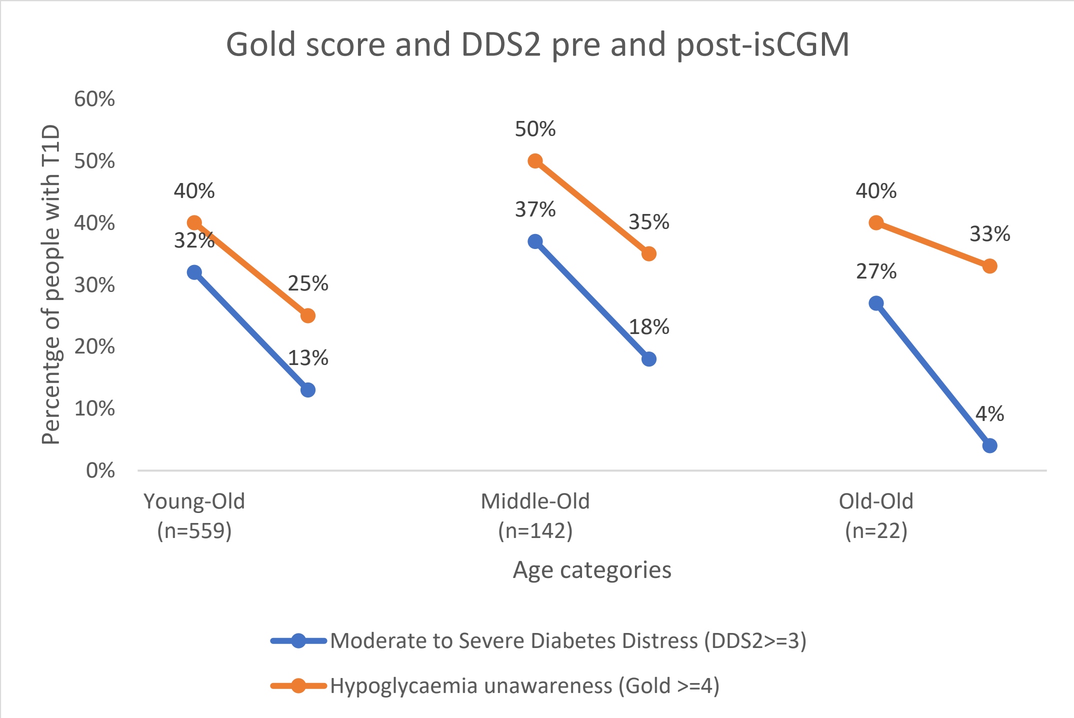
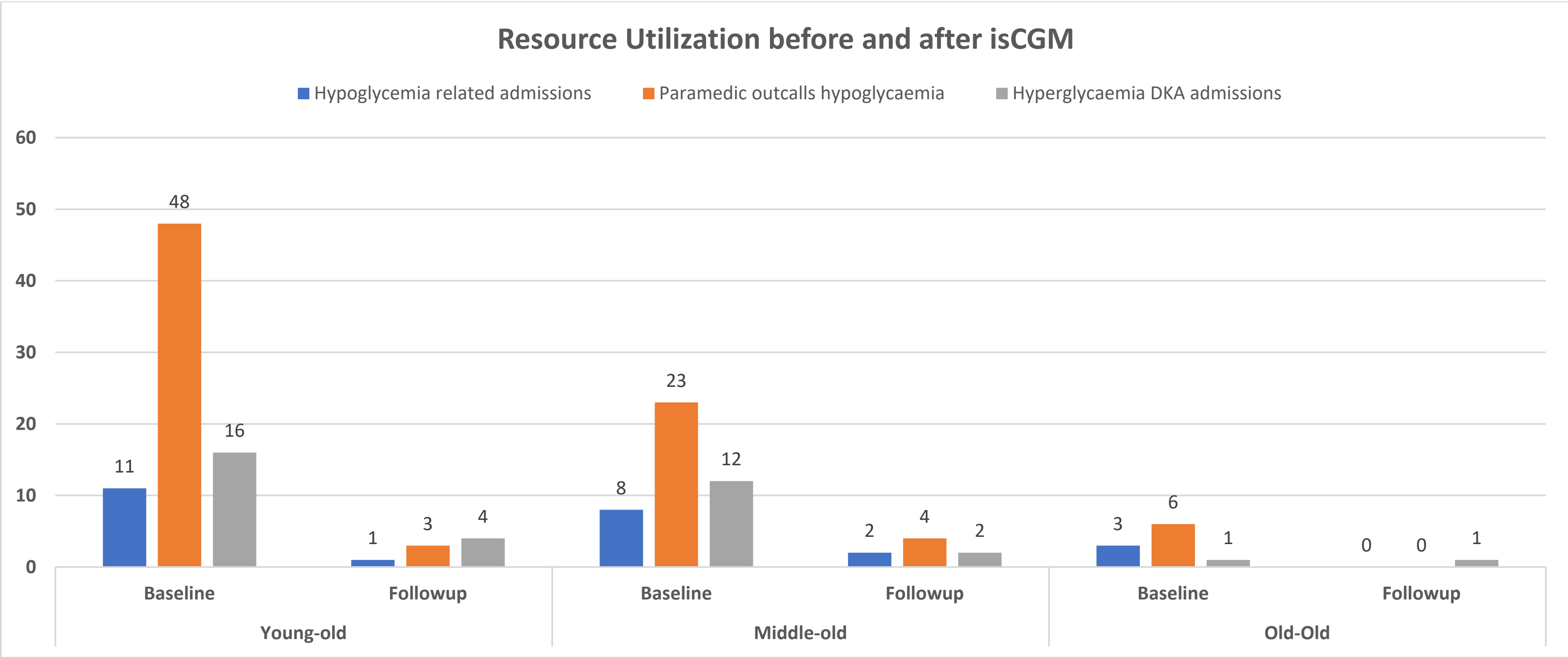


Figure 2: Hypoglycaemia, Hyperglycaemia related hospital admissions and paramedic out-calls by age-categories



Author contributions: HD, EGW and TS conceived the presented idea. KAA and HD contributed to data analysis. HD wrote the first draft of the manuscript. All of the authors reviewed the manuscript and made comments, criticism, and changes in the final draft of the paper and approved the paper. HD is the guarantor of this work and, as such, had full access to all of the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis.

Conflicts of interest:

The ABCD nationwide FSL audit is supported by an unrestricted grant from Abbott Laboratories. The FSL audit was independently initiated and performed by ABCD, and the authors remain independent in the analysis and preparation of this report.

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