

Hybrid closed-loop insulin therapy from diagnosis for all type 1 diabetes paediatric patients: Hillingdon Hospital's experience

Catherine Tapping, Sharanjit Cheema, Jaikumar Ganapathi, Jasjit Bhandari, Manpreet Mudher, Debbie Blissitt and Jo-Anne Ellis

The primary goal of diabetes management is to help patients achieve near-normal glycaemia as safely as possible to minimise complications, with research supporting early, intensive glycaemic control for long-term benefits. Hybrid closed-loop (HCL) systems, combining insulin pumps and continuous glucose monitors, use algorithms to automatically adjust insulin delivery in response to glucose levels, promoting improved glycaemic control. HCL therapy is currently the most effective treatment for type 1 diabetes in children and young people (CYP), as evidenced by lower mean HbA_{1c} levels in those using HCL compared to other treatment. Therefore, Hillingdon Hospital's Paediatric Diabetes Team introduced HCL therapy as standard care for new diagnoses. This article reports on its approach to initiating HCL insulin therapy at diagnosis for all paediatric patients with type 1 diabetes. The team presents its experience, including practical implications, clinical outcomes, patient satisfaction and healthcare professional experience, to support the introduction of this practice across other paediatric diabetes services.

Hybrid closed-loop (HCL) systems comprise an insulin pump and a continuous glucose monitor (CGM). The system uses a mathematical algorithm to automatically adjust and deliver insulin in response to CGM data, increasing, decreasing and suspending insulin delivery to reduce hyper- and hypoglycaemia (NICE, 2023).

The overarching aim of diabetes management is for patients to achieve glycaemia that is as close to normal as safely as possible, to reduce the development and progression of diabetes-related complications (DCCT Research Group, 1993). The EDIC study recommended that intensive therapy, to achieve early tight glycaemic control, should be implemented as soon as possible from diagnosis, so that patients can benefit from the metabolic memory (Writing Team for DCCT/EDIC Research Group, 2003).

It is well evidenced that HCL is currently the most effective treatment for type 1 diabetes in children and young people (CYP) (Asgharzadeh et al, 2024; RCPCH, 2024a). The 2022/2023 National Paediatric Diabetes Audit (NPDA) annual report showed that those on HCL, when compared to other treatment combinations, had a lower mean HbA_{1c} (RCPCH, 2024a). Despite this, it is not common practice to start HCL at diagnosis.

Technical appraisal guidance TA943 from NICE (2023) advocates for HCL use in CYP regardless of HbA_{1c} levels or hypoglycaemia risk. However, despite robust clinical evidence and national recommendations, barriers such as delayed implementation, disparities in access to this technology and inconsistent adoption across the country persist (NICE, 2023; RCPCH, 2024a).

Hillingdon Hospital's Children and Young People

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Article points

1. Hybrid closed-loop (HCL) systems combine insulin pump and continuous glucose monitoring technologies to automatically adjust insulin delivery.
2. NICE advocates HCL therapy in children and young people (CYP) with type 1 diabetes, but adoption is inconsistent.
3. Hillingdon Hospital has adopted HCL therapy from diagnosis as standard care for all CYP with type 1 diabetes.
4. Structured education for staff and careful planning have been central to implementing the policy, which has seen glycaemic outcomes improve.
5. A survey showed that the families of patients were supportive of the policy.
6. Ward nurses were generally positive about the adoption of HCL from diagnosis, but emphasised the need for ongoing training.

Key words

- Children and young people
- Hybrid closed-loop insulin therapy
- Patient satisfaction
- Type 1 diabetes

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with Diabetes Team (CYPDT) has been an early adopter of technology, when compared to national technology use (RCPCH, 2024b). This approach is supported by Ware et al (2024) who demonstrated improved and sustained glycaemic control with the introduction of HCL at diagnosis. Hillingdon CYPDT has been starting children of 6 years of age and under on insulin pumps at diagnosis since 2010. Then, with the introduction of HCL in 2021, all patients 6 years old and under were started on HCL at diagnosis. In 2024, we moved to offering HCL at diagnosis to all CYPD up to the age of 16 years. As this is not yet common practice across national paediatric diabetes services, this article will explore the perceived barriers to HCL at diagnosis, how the CYPDT at Hillingdon Hospital have implemented this as standard practice, the experience of families, ward staff and the CYPDT, and will discuss the clinical outcomes.

Perceived barriers to HCL at diagnosis

The Hillingdon CYPDT presented the use of HCL at diagnosis at nationwide conferences and local networks and, from these, we are aware of perceived barriers to HCL at diagnosis.

Staff training

Effective training of the inpatient ward nursing team, in the management of type 1 diabetes and associated technology, is essential to ensure they are both competent and confident in supporting the family during their diagnosis admission. All members of the ward nursing team attend a diabetes study day, facilitated by the CYPDT, which provides education on all aspects of diabetes management, including the use of HCL. The ward

nurses are not permitted to be the allocated nurse for any patient with type 1 diabetes until they have attended the study day. The training runs two or three times a year to ensure that all nurses can attend shortly after joining the ward team.

Following training, all ward nurses complete a mandatory annual e-learning refresher module (internally produced). The CYPDT also provides *ad hoc* ward-based training, as required, to ensure ward staff competence with rapidly changing diabetes technologies. During an HCL at diagnosis admission, the CYPDT will offer both in-person and phone support to the ward team, alongside a written HCL-specific care plan.

Technology requirements

Many HCL systems require access to additional technology, such as a compatible mobile phone. Adolescents often already own a mobile phone, but this may not be the case for younger children. Hillingdon Borough has high deprivation rates (Figure 1). The CYPDT has found that most families have been able to obtain a compatible mobile phone from family or friends, or to purchase a suitable phone. For those families who have not been able to, charities were approached to provide one. Families have also donated old phones, which were factory reset, either to be given permanently to a new family or until they have their own.

Procurement

To enable HCL to start at diagnosis, appropriate insulin pumps and CGM systems must be available. Three different HCL systems were selected by the CYPDT to offer at diagnosis – two tubed pumps and one patch pump. This ensures that a range of suitable options are available on site immediately at diagnosis for different ages or patient-specific needs. The hospital procurement process is completed without patient allocation, and a company-specific order form is completed with the initial order for three months of consumables to be delivered directly to the hospital.

At diagnosis, a member of the multidisciplinary team (MDT) will discuss HCL therapy and pump options with the family and a decision on the appropriate HCL system will be made in collaboration between the family and the CYPDT. Once the pump is allocated to a patient at diagnosis,

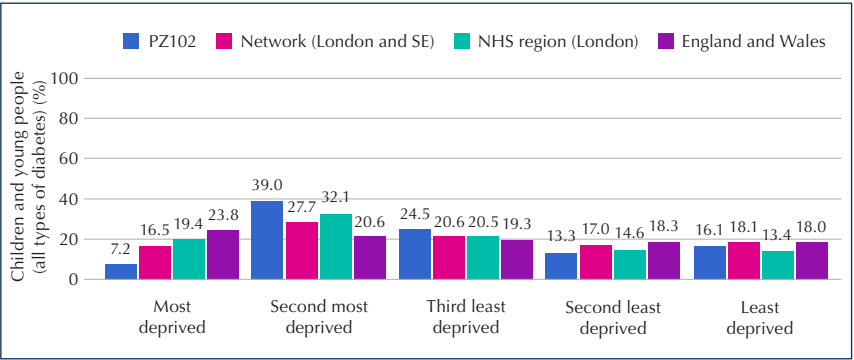


Figure 1. Patient deprivation profile of Hillingdon Hospital (PZ102; RCPCH, 2024b).

full patient details are provided to the hospital finance team and the specific company for ongoing delivery and funding.

Language

Hillingdon Hospital is situated in a diverse London borough. In 2021, Hillingdon borough was made up of a 48.2% white population, with the remaining from Asian (33%), black (7.8%) and other/mixed (10.7%) ethnic groups (Office for National Statistics, 2023).

From 2021 until 2024, 33.3% of CYP and their families started on HCL at diagnosis did not speak English as their first language. The need for an interpreter was assessed on an individual basis according to the NHS England Accessible Information and Communication Policy (NHS England Patient and Public Participation and Insight Group, 2016). When required, a face-to-face interpreter was arranged for each day of the admission and for all review appointments following discharge. No patient was denied a pump start at diagnosis due to language barriers or due to lack of interpreting service.

Interpreters have been used to translate written information for some patients and existing platforms, such as DigiBete, have been used for translated videos on HCL (www.digibete.org).

Patient/family education

Structured education on diabetes management and HCL use is delivered by members of the CYPDT. All team members are trained to the same level in HCL initiation and use, so the paediatric DSNs (PDSNs), dietitian and consultants can all provide uniform education. Occasionally, pump company representatives will attend the ward to support the CYPDT in providing HCL education at diagnosis, which reduces workload. However, the education is primarily delivered by the CYPDT.

Insulin pump-related adverse events, such as infusion set failures or pump failure are common. ISPAD consensus guidance states these events occur in 40%–68% of pump users (Lawrence et al, 2022). The team ensures, therefore, that CYPD and their families are competent in the management of hyperglycaemia and how to avoid diabetic ketoacidosis.

Injection technique is taught and practised during

the admission and competence is assessed before discharge. HCL is often commenced on day 1 of admission and injection technique is practiced whilst on HCL. To achieve this, the family will administer a mealtime bolus via injection. To maintain the pump insulin onboard data, different approaches are taken depending on the HCL system being used. For tubed pumps, the tubing will be disconnected and a bolus equal to that being delivered via injection will be programmed through the pump before reconnecting. As patch pumps cannot be temporarily disconnected, the injections will be practised when a pump change is required, or part of a bolus will be administered by injection and part via the pump to maintain pump insulin onboard data. For example, a 4-unit bolus will be administered as 3.5 units via the pump and 0.5 via injection.

Hillingdon Hospital NPDA data does not show an increased rate of hospital admissions when compared nationally (4.2% at Hillingdon Hospital vs 5.2% nationally), demonstrating no increased risk of hospital readmission in the patient cohort (RCPCH, 2024b).

Follow-up

After discharge, CYP and their families have a minimum of weekly appointments for four weeks, in addition to their routine three-monthly MDT clinic appointments. These appointments will always include a home visit, then virtual or face-to-face appointments, depending on individual family need. Access to real-time online pump and glucose data facilitates regular virtual reviews, and enhances out-of-hours advice provision.

At Hillingdon Hospital, 24/7 telephone advice, as required by the Best Practice Tariff, is provided directly by the CYPDT PDSNs, dietitian and consultants (NHS England, 2024). This ensures that families get expert and personalised advice from professionals they know. The families also have access to the 24/7 insulin pump company support, if they have pump-specific issues to troubleshoot.

A school visit is arranged promptly at diagnosis to minimise absence. The CYPDT provides face-to-face training for school staff, so they are both competent and confident in diabetes management, including HCL. The length of this training varies, depending on the previous diabetes management

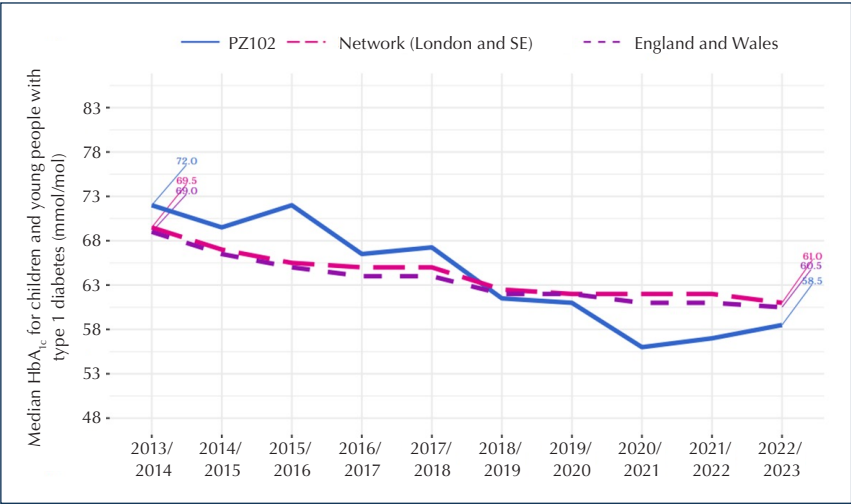


Figure 2. Median HbA_{1c} for children and young people with diabetes at Hillingdon Hospital (PZ102). Type 1 diabetes patient number in 2024 was 225 (RCPCH, 2024b).

experience of the school staff; however, we will ask the school to allocate up to 3 hours. This training is further supported with the provision of a DigiBete school care plan and a Hillingdon-produced document containing step-by-step guides to using the specific HCL system in school. School staff are also signposted to training resources, including the Breakthrough T1D diabetes training platform for schools and DigiBete school resources (Breakthrough T1D, 2024; Digibete, 2025).

Prior to the introduction of HCL at diagnosis, the team would provide face-to-face training for school staff and then a second training visit would be required once the CYP was started on HCL. Starting HCL at diagnosis negates the need for two training visits and care plan revisions, thereby reducing workload.

Clinical outcomes
HbA_{1c} and pump uptake

The national median HbA_{1c} for CYP with type 1 diabetes in England and Wales was 60.5 mmol/mol (RCPCH, 2024a). At 58.5 mmol/mol, the median HbA_{1c} at Hillingdon Hospital was lower than this (Figure 2). The contributing factors to a service’s median HbA_{1c} are multifactorial, but the increased use of HCL may be a component in the success. At the time of the NPDA 2022–23 submission, HCL use was at 39.2% (RCPCH, 2024b). This has increased significantly and, at the time of article submission, HCL use was 66% of total patients, while 95% of pump users are on HCL.

For those started on HCL from diagnosis between 2021 and 2023, the first year HbA_{1c} was analysed, the median HbA_{1c} was 57.4 mmol/mol. The median HbA_{1c} is considered as further evidence of the success of HCL at diagnosis.

| Table 1. Demographics of children and young people using an insulin pump. | | | | |
|---|--|-------------------------|---------------------|-------------------|
| | Children and young people with type 1 diabetes using an insulin pump (%) | | | |
| | PZ102 | Network (London and SE) | NHS region (London) | England and Wales |
| Deprivation quintile | | | | |
| Least | 62.5 | 53.0 | 55.2 | 50.8 |
| Second least | 66.7 | 50.6 | 52.3 | 50.1 |
| Third least | 70.8 | 46.1 | 47.7 | 46.3 |
| Second most | 53.4 | 44.1 | 43.7 | 43.8 |
| Most | 64.3 | 41.4 | 42.7 | 39.2 |
| Ethnicity | | | | |
| Ethnic minority | 61.6 | 42.7 | 42.6 | 39.5 |
| White | 60.5 | 50.5 | 53.7 | 47.8 |
| PZ102=Hillingdon Hospital. | | | | |

Duration of admission

Since 2021, the average length of admission for those started on multiple daily injections (MDI) at diagnosis was 3.5 days, while for those started on HCL it was 5.7 days. It was felt that this significantly longer stay was mitigated by improvements in HbA_{1c}, reduced outpatient activity later and less school training (no change in treatment).

In 2024, the average stay for HCL at diagnosis had fallen to 4.7 days. The reason for this reduction is not clear, but may be due to a more streamlined process or less complexity of patient seen.

National inequalities

NPDA results continue to show persistent inequalities associated with ethnicity and deprivation (RCPCH, 2024b). Nationally, the percentage of white CYP using an insulin pump is 47.8%, compared to 39.5% in the ethnic minorities (Table 1). The reason for the national inequalities is not clear.

In 2022–23, Hillingdon Hospital had no significant difference in insulin pump usage between white and ethnic minority groups (60.5% vs 61.6%). The team aspires to equality and impartiality in the treatment of all patients, but understand that unconscious bias can be present in any staff (FitzGerald and Hurts, 2017). Hillingdon Hospital CYPDT feels that starting all patients on HCL at diagnosis, regardless of age, ethnicity, deprivation or sex, eliminates the risks of conscious and unconscious bias in selection for HCL.

Experience of HCL at diagnosis

Patient/family experience of HCL at diagnosis

An electronic questionnaire was developed in three languages and was distributed to all CYPD and their families ($n=33$) who started on HCL from 2021 to 2024, with the aim of understanding the experiences. Multiple circulations of the questionnaire (Box 1), via both text and email, resulted in a 39% response rate. Despite this, valuable data was attained, which indicated strong support for HCL at diagnosis, and a preference for HCL insulin therapy over insulin injections (Table 2 and Box 2). Over 90% of respondents felt that the best time to start HCL therapy was during the ward stay following diagnosis.

Box 1. Parental and patient experience questionnaire.

- Q1.** I feel that starting on an insulin pump at diagnosis, rather than insulin injections, was the best treatment choice for my family. [Rated answer]
- Q2.** I feel that the amount of education and training I received from the diabetes team **before discharge** was appropriate. [Rated answer]
- Q3.** I received enough support from the diabetes team **following discharge** from hospital. [Rated answer]
- Q4.** I felt confident in how to give an insulin injection, if needed. [Rated answer]
- Q5.** When do you think would have been the best time for your child to start on HCL insulin pump?
- Q6.** Any other comments about your experience of starting on HCL at diagnosis?

Table 2. Parental responses to survey questions 1–4 ($n=13$).

| Question | Strongly agree | Agree | Neutral | Disagree |
|----------|----------------|-------|---------|----------|
| Q1 | 92% | 8% | 0% | 0% |
| Q2 | 77% | 23% | 0% | 0% |
| Q3 | 100% | 0% | 0% | 0% |
| Q4 | 77% | 8% | 15% | 0% |

Box 2. Selected responses to question 6 on the parental experience survey.

- “Getting to know other family experiences with injections and finger pricks, I feel lucky and grateful that the pump and sensor was available to us at diagnosis.”
- “Starting pump should be essential before discharged from the ward.”
- “The best decision to start on an HCL for the 16-month-old at the beginning of an unexpected diagnosis. Very grateful that Hillingdon has an extremely supportive 24/7 diabetic team.”
- “Being on the pump straight away had problems as my child went straight into honeymoon... Either way, this is a lot to adjust to but having the pump made hypers a lot less stressful as the pump and app did the work.”
- “Very grateful that our daughter was given access to a pump at diagnosis. Made her transition back to nursery and getting on with life so much easier. She was given much more independence with the pump and able to be like everyone else.”
- “They made the whole thing easy for us.”
- “Being able to start an HCL at the time of diagnosis prevented further distress. Having an HCL meant he didn’t have to experience insulin injections and finger pricks, which we were extremely grateful for.”

Ward nurse experience of HCL at diagnosis

An anonymous survey was sent out to all inpatient ward nurses. Eighteen of a total of 42 nurses responded, all of whom had cared for patients started on both HCL and MDI during their diagnosis admission. The questions are listed in Box 3.

Box 3. Ward nurses' questionnaire.

Q1.

Have you looked after a newly diagnosed patient who was started on HCL at diagnosis?

Q2.

Have you looked after a newly diagnosed patient who was started on insulin injections at diagnosis?

Q3.

I feel confident caring for a patient started on HCL at diagnosis. [Rated answer]

Q4.

I received adequate support and training from the diabetes team to safely care for patients started on HCL at diagnosis. [Rated answer]

Q5.

I feel competent in carbohydrate counting. [Rated answer]

Q6.

If you have cared for newly diagnosed patients on both HCL and insulin injections, which do you prefer?

Q7.

Any other comments about your experience of HCL at diagnosis?

| Table 3. Ward nurse responses to survey questions 3–6 (n=18). | | | | | |
|---|----------------|-------|---------|----------|-------------------|
| Question | Strongly agree | Agree | Neutral | Disagree | Strongly disagree |
| Q3 | 3 | 10 | 4 | 1 | 0 |
| Q4 | 9 | 7 | 2 | 0 | 0 |
| Q5 | 15 | 2 | 0 | 1 | 0 |
| Question | HCL | MDI | | | |
| Q6 | 16 | 2 | | | |

HCL=hybrid closed-loop; MDI=multiple daily injections.

Box 4. Selected responses to question 7 on the ward nurse survey.

"Insulin pumps are generally easy to use."

"Over time I have learnt about different ones and closed loop."

"Insulin pumps are great."

"They change regularly as technology develops, so training has to be kept up."

"It's less traumatic for the patient."

"My lack of confidence is due to my infrequent experience because I only work occasional shifts."

"Pumps are so much kinder to the patient."

"More refreshers needed."

89% of respondents prefer caring for a child or young person at diagnosis with HCL compared to MDI. Whilst a majority of respondents reported that they feel confident with HCL and carbohydrate counting, and have received adequate training, there were some neutral and negative responses (Table 3). This highlights the importance of an ongoing programme of training for ward nurses. Themes

identified from the “any other comments” responses included the benefit to patients of HCL, its ease of use, and the importance of regular training to maintain competence and confidence (Box 4).

Diabetes MDT experience of HCL at diagnosis
The team consists of PDSNs, consultants, dietitian, psychologist and clinical support worker. All have equal involvement in decisions regarding HCL starts at diagnosis, including which HCL systems to offer and the decision to offer it to all patients at diagnosis. Although the team had some apprehension about this decision, specifically around those with language barriers or complex social circumstances, all members were fully committed to it. Since implementation, all team members agree about the positive impact of HCL at diagnosis not only on the families living with diabetes, but also the MDT.

Some key themes emerged from the feedback regarding HCL start at diagnosis. The CYPDT viewed improved glycaemic control and the perceived emotional benefit to the young person and parents/carers as the primary drivers in implementing the policy. Although not measured, the CYPDT have not observed an increase in out-of-hours calls from those starting HCL at diagnosis, either during their initial admission or following discharge. Furthermore, the CYPDT identified a reduction in overall workload when compared with implementing HCL at a later date. Specifically, later pump start preparation and appointments were no longer required, and pump follow-up reviews were incorporated as part of initial diagnosis follow-up. The CYPDT did not identify any adverse consequences in terms of clinical outcomes, structured education, workload, or staff, patient or parent/carer experience.

Conclusion

In conclusion, the implementation of HCL at diagnosis has proven an effective and successful approach, as evidenced by positive clinical outcomes and patient experience and absence of increased readmissions following discharge. The Hillingdon CYPDT has embraced new diabetes technologies and advocate prompt access to technology for all CYP living with diabetes. Potential barriers to access, such as staff

competency, access to technology and language, were overcome to ensure the seamless integration of HCL as standard care at diagnosis regardless of age, socioeconomic or ethnic background. The training of ward healthcare professionals must be prioritised, alongside the robust structured education and support of the child/young person and their family. The Hillingdon Hospital CYPDT endorses the introduction of HCL technology at diagnosis as the gold standard care for all children, young people and families navigating the challenges of type 1 diabetes. ■

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