The impact of the Diabetes Inpatient Care and Education (DICE) project on length of stay and mortality

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Supplementary Material

Appendix 1: The DICE programme

The Diabetes Inpatient Care and Education (DICE) programme comprised several elements in a multi-faceted approach to improving inpatient care. The care pathway and electronic tools are outlined below.

The DICE care pathway

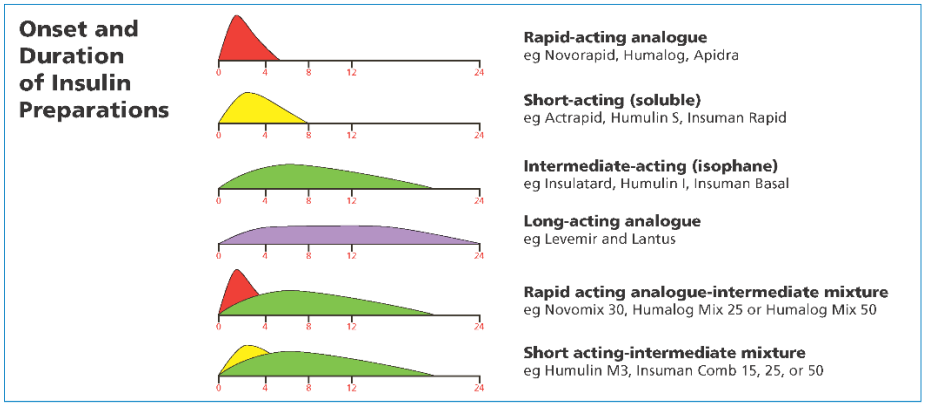
The first page requires identification of type of diabetes and instructs the admitting team on issues related to their diabetes type (e.g. never stop insulin in type 1 patients). There is a novel scoring system [the Diabetes Patient At Risk score (DPAR)] which helps ward staff identify those patients with diabetes who should be referred to the inpatient diabetes team (or foot team). The referral made instant online bypasses the need to wait for a doctor's approval, which previously resulted in non-referral or delayed referral. The scoring system prioritises the urgency of review and indicates whether this should be by a consultant (for Diabetic Ketoacidosis, Hyperosmolar Hyperglycaemic Syndrome, Diabetic Foot Syndrome) or a diabetes nurse. Being electronic, it allows for regular audit of the timeliness of reviews.

To prevent hospital-acquired foot lesions and to ensure that unknown foot ulceration does not go undetected, there is a foot check form to be completed on admission with instructions on how to perform a simple foot examination. The form also contains space for entry of daily heel checks and guidance on referral to the multidisciplinary foot team.

The relevant papers which provide more detail, with illustrations of the DPAR score and the Ipswich Touch Test, are referenced below (1,2).

User-friendly charts were designed to improve patient safety, including combined glucose and insulin diabetes charts, specific treatment charts for diabetic ketoacidosis and hyperosmolar hyperglycaemic state, and charts for insulin dosing when on an intravenous insulin infusion.

An illustration of the insulin time action profiles for the different types of insulins and an algorithm to direct management of hyperglycaemia are shown below in supplementary figures 1 and 2.



Supplementary figure 1. DICE chart illustration of insulin profiles.

Surname: ..... First name: ..... Hosp no: ..... NHS no: .....

Guidance for Medical and Nursing Staff:

Hyperglycaemia requiring treatment: Capillary blood glucose (CBG) ≥ 15 mmol/L

Type of diabetes	*Patient well:* mobile, eating and drinking,	*Patient unwell:* nausea, vomiting, and / or urine ketones *Check patient for sepsis*
Type 1 (Check urine ketones)	**NO URINE KETONES** **Repeat:** • Capillary blood glucose after 2 hours; • Urine ketones after 2 hours. **Review:** • Regular doses of insulin. [See below for insulin profiles.] • Consider updating DPAR score.	**STEP 1** Capillary blood glucose ≥ 15 mmol/L → **STEP 2** Give 6 units of Actrapid insulin subcutaneously → **STEP 3** Check for ketosis (capillary blood or urine): • If capillary blood ketones ≥ 1.5 mmol/L or urine ketones 2+ or more: proceed to DKA protocol. ***OR*** • If capillary blood ketones < 1.5 mmol/L or urine ketones 1+ or less: repeat step 1 after 2 hours. Cycle can be repeated once. If CBG remains ≥ 15mmol/L, 2 hours after second dose of 6 units stat Actrapid insulin, then commence variable rate intravenous insulin infusion (VRIII) and refer using DPAR score.
Type 2	**Review:** • Diet. • Oral hypoglycaemic or insulin doses if persistently high [See below for insulin profiles] **Consider:** • Switch to insulin therapy if persistently high. • Updating DPAR score.	**STEP 1** Capillary blood glucose ≥ 20 mmol/L → **STEP 2** Give 6 units of Actrapid insulin subcutaneously → **STEP 3** Check for ketosis (capillary blood or urine): • If capillary blood ketones ≥ 1.5 mmol/L or urine ketones 2+ or more: treat as per 'Unwell Type 1' – proceed to DKA protocol. ***OR*** • If capillary blood ketones < 1.5 mmol/L or urine ketones 1+ or less: repeat step 1 after 4 hours. Cycle can be repeated once. If CBG remains ≥ 20mmol/L, 4 hours after second dose of 6 units stat Actrapid insulin, then commence variable rate intravenous insulin infusion (VRIII) and refer using DPAR score. Consider excluding HHS (HONK)

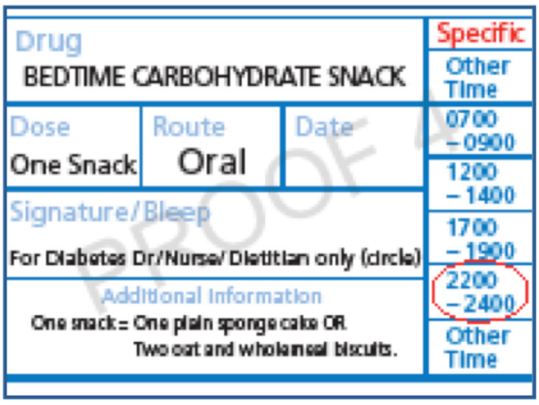
Hypoglycaemia: Capillary blood glucose (CBG) < 4mmol/L

Full guidance given in HYPOBOX and on intranet.

- Symptoms and signs are variable but include sweating, palpitations, shaking, hunger, drowsiness, odd behaviour, convulsions, coma etc.
- Do not delay treatment to wait for doctor to be available – suggestive symptoms and low capillary blood glucose (< 4mmol/L) are sufficient grounds to treat as per protocol.
- Following a hypo, **DO NOT** omit insulin if due (dose review may be needed).

Supplementary figure 2. DICE chart illustration of hyperglycaemia treatment algorithm.

For those on insulin or sulphonylureas, there is also the requirement to prescribe a bedtime snack to prevent overnight hypoglycaemia, which we previously reported to be an issue in hospitalised patients (supplementary figure 3) (3).



Supplementary figure 3. DICE chart illustration of bedtime snack sticker.

The booklet contains a tool to enable patients to self-manage their insulin during hospitalisation and finally a checklist to ensure safe discharge from hospital.

In addition to the booklet two key electronic interventions were implemented with the help of the IT department for the programme.

Web-linked Point of Care Blood Glucose Meters and bespoke Hypoglycaemia Alert
We upgraded our point of care glucose meters to a web-based system (FreeStyle Precision Pro Blood Glucose Monitoring System™ - Abbott Diabetes Care, Witney, UK) and developed a bespoke system to identify all patients with hypoglycaemia; the list is generated every morning directly from a central server to which the ward glucose meters are web-linked. This hypoglycaemia list enables the specialist nurses to prioritise these patients on the ward visits to make prompt adjustments to medication with the aim of preventing recurrent hypoglycaemia.

Identifying, and input into the care of, all new diabetes admissions
A list of all diabetes admissions is generated each morning based on triangulating diagnoses from previous admission records, attendance at the Diabetes Centre and SystmOne data. This allows prompt review of newly admitted patients who had not been referred via the DPAR system for medication review and adjustment, initiation of patient self-management where appropriate, and other measures to prevent hypo- and hyperglycaemia.

References

1. Rajendran R, Raound RM, Kerry C, Barker S, Rayman G. Diabetes patient at risk score - a novel system for triaging approriate referrals or inpatients with diabetes to the diabetes team. *Clinical Medicine* (London), 2015, Vol. 3.

2. Rayman G, Vas P, Baker N, Taylor C. A simple and novel method to identify patients with diabetes at risk of foot ulceration. *Diabetes Care* 2011;34:1517-1518.

3. Kerry C, Mitchell S, Sharma S, Scott A, Rayman G. Diurnal temporal patterns of hypoglycaemia in hospitalised patients with diabetes may reveal potentially correctable factors. *Diabetic Medicine* 2013;30:1403-1406.

Appendix 2: Methods

We fitted a model of the form:

$$Y_t = \beta_0 + \beta_1 Time_t + \beta_2 X_1 + \beta_3 X_1 Time_{t-67} + \beta_4 X_2 + \beta_5 X_2 Time_{t-73}$$

Here, Y_t indicates the outcome at time *t*. $Time_t$ indicates time since the study started. X_1 is a binary indicator for whether the intervention has begun, 1 if yes, 0 if no. X2 is a binary indicator, 1 if intervention period has ended, 0 otherwise. M indicates number of weeks since the intervention began, 0 before the intervention began. N indicates number of weeks since the intervention period ended, 0 beforehand. β_0 is constant – indicates starting value of the outcome, β_1 is pre-intervention slope – i.e. monthly change in the outcome before intervention. β_2 is level change in outcome variable when intervention began (immediate impact of intervention on the outcome. β_3 is the monthly change in outcome during intervention period relative to the pre-intervention slope. β_4 is the level change in the outcome variable when the intervention period ended (immediate impact of stopping the intervention). β_5 is the monthly change in outcome post intervention period relative to pre-intervention and during-intervention slopes.

Supplementary Table 1: Results of the ITS analysis

a. Summary of outcomes

	Control period			Post-intervention period		
	Deaths	**Admissions**	**IR**	**Deaths**	**Admissions**	**IR**
Diabetes	1,367	23,161	0.06	678	13,683	0.05
Non-diabetes	5,708	154,292	0.04	2,501	75,643	0.03
	Readmissions	**Admissions**	**IR**	**Readmissions**	**Admissions**	**IR**
Diabetes	3,916	23,148	0.17	2,377	13,199	0.18
Non-diabetes	17,434	154,079	0.11	9,439	72,929	0.13
	Length of stay (hours), mean (SD)			**Length of stay (hours), mean (SD)**		
Diabetes	180.2 (18.9)			155.7 (11.2)		
Non-diabetes	120.7 (6.8)			112.0 (3.8)		

IR = Incidence rate.

b. Impact of the DICE intervention on the underlying time trends

	Time, pre-intervention		Time, post-intervention	
Deaths	**IRR (95% CI)**	**p-value**	**IRR (95% CI)**	**p-value**
Diabetes	0.98 (0.91, 1.06)	0.682	1.12 (0.88, 1.45)	0.344
Non-diabetes	0.73 (0.62, 0.86)	<0.001	1.51 (0.91, 2.50)	0.108
Readmissions	**IRR (95% CI)**	**p-value**	**IRR (95% CI)**	**p-value**
Diabetes	1.31 (1.18, 1.46)	<0.001	3.38 (2.21, 5.16)	<0.001
Non-diabetes	1.07 (0.81, 1.43)	0.624	58.52 (20.28, 168.07)	<0.001
Length of stay (hours)	**MD (95% CI)**	**p-value**	**MD (95% CI)**	**p-value**
Diabetes	-0.27 (-0.36, -0.18)	<0.001	-0.68 (-1.00, -0.35)	<0.001
Non-diabetes	-0.02 (-0.19, 0.14)	0.762	-0.21 (-0.72, 0.29)	0.405

IRR = Incidence rate ratio. CI = Confidence interval. MD = Mean difference.

The IRR for time describes the change in rate of mortality or readmissions for each month that passes – before and after the DICE intervention. For example, an IRR of 0.98 indicates a 2% decrease in rate (of mortality) per month. The MD for time describes the change in the average length of stay for each month that passes. For example, a MD of -0.27 indicates a decrease each month in length of stay of 0.27 hours.