Variable rate intravenous insulin infusions on medical and surgical wards – are we getting it right?

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Delivering the best in care

Queen Elizabeth Hospital Birmingham

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Introduction

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- Background - why did we undertake this Quality Improvement Project (QIP)?
- Aims.
- Method- Baseline study and repeated PDSA cycles.
- Results.
- Conclusions.
- Next steps.

Queen Elizabeth Hospital Birmingham (University Hospital Birmingham NHS FT)

Highly specialist cardiac & liver services

2nd largest UK renal dialysis programme

Largest solid organ transplant centre in Europe

Largest single site UK hospital with major trauma centre - 1213 beds (100 critical care), 32 theatres & >9000 staff

Larger than national average number of patients on sc insulin and iv insulin.

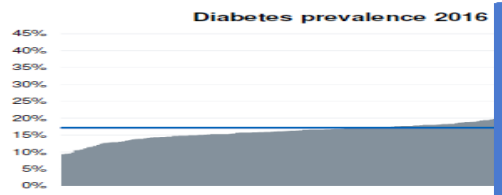
Kidney problems

14.2 per cent of patients with diabetes in Queen Elizabeth Hospital (Birmingham) were receiving renal replacement therapy in 2016 (unable to assign to quartiles due to the high proportion of organisations with 0.0 per cent returned). The table shows the historical receiving renal replacement therapy values, with corresponding quartiles, for Queen Elizabeth Hospital (Birmingham), as well as the overall England values for each of these years.

Receiving renal replacement therapy 2010 - 2016

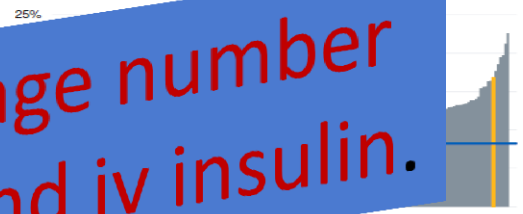
Audit year	Chosen site	Quartile †	England
2010	9.4%	N/A	3.5%
2011	16.1%	N/A	3.3%
2012	12.4%	N/A	3.7%
2013	11.3%	N/A	4.2%
2015*	8.3%	N/A	3.7%
2016	14.2%	N/A	3.5%

* There was no audit collection or report in 2014, so 2014 data is not available.
† Where N/A is returned, it is not possible to allocate results to quartiles due to the high proportion of organisations with 0.0% returned



			15.6%
		uartile 4	16.8%
	22.1%	Quartile 4	17.2%

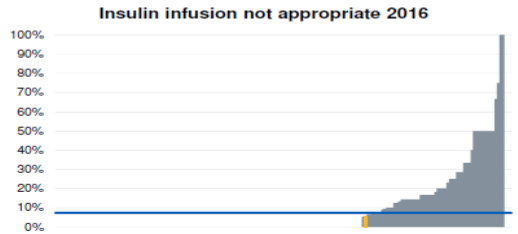
* There was no audit collection or report in 2014, so 2014 data is not available.



Use of insulin infusions 2010 - 2016

Audit year	Chosen site	Quartile	England
2010	18.0%	Quartile 4	12.5%
2011	12.3%	Quartile 3	11.5%
2012	16.3%	Quartile 4	10.8%
2013	16.0%	Quartile 4	10.2%
2015*	17.8%	Quartile 4	9.1%
2016	16.8%	Quartile 4	8.2%

* There was no audit collection or report in 2014, so 2014 data is not available.



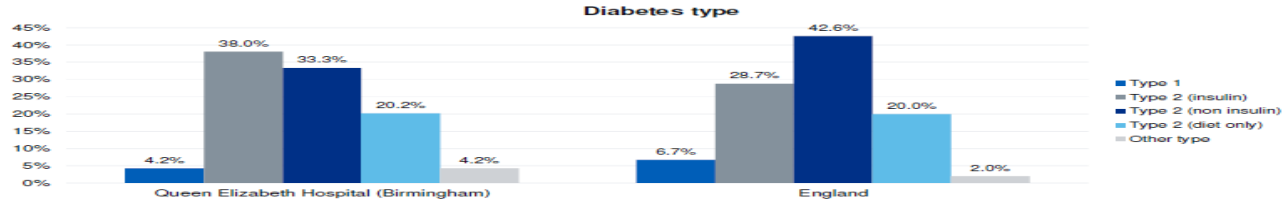
Insulin infusion not appropriate 2010 - 2016

Audit year	Chosen site	Quartile †	England
2010	4.3%	N/A	7.4%
2011	6.3%	N/A	6.7%
2012	4.0%	N/A	6.4%
2013	3.2%	N/A	6.4%
2015*	5.3%	N/A	6.1%
2016	5.7%	N/A	7.4%

* There was no audit collection or report in 2014, so 2014 data is not available.
† Where N/A is returned, it is not possible to allocate results to quartiles due to the high proportion of organisations with 0.0% returned

Type of diabetes

Of the inpatients with diabetes in Queen Elizabeth Hospital (Birmingham), 4.2 per cent had Type 1 diabetes and 38.0 per cent had Type 2 diabetes treated with insulin. The chart allows you to see how the site compares to the overall England values.



The danger of VRIII use

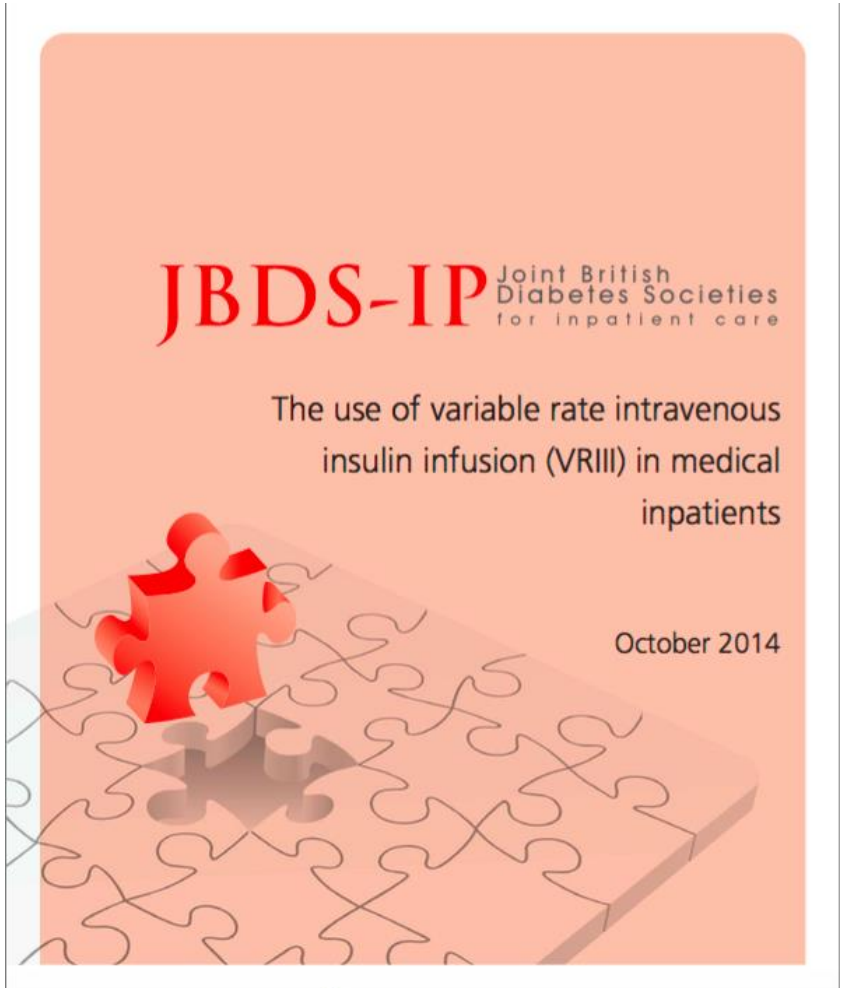
	The use of insulin infusions
11.2%	had been on an insulin infusion in the last 7days
7.0%	of infusions were considered inappropriate
8.3%	were considered inappropriately long
8.0%	exceeded 7 days
18.9%	the transfer to s.c. insulin was not managed appropriately

The National Diabetes Inpatient Audit (NaDIA) 2011

Glucose control on insulin infusion	
24.2%	on an infusion had more than half of readings >11mmol/L
3.3%	had hypoglycaemic readings (<4mmol/L) 25% of the time
6.4%	on an infusion had less than 4 glucose tests in the previous 24 hrs.

JDBS VRIII guidelines: key points

- The Joint British Diabetes Societies (JBDS) advise **0.45% saline with 5% glucose** and either **0.15% or 0.3% potassium chloride** (KCl) IVI
- All patients with **potassium (K) <5.5 mmol/l** should have **potassium added** to fluid
- **Basal insulin** should be **continued** while on VRIII and **all** other diabetic medications **stopped**



Initial research: Baseline

Slipping up on the sliding scale: fluid and electrolyte management in variable rate intravenous insulin infusions

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Abstract

This study aimed to analyse variations in intravenous fluid therapy and electrolyte management with variable rate intravenous insulin infusions (VRIIIs); and to quantify serum electrolyte changes pre- versus post-VRIII and variations therein depending on supplemented fluid electrolyte compositions.

A retrospective study was undertaken involving 174 VRIIIs prescribed over a 10-week period at a tertiary teaching hospital. Each VRIII had their associated fluid prescription and serum electrolytes analysed.

The results showed that 5% dextrose (46%) and 0.9% NaCl (34%) were the most commonly prescribed fluids; 64% of fluids did not have the recommended potassium supplementation. Administration of a VRIII resulted in a significant drop in serum potassium levels ($p<0.0001$) for those who did not receive supplementation. There was no drop in serum potassium for those patients who did receive supplemental potassium. Eleven patients (6.4%) developed new-onset hypokalaemia ($K \leq 3.5$mmol/L) after implementation of a VRIII.

Our study supports the hypothesis that VRIIIs cause hypokalaemia and that this can be averted by supplemental potassium, thus preventing potentially avoidable hypokalaemic complications. A large variation exists in prescribing fluids with VRIIIs. Introduction of the national surgical and medical VRIII guidelines, together with improved availability to recommended fluids, and a quality improvement project, are our next steps to improve patient outcomes.

Practical Diabetes 2016; 33(5): 159–162

Key words

variable rate intravenous insulin infusion; electrolyte; hypokalaemia; intravenous fluids

- Initial study completed by **Dr Lloyd Rickard et al** in **2016**
- **Poor adherence** to JBDS Guidelines in **fluid prescribing** during VRIII and **hypokalaemia**
- As a result, **education** was delivered and **new trust guidelines** developed

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Project Aims

- **In keeping with JDBS guidelines, our primary aims were to achieve improvements on following parameters:**

1. **Fluid use:**

   (>80% of patients should be given IV fluids and potassium replacement in accordance to the JBDS guidelines.)

2. **Hypokalaemia reduction:**

   {<5% of patients should develop hypokalaemia (K <3.5) while on VRIII (aimed to improve from baseline audit – 6.4%)}.

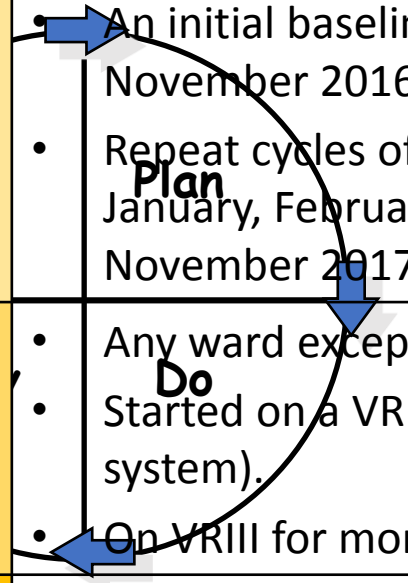
3. **Hypoglycaemia reduction:**

   {<20% of patients should develop hypoglycaemia (BG <4) while on VRIII (national average of hypoglycaemia rate on from NADIA 2015)}.

PDSA (**Plan**-Do-Study-Act)

Planning and methodology

Which data did we collect?	• Any adult on a variable rate intravenous insulin infusion (VRIII) between selected dates on any medical or surgical ward. • A list of parameters were be looked at.
How much data did we collect?	• An initial baseline of data of 10 weeks from September to November 2016. • Repeat cycles of 2 weeks of data collected in the months of January, February, March, September, October and November 2017.
What inclusion/ exclusion criteria were there?	• Any ward excepting ITU. • Started on a VRIII prescribed on PICS (electronic prescribing system). • On VRIII for more than 1 hour.
What interventions were used between each cycle of data collection and analysis?	• Education • Guidelines • Pharmacy involvement • Posters



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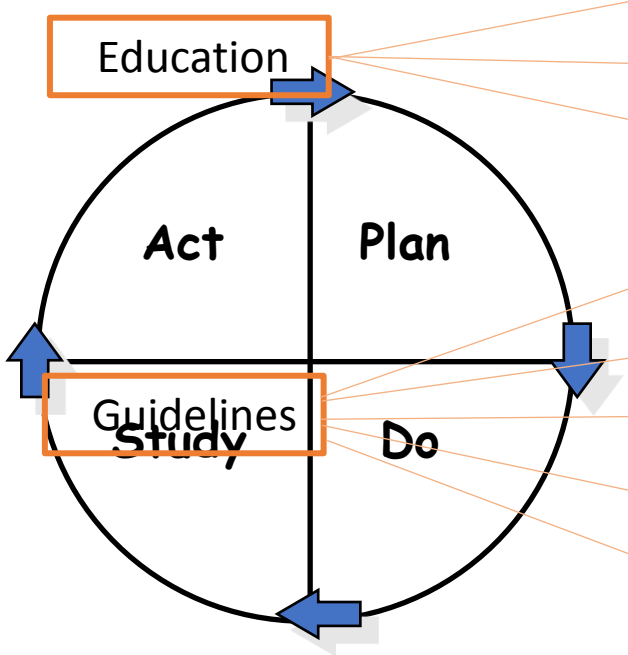
Driver diagram

PDSA (Plan-**Do**-Study-Act)

Project aims

1. >80% of patients should be given IV fluids and potassium replacement in accordance to the JBDS guidelines
2. <5% of patients should develop hypokalaemia (K <3.5) while on VRIII
3. <20% of patients should develop hypoglycaemia (BG <4) while on VRIII

Primary Drivers



Secondary Drivers

Education

- Doctors Education
- Nursing Education
- Experiential learning

Guidelines

- Intranet
- Trust approval
- Pharmacy/financial approval of fluids.
- Dissemination of information – posters/trust screen savers

Resources

- Safe monitoring of patients on VRIII
- Fluid availability from pharmacy
- Guidelines/ Posters

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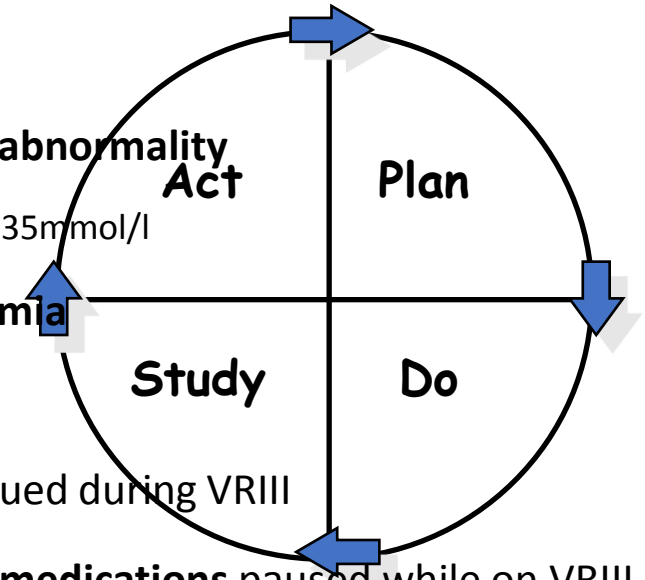
PDSA (Plan-Do-**Study**-Act)

- Parameters collected and analysed following each intervention:
  - **Fluid** use with VRIII and addition of **potassium**
  - **Daily** monitoring of **U+Es**
  - Number of episodes of **electrolyte abnormality**
    - Potassium <3.5mmol/l or Sodium <135mmol/l
  - Number of episodes of **hypoglycaemia**
  - Frequency of **CBG** measurements
  - Whether **long-acting insulin** continued during VRIII
  - Whether all **other insulin/diabetic medications** paused while on VRIII



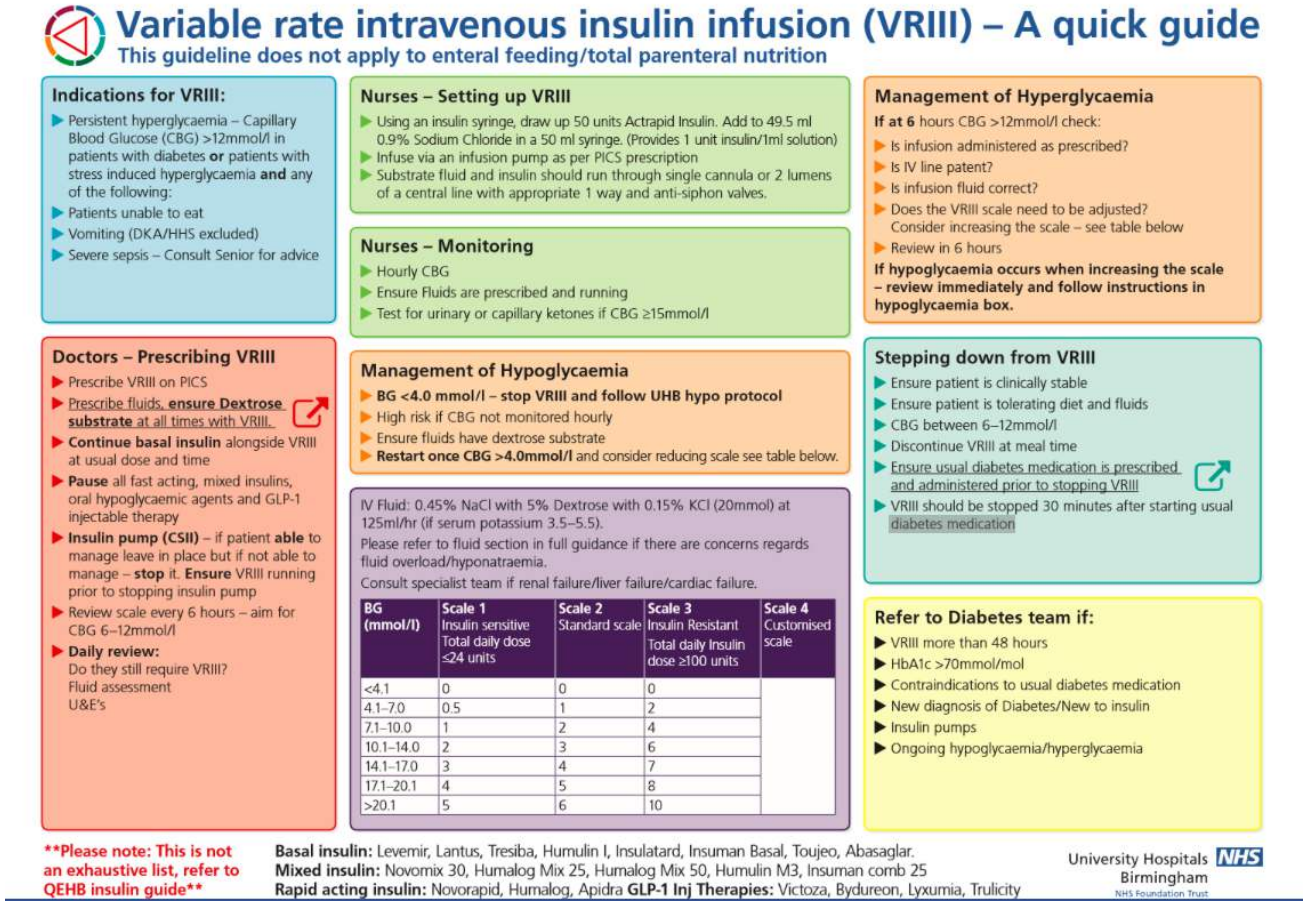
Test of change

PDS**A** (Plan-Do-Study-**Act**)

- Test the change with repeat data collection

Sep- Nov 2016 (Baseline)	Jan 17	Feb 17	Mar 17	Sep 17	Oct 17	Nov 17
10 weeks	2 weeks	2 weeks	2 weeks	2 weeks	2 weeks	2 weeks

	Cycle 1	Cycle 2	Cycle 3	Cycle 4	Cycle 5	Cycle 6
P	To improve the management of patients on VRIII in accordance with JBDS Guidelines: 1. >80% of patients given correct IV fluids 2. <5 % have K <3.5 while on VRIII 3. <20% have hypoglycaemia (BG <4) while on VRIII					
D	Presented baseline data/ education at grand round	Trust guidelines approved and on Intranet	Distribution and education of guidelines via posters Ward education Formal nurse/doctor teaching	Formal teaching to doctors at induction. Diabetes moodle made available Re-presented at Grand Round	F1 teaching as part of formal foundation teaching program	Experiential learning
S	Measured parameters of test of change (see run charts)					
A	Tested the change with repeat data collection					



Variable rate intravenous insulin infusion (VRIII) – A quick guide

This guideline does not apply to enteral feeding/total parenteral nutrition

Indications for VRIII:

- Persistent hyperglycaemia – Capillary Blood Glucose (CBG) >12mmol/l in patients with diabetes **or** patients with stress induced hyperglycaemia **and** any of the following:
- Patients unable to eat
- Vomiting (DKA/HHS excluded)
- Severe sepsis – Consult Senior for advice

Nurses – Setting up VRIII

- Using an insulin syringe, draw up 50 units Actrapid Insulin. Add to 49.5 ml 0.9% Sodium Chloride in a 50 ml syringe. (Provides 1 unit insulin/1ml solution)
- Infuse via an infusion pump as per PICS prescription
- Substrate fluid and insulin should run through single cannula or 2 lumens of a central line with appropriate 1 way and anti-siphon valves.

Nurses – Monitoring

- Hourly CBG
- Ensure Fluids are prescribed and running
- Test for urinary or capillary ketones if CBG ≥15mmol/l

Management of Hyperglycaemia

If at 6 hours CBG >12mmol/l check:

- Is infusion administered as prescribed?
- Is IV line patent?
- Is infusion fluid correct?
- Does the VRIII scale need to be adjusted? Consider increasing the scale – see table below
- Review in 6 hours

If hypoglycaemia occurs when increasing the scale – review immediately and follow instructions in hypoglycaemia box.

Doctors – Prescribing VRIII

- Prescribe VRIII on PICS
- Prescribe fluids, **ensure Dextrose substrate** at all times with VRIII.
- **Continue basal insulin** alongside VRIII at usual dose and time
- **Pause** all fast acting, mixed insulins, oral hypoglycaemic agents and GLP-1 injectable therapy
- **Insulin pump (CSII)** – if patient **able** to manage leave in place but if not able to manage – **stop** it. **Ensure** VRIII running prior to stopping insulin pump
- Review scale every 6 hours – aim for CBG 6–12mmol/l
- **Daily review:**
  Do they still require VRIII?
  Fluid assessment
  U&E's

Management of Hypoglycaemia

- **BG <4.0 mmol/l – stop VRIII and follow UHB hypo protocol**
- High risk if CBG not monitored hourly
- Ensure fluids have dextrose substrate
- **Restart once CBG >4.0mmol/l** and consider reducing scale see table below.

IV Fluid: 0.45% NaCl with 5% Dextrose with 0.15% KCl (20mmol) at 125ml/hr (if serum potassium 3.5–5.5).

Please refer to fluid section in full guidance if there are concerns regards fluid overload/hyponatraemia.

Consult specialist team if renal failure/liver failure/cardiac failure.

BG (mmol/l)	Scale 1 Insulin sensitive Total daily dose ≤24 units	Scale 2 Standard scale	Scale 3 Insulin Resistant Total daily Insulin dose ≥100 units	Scale 4 Customised scale
<4.1	0	0	0	
4.1–7.0	0.5	1	2	
7.1–10.0	1	2	4	
10.1–14.0	2	3	6	
14.1–17.0	3	4	7	
17.1–20.1	4	5	8	
>20.1	5	6	10	

Stepping down from VRIII

- Ensure patient is clinically stable
- Ensure patient is tolerating diet and fluids
- CBG between 6–12mmol/l
- Discontinue VRIII at meal time
- Ensure usual diabetes medication is prescribed and administered prior to stopping VRIII
- VRIII should be stopped 30 minutes after starting usual diabetes medication

Refer to Diabetes team if:

- VRIII more than 48 hours
- HbA1c >70mmol/mol
- Contraindications to usual diabetes medication
- New diagnosis of Diabetes/New to insulin
- Insulin pumps
- Ongoing hypoglycaemia/hyperglycaemia

****Please note: This is not an exhaustive list, refer to QEHB insulin guide****

Basal insulin: Levemir, Lantus, Tresiba, Humulin I, Insulatard, Insuman Basal, Toujeo, Abasaglar.
Mixed insulin: Novomix 30, Humalog Mix 25, Humalog Mix 50, Humulin M3, Insuman comb 25
Rapid acting insulin: Novorapid, Humalog, Apidra **GLP-1 Inj Therapies:** Victoza, Bydureon, Lyxumia, Trulicity

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VRIII Poster

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Trust guidelines

CONTROLLED DOCUMENT

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The Use of Variable Rate Intravenous Insulin Infusion (VRIII) in Medical Patients

CATEGORY:	Clinical Guidelines
CLASSIFICATION:	Clinical
Controlled Document Number:	CG256
Version Number:	1
Controlled Document Sponsor:	Clinical Guidelines Group
Controlled Document Lead (Author):	Sofia Salahuddin - Consultant Diabetes Brighid Lane – Diabetes Specialist Nurse Deborah Dawson – Diabetes Specialist Nurse Lesley Peters – Diabetes Specialist Nurse
Approved By:	Clinical Guidelines Group
On:	February 2017
Review Date:	February 2020

Results

Demographics

	Baseline	Jan-17	Feb-17	Mar-17	Sep-17	Oct-17	Nov-17
Total number of VRIII episodes (final cohort)	182	23	27	16	42	54	36
Mean age	63	61	63	64	58	58	58
Male: Female ratio	113:69	16:07	12:15	09:07	19:23	33:21	19:17

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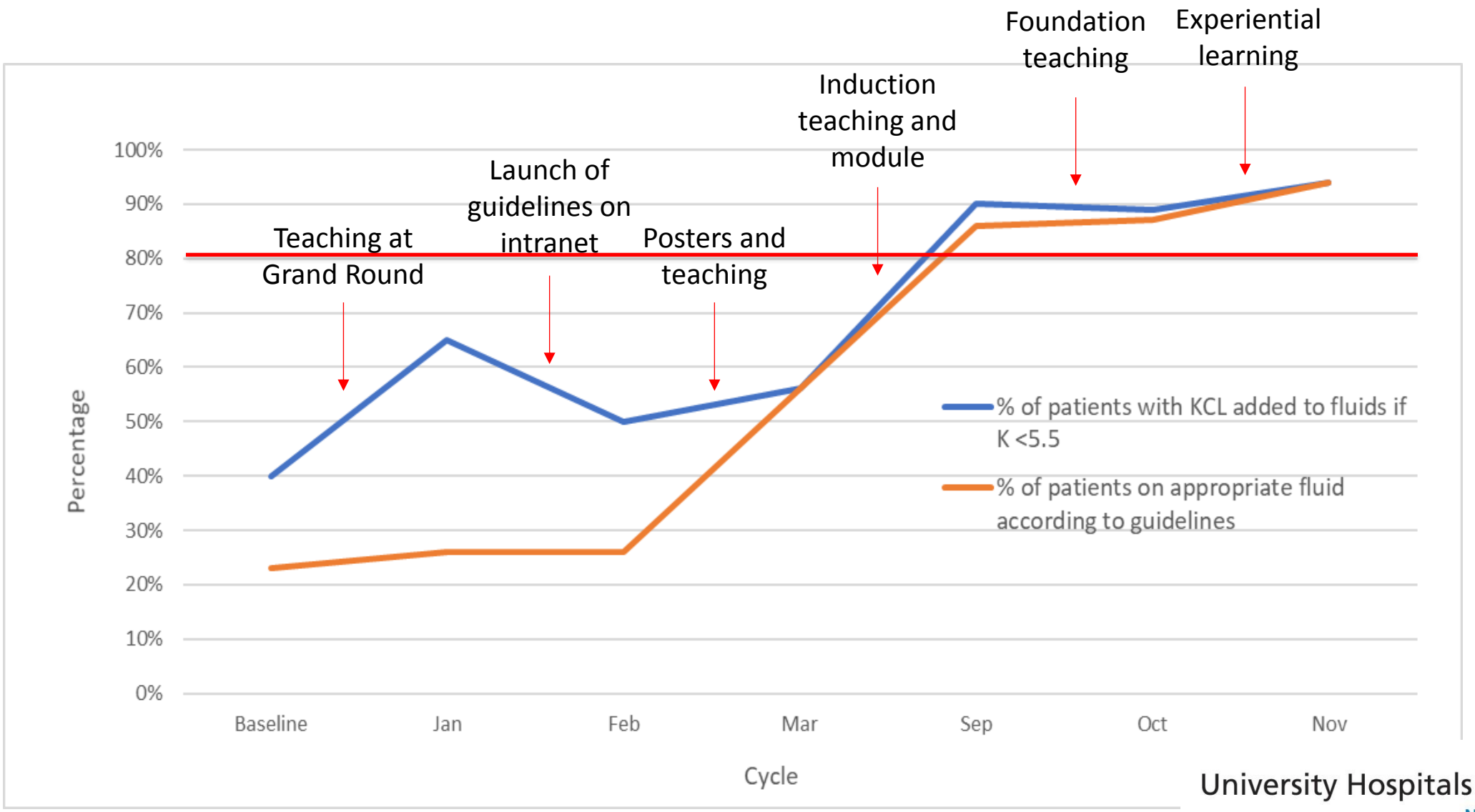
Fluid use with VRIII

P= <0.0001

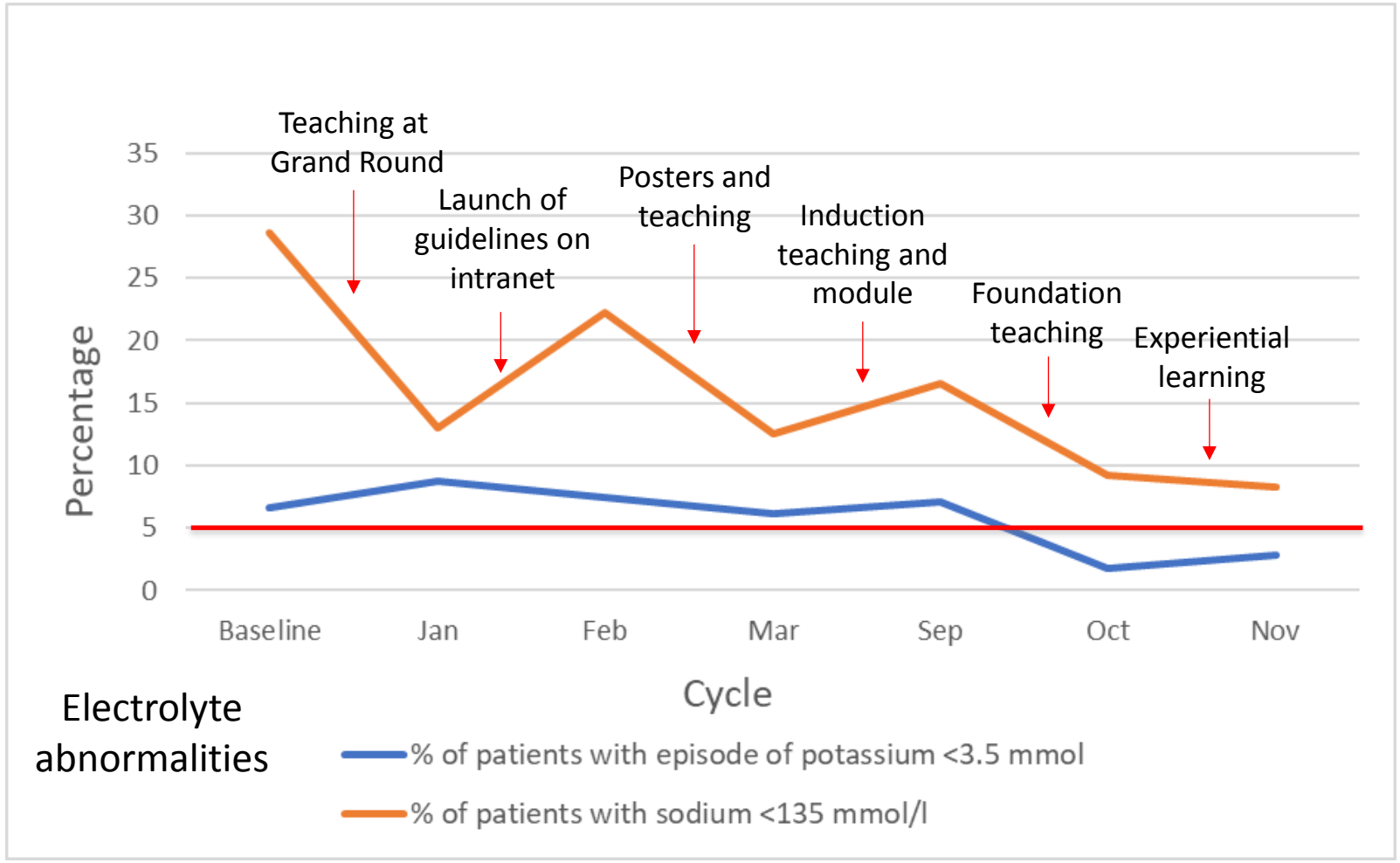
Most common type of fluid prescribed	Baseline (182)	Jan 17 (23)	Feb 17 (27)	Mar 17 (16)	Sep 17 (42)	Oct 17 (54)	Nov 17 (36)
5% dextrose	54 (29%)	5 (22%)	2 (7%)	1 (6%)	0 (0%)	1 (2%)	0 (0%)
0.9% NaCl	47 (26%)	6 (26%)	10 (37%)	2 (12%)	2 (5%)	1 (2%)	2 (5%)
0.9% NaCl/ 5% glucose	27 (15%)	6 (26%)	1 (4%)	0 (0%)	7 (17%)	5 (9%)	6 (17%)
Hartmanns	17 (9%)	3 (13%)	1 (4%)	1 (6%)	0 (0%)	0 (0%)	0 (0%)
0.45% NaCl/ 5% glucose	14 (8%)	3 (13%)	6 (22%)	9 (56%)	29 (69%)	42 (78%)	28 (78%)
No fluids	14 (8%)	0 (0%)	1 (4%)	1 (6%)	2 (5%)	3 (5%)	0 (0%)
0.18% NaCl/ 4% glucose	7 (4%)	1 (4%)	3 (11%)	1 (6%)	1 (2%)	1 (2%)	0 (0%)
Other	2 (1%)	2 (9%)	3 (11%)	1 (6%)	1 (2%)	1 (2%)	0 (%)

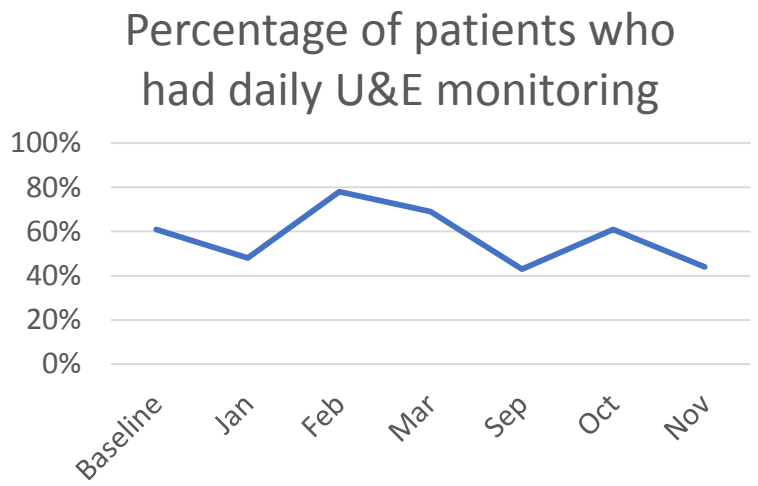
Run chart: Percentage of patients on correct fluids and if potassium added



Project aim based on JDBS guidelines

Electrolytes





Project aim based on JDBS guidelines

Reduction in episodes of hyponatraemia from 28.6% to 8.3% (p=0.01)

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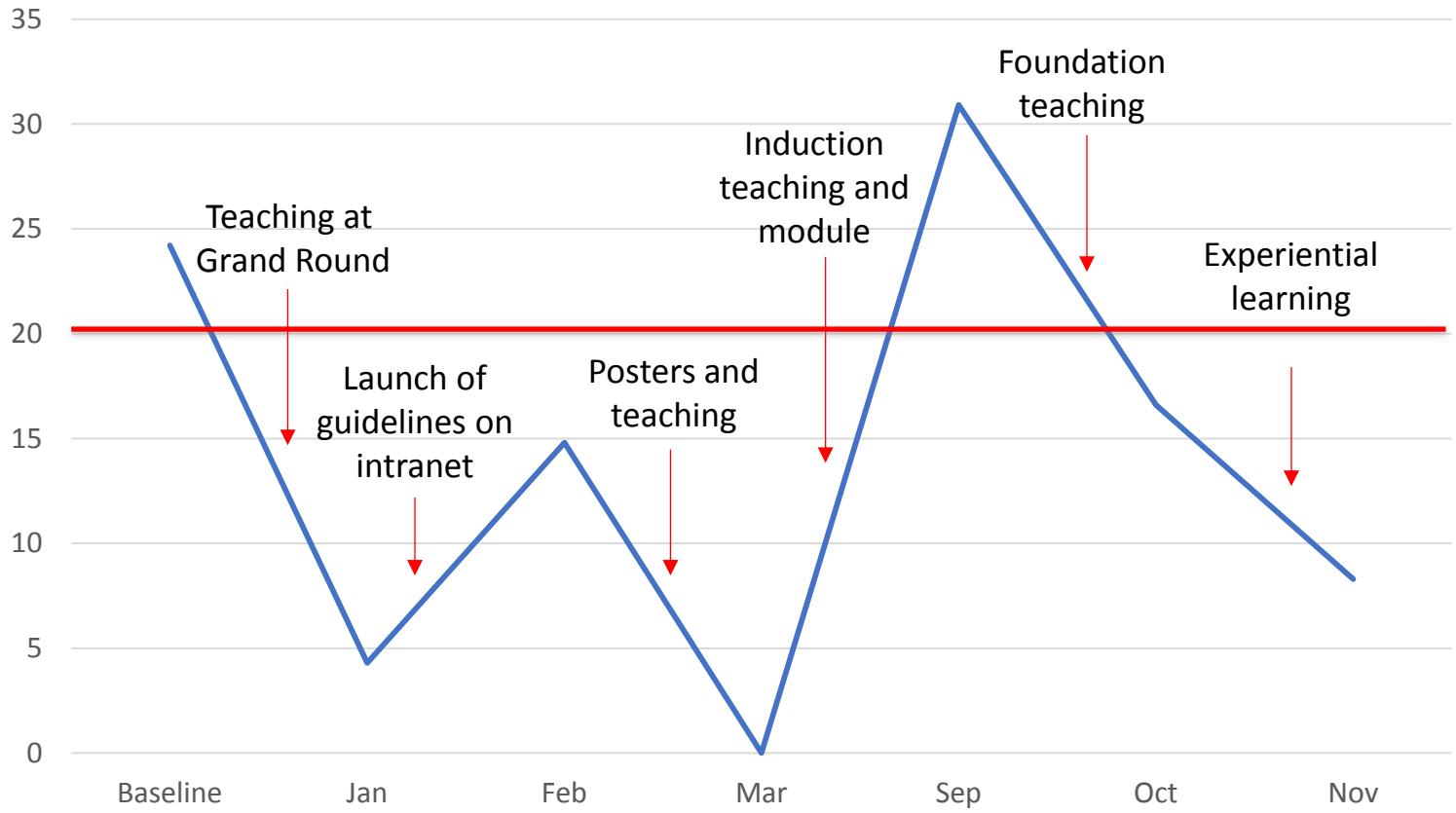
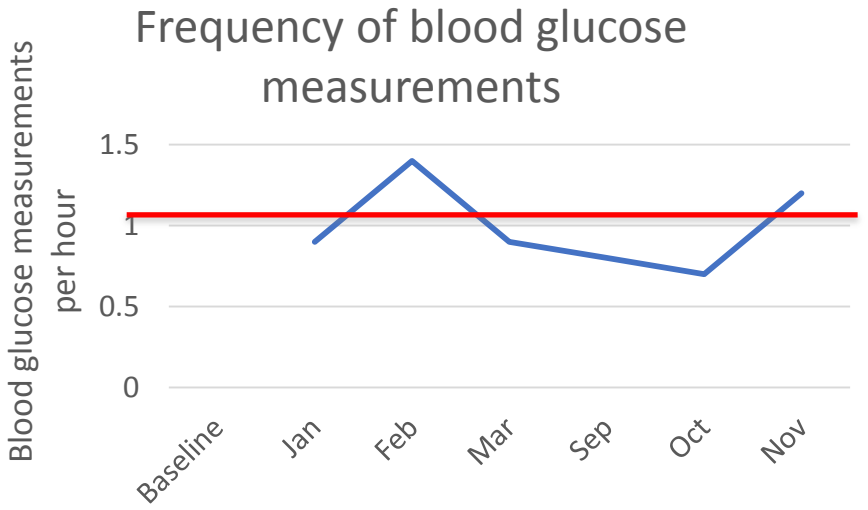
CBG measurements and hypoglycaemia



Percentage of patients with at least one episode of hypoglycaemia (CBG <4mmol/)



Project aim based on JDBS guidelines

Reduction in episodes of hypoglycaemia from 24.2% to 8.3% (p=0.03)

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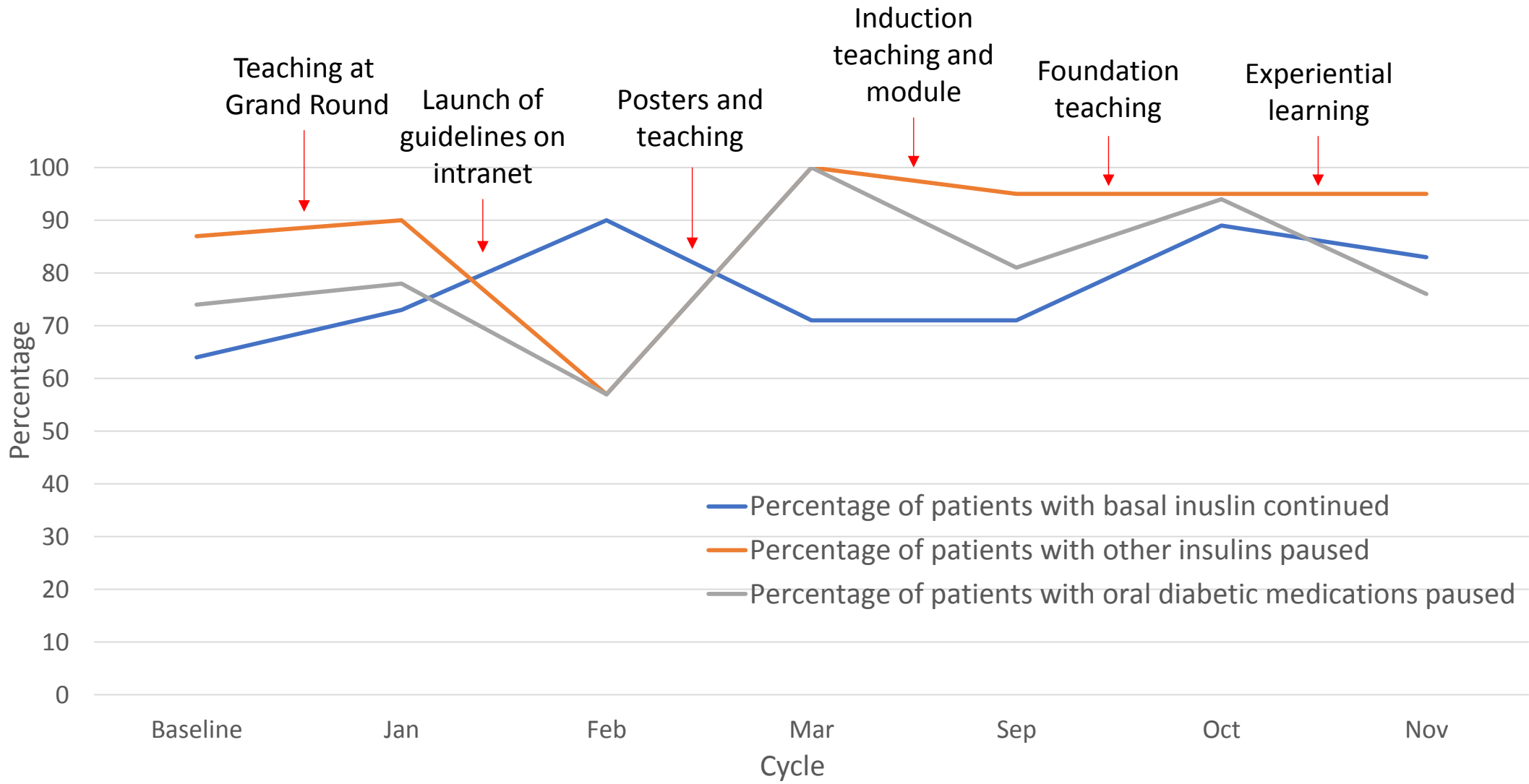
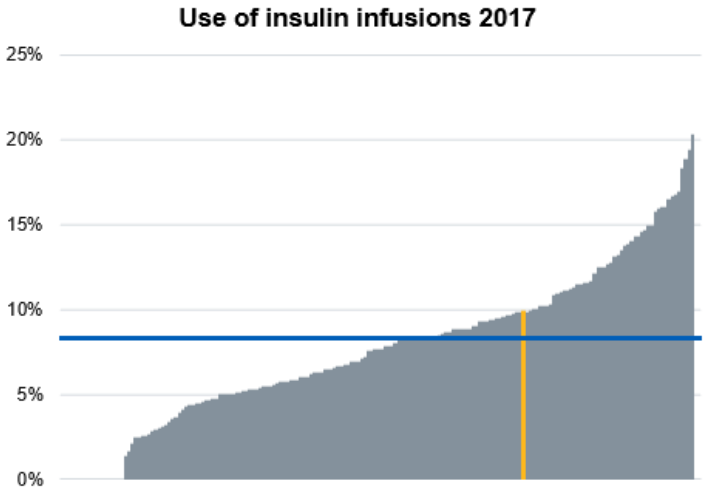
Diabetic medications and long acting insulin



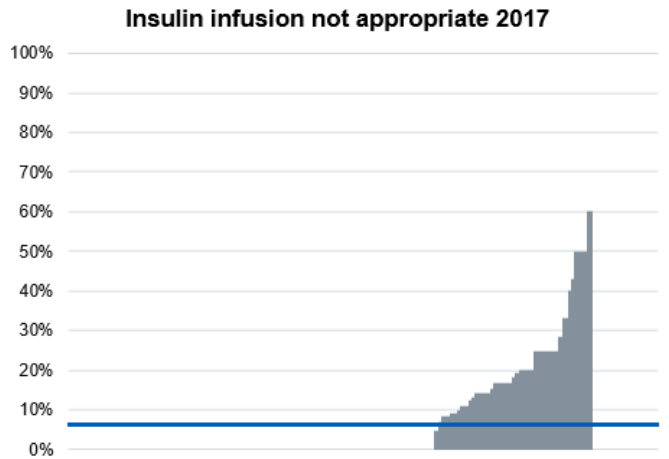
NaDIA 2017: QEHB use and inappropriate use of insulin infusions



Use of insulin infusions 2010 - 2017

Audit year	Chosen site	Quartile	England
2010	18.0%	Quartile 4	12.5%
2011	12.3%	Quartile 3	11.3%
2012	16.3%	Quartile 4	10.6%
2013	16.0%	Quartile 4	10.1%
2015[b]	17.8%	Quartile 4	9.0%
2016	16.8%	Quartile 4	8.2%
2017	9.9%	Quartile 3	8.3%

b = break in time series.



The 2017 chart value for Queen Elizabeth Hospital (Birmingham) is 0.0%.

Insulin infusion not appropriate 2010 - 2017

Audit year	Chosen site	Quartile †	England
2010	4.3%	N/A	7.4%
2011	6.3%	N/A	6.8%
2012	4.0%	N/A	6.5%
2013	3.2%	N/A	6.4%
2015[b]	5.3%	N/A	6.2%
2016	5.7%	N/A	7.4%
2017	0.0%	N/A	6.3%

b = break in time series.

† Where N/A is returned, it is not possible to assign results to quartiles

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Have we made a difference?

- Implemented trust guidelines to improve standard of care for all patients treated with VRIII
- Appropriate fluid choice increased from **23%** at baseline to **95%** at the final cycle (**p=<0.0001**)
- Reduction in the incidence of episodes of hyponatraemia from **28.6%** to **8.3%** (**p=0.01**)
- Reduction in the incidence of episodes of hypoglycaemia from **24.2%** to **8.3%** (**p=0.03**)
- Absolute (but non significant) reduction in incidence of hypokalaemia from 6.6% to 2.8% (p=0.38)
- Reduction in use of VRIII by nearly **80%** from 2016 with no inappropriate use

Financial implications

- **Hypoglycaemia costs/ savings**
  - Average cost of hypoglycaemia in VRIII= **£2235**
  - Average no. of patients on VRIII in 2 weeks= **36**
  - Hypo pre vs post **24.2% : 8.3%**
  - Savings in 2 wee
  - Savings in 1 year
- **Hyponatraemia**
  - Average cost of **£1670**
  - Hyponatraemia post fluid introduction= **28.6%: 8%**
  - Savings over 2 weeks = £12024
  - Savings in 1 year= **£312, 624**
- **Fluid costs (Potassium Chloride 0.15% in Sodium Chloride 0.45% & Glucose 5% (500ml)**
  - Cost per bag= **£3.43**
  - Use)
  - eks = £193.12
  - **fluid)**
  - 021 x £3.43)=

Annual saving of over £600 k for a single hospital with improved patient outcomes.

First presented efficacy report of the JBDS recommended 'expensive' fluid.

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Where to go from here?

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- **Development of VRIII management quality standards for audit**:
  - Recommended fluid use in non-critical care areas to be more than 90%
  - Continuation of long acting insulin while on VRIII in more than 90% patients
  - Average glucose monitoring per hour while on VRIII should not be less than 1
  - Senior review daily if VRIII more than 24 hours
- **Proposal of National QIP:**
  - No previous evidence to suggest economic benefits of this expensive fluid
  - This QIP shows evidence of economic benefit
  - Baseline survey questionnaire to find out more on the current use of VRIII in different hospitals
    - Then initiate QIP.
    - Liaison with RC Anaesthetists and RC Physicians required.
- **Future Research:**
  - Possible trials with continuous glucose monitoring / flash glucose monitoring in this cohort.
  - Possibility of testing Hypoglycemia Prevention by Algorithm Design in VRIII in UK population.

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Thank you for listening

- Any questions?

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