

Diabetic Ketoacidosis: Quality Analysis and Improvement

Northwestern Medicine

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Glycemic Control Committee Co-Chair, NM

Summer 2018



Overview

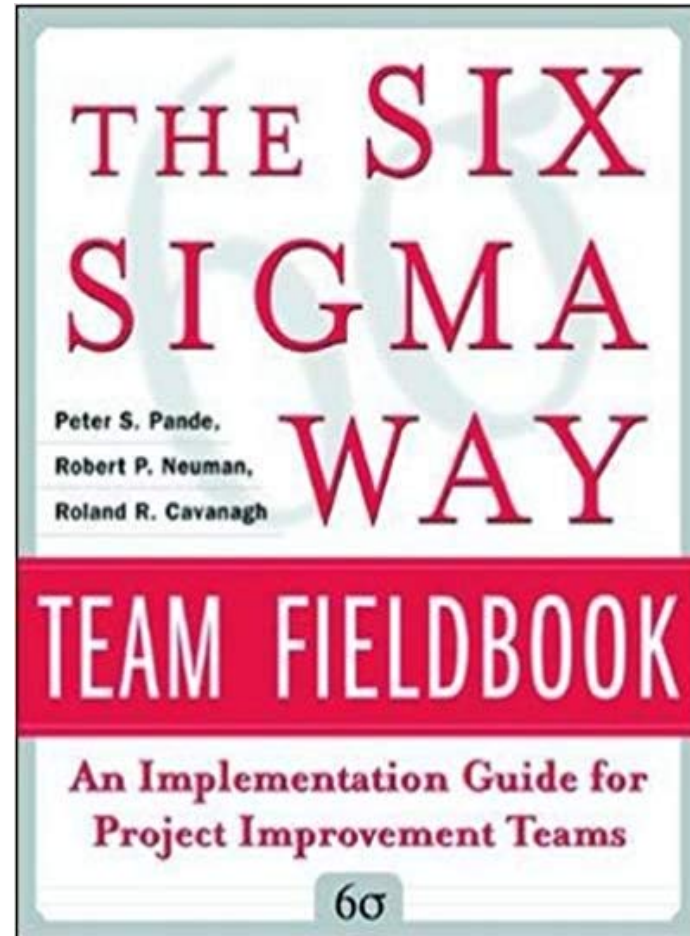
- ▶ Concept -> Ideation to Reality
- ▶ Infrastructure
- ▶ Methodology
- ▶ Baseline Data
- ▶ Protocol Implementation
- ▶ Post Protocol Data
- ▶ Improvement Recommendations

Utilization of Infrastructure

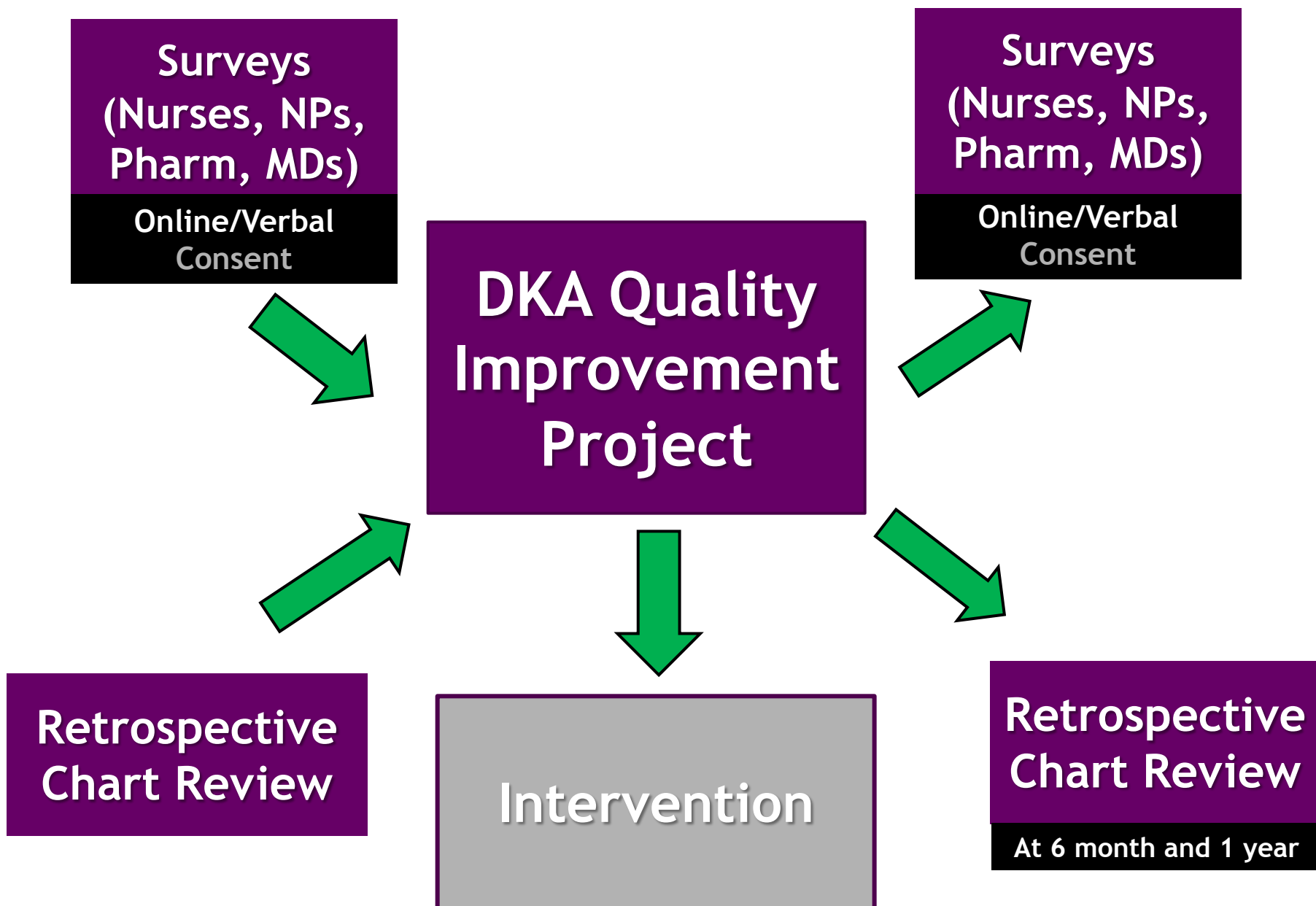
- ▶ Academy for Quality and Safety Improvement
 - ▶ Collaboration between the Department of Medicine and the Center for Healthcare Studies, and NM Process Improvement
- ▶ Application to address Diabetic Ketoacidosis
- ▶ Capitalized on both research, trainee, and quality infrastructure

DMAIC Methodology with Formal Training

- ▶ Define
- ▶ Measure
- ▶ Analyze
- ▶ Improve
- ▶ Control



Outline for Research Methods



Building a Database: Inclusion Criteria

- ▶ Diabetes and DKA diagnosis code
 - ▶ 250.10, 250.11, 250.12, 250.13
 - ▶ E08.10, E08.11, E09.10, E09.11, E10.10, E10.11, E11.69, E13.10, E13.11
- ▶ Diabetes and DKA lab criteria
 - ▶ 250.XX, E08.xx, E09.xx, E10.xx, E11.xx, E13.xx
 - ▶ Glucose ≥ 250 mg/dL **and** HOC3 ≤ 18 **and**
Arterial pH ≤ 7.32 or Venous pH ≤ 7.22
- ▶ DKA Intravenous Insulin Infusion Protocol Order Set

Baseline Data

Jan 1, 2010- June 30, 2013

N=310 Encounters (240 patients)

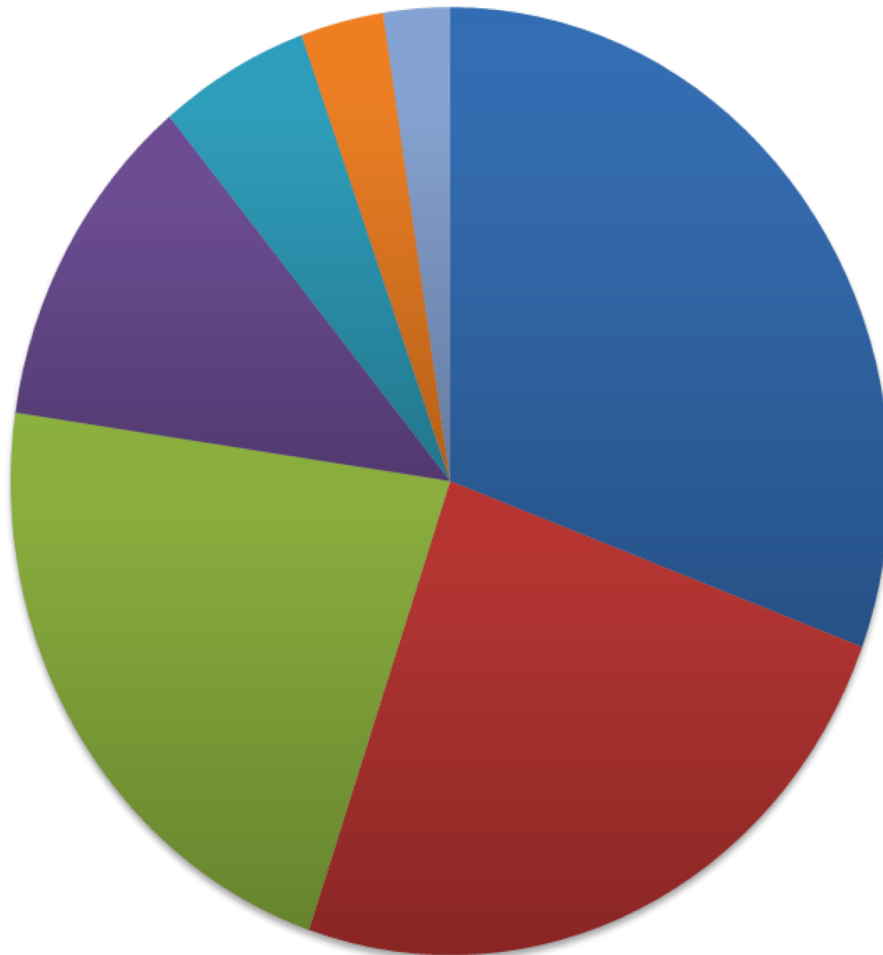
▶ Quantitative Data

- ▶ 70 of 310 (22.6%) DKA readmissions
- ▶ 25 of 240 (10.4%) patients readmitted during study timeframe (other dx)

▶ Qualitative Data (provider surveys)

- ▶ Where do you think improvements in care are needed?

Survey Results



■ Clinical care management (choice of insulin doses) in ER or ICU

■ Metabolic derangements (orders for potassium, dextrose, etc)

■ Transition to floor order set

■ Discharge planning

■ Delivery of insulin from pharmacy

■ Patient barriers

■ All of the above

AQSI- DKA TREATMENT GUIDELINES

Do not use if Cr >3, Can consider Endocrinology

Consult if GFR < 30

Monitor	
Arrival	VS, ABG, CBC, BMP, PO ₄ , Mg ⁺⁺ , UA
Q 1 hr	VS, I&O, Accucheck or ABG-glucose value
Q 2 hr	BMP and ABG (PRN)
Q 4 hr	Ca ⁺⁺ , PO ₄ , Mg ⁺⁺

Electrolytes
Add 40 mEq KCL to IV infusion after first void and if K ⁺ < 4.5
Optional - If PO ₄ <2 mEq/l consider a phosphate rider

CRITERIA FOR ICU ADMISSION Triage with Arterial Blood Gases
Admit to ICU if: (2 or > present, and @ Physician Discretion)
1. BG>250, HCO ₃ <10, pH<7.25 (by ABG)
2. Secondary factors:
<ul style="list-style-type: none"> • Fever • Hypotension • Infection • Evidence of infiltration on Chest X ray • Elevation of troponin level or cardiac dysfunction • CKD III or worse
3. Admission time from ED 8 PM-5 AM
4. Expected IV drip duration of ≥ 6 hours
CRITERIA FOR FLOOR/ OBSERVATION ADMISSION
Admit to ER Observation or Floor if: (ALL 3)
1. BG ≤ 250, HCO ₃ >15, pH >7.25 (by ABG)
2. Expected IV drip duration of < 6 hours
3. Admission time from ER 5 AM-8 PM

**On Admission Orders:
Order Diabetes Education if Applicable**

INSULIN PROTOCOL

TABLE 1. INITIAL INSULIN DOSE AND INFUSION RATE

Blood Glucose	Bicarb	Insulin Bolus Dose	Insulin Infusion Rate	IV Fluid Bolus	IV Fluid Rate per MD Orders
>300	<18	0.1unit/kg Bolus	0.1unit/kg	0.9N% NaCl 1-2 L bolus	0.9%NaCl

TABLE 2. BLOOD GLUCOSE INCREASING TITRATION TABLE (> 50 mg/dl)

Current Glucose	Bicarb	Insulin Drip Titration (u/hr)	IV FLUIDS
>250	<18	INCREASE infusion by 50% of current rate	0.9%NaCl
151-250	<18	INCREASE infusion by 25% of current rate	CHANGE TO: D5% 0.45%NaCl
101-150	<18	NO CHANGE	CONTINUE D5% 0.45%NaCl

TABLE 3. BLOOD GLUCOSE DECREASING TITRATION TABLE

Blood Glucose Decrease					
Current Glucose	Bicarb	LESS THAN 50mg/dl	BETWEEN 50-100mg/dl	GREATER THAN 100mg/dl	IV FLUIDS
>250	<18	INCREASE infusion by 50% of current rate	NO CHANGE	DECREASE infusion by 25% of current rate	0.9%NaCl
151-250	<18	NO CHANGE	DECREASE infusion by 25% of current rate	DECREASE infusion by 50% of current rate	CHANGE TO: D5% 0.45%NaCl
101-150	<18	DECREASE infusion by 50% of current rate	DECREASE infusion by 75% of current rate	DECREASE infusion by 75% of current rate	CONTINUE D5% 0.45%NaCl
71-100	<18	DECREASE infusion by 75% of current rate	STOP INFUSION Page service for orders	STOP INFUSION Page service for orders	CONTINUE D5% 0.45%NaCl
≤70	<18	STOP INFUSION , give 15 g carb PO or 25 ml of 50% dextrose IV, recheck glucose q 20 min until greater than 70, then hourly. Restart insulin infusion at 25% of previous rate if glucose is 100-150. Restart insulin infusion at 50% of previous drip rate once glucose is greater than 150 mg/dl.			D5% 0.45%NaCl

PROVIDER CRITERIA FOR TRANSFER FROM IV TO SUBQ:

BG \leq 250 mg/dL, HCO₃ \geq 18, able to take oral intake
 Patient transitioning to subcutaneous insulin regimen (or ICU to Floor)

THE FOLLOWING OCCURS AT THE SAME TIME

Convert to Subcutaneous Insulin when patient has the following: Glucose \leq 250mg/dl, and HCO₃ \geq 18 can start Basal/Bolus Insulin per below(RN to page pharmacist to expedite Glargine administration)

1-Discontinue D5/0.45% NaCl , if tolerating po

2- Give Glargine Insulin (long acting) 0.3 units/kg OR by drip rate [50% of Total Daily Dose estimated from stable 4 hour drip rate]. If greater than 20% discrepancy between both calculations and/or from the home dose of long acting insulin, consider Endo consult)

3- Give Lispro Insulin (bridge dose) = 10% of Glargine Dose at same time as Glargine

4- Discontinue insulin drip after pt receives Glargine and Lispro bridge insulin injections

AFTER 1-4 HAS BEEN DONE:

Check Glucose 2 hrs after insulin drip is discontinued & cover per Lispro supplemental scale

Subcutaneous Insulin Regimen Guidelines

Diet	Accucheck	Subcutaneous Insulin Regimen
NPO	Q 4 hrs	Lispro medium dose supplemental scale if glucose >150mg/dl
Eating	Q AC	Lispro 0.1 unit/Kg (if greater than 20% discrepant from 33% glargine dose with each meal OR from the home dose of Lispro, consider Endo consult) Lispro medium dose supplemental scale if glucose > 150mg/dl

Lispro Medium Dose Supplemental Scale

Glucose (mg/dL)	Lispro Dose (Units)-subcutaneous
151-200	1
201-250	3
251-300	5
301-350	7
351-400	9

Criteria for DM education consult:

New Diagnosis of DM (Type 1 or 2)
 Recurrence of DKA within 30 days
 Length of stay >3 days (related to glucose control)
 Inability to manage d/c DM home regimen

Criteria for Consideration of Endocrine consult:

DM and CKD (Stage 3 or >)
 Need to start D10% infusion
 New Diagnosis of DM (Type 1)
 Length of stay >3 days (related to glucose control)

Criteria for Discharge to Home (All criteria)

- Hemodynamic and metabolic stability (bicarb > 18, K < 5.5, Mean glucose <300)
- Determine diabetes knowledge, consult DM Educator or case management as needed (able to self-monitor glucose levels and administer insulin)
- Schedule appointment with PCP or Endocrinologist in 2-4 weeks
- Patient has insulin/supplies (able to obtain insulin-verification of coverage through pharmacy, social work vouchers as needed)
- Tolerating PO intake
- Resolution of any precipitating medical factor(s)

DKA Protocol Implementation

Launch Date: July 1, 2015

- ▶ **NM Departments Involved**
 - ▶ **Emergency Department**
 - ▶ **MICU**
 - ▶ **Medicine**
 - ▶ **Endocrinology**

Implementation Methods

▶ Education Training

- ▶ Glucose Management Service and Certified Diabetes Educator led training of bedside nurses with quiz (ED/Medicine)
- ▶ Endocrine Attending modular lecture to resident physicians (ED/Medicine)
- ▶ Endocrine led seminar (Endocrine Fellows)

▶ Resources

- ▶ DKA pocket card distributed to all residents

▶ IT Intervention

- ▶ Powerchart Order set
- ▶ DKA protocol available on NM Resources page

Patient Population

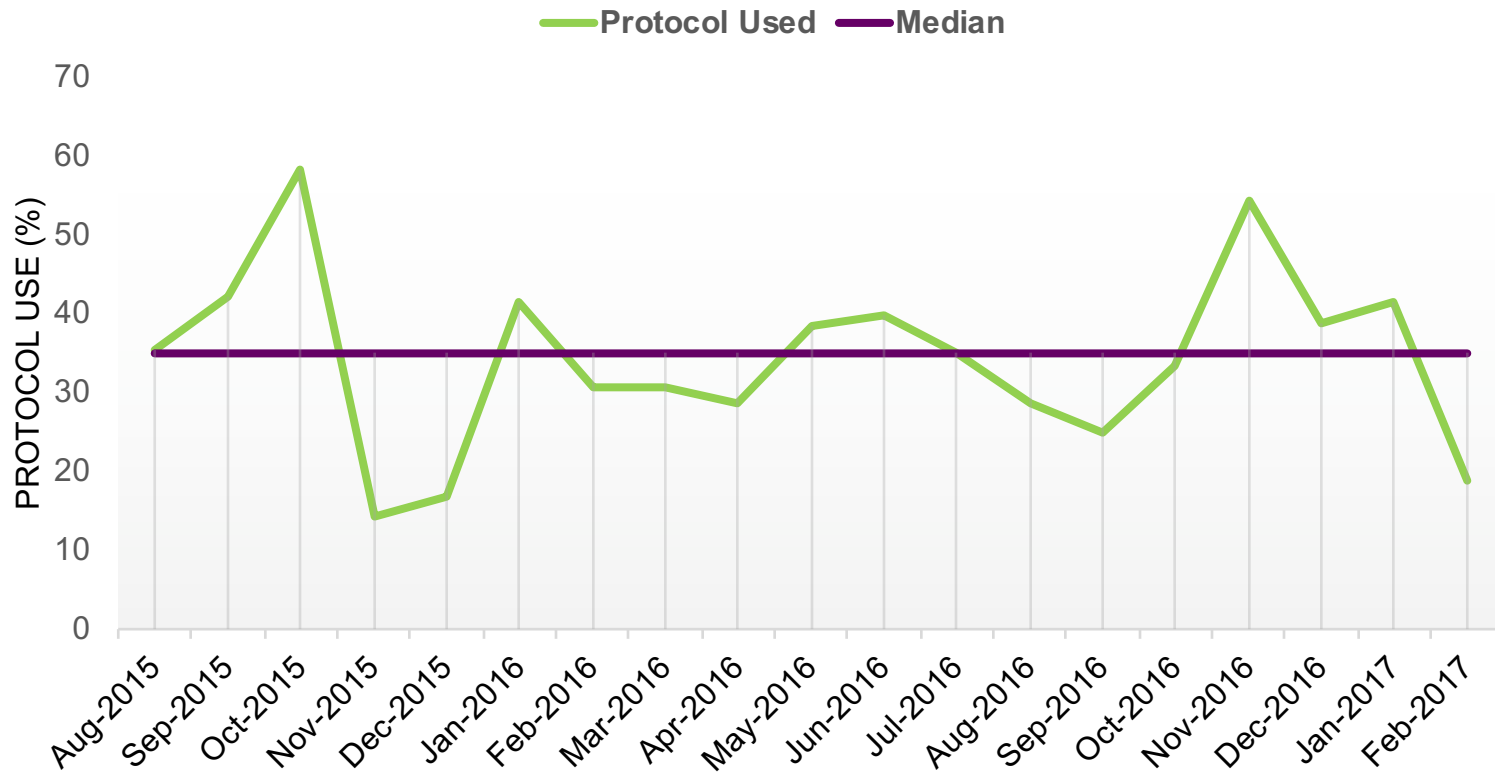
Baseline and Post Protocol Implementation

	1/1/2010-6/30/2013	8/1/2015-2/28/2017
	Baseline N=240	Post N=256
Age, median (min, max)	41.5 (19, 92)	57 (18, 91)
BMI*	27.7 ± 8.2	30.0 ± 10.9
Sex n (%)		
Male	124 (51.7)	138 (53.9)
Female	116 (48.3)	118 (46.1)
Race, n(%)		
Black or African American*	109 (45.4)	57 (22.3)
Hispanic or Latino*	24 (10.0)	10 (3.9)
White	103 (42.9)	128 (50.0)
Other*	4 (1.7)	44 (17.2)
Declined or not Reported*	0	17 (6.6)
Diabetes Status, n (%)*		
T1D	210 (67.7)	96 (32.5)
T2D	100 (32.2)	154 (52.2)
Unknown		45 (15.3)
* p value <0.01		

Post Protocol Implementation

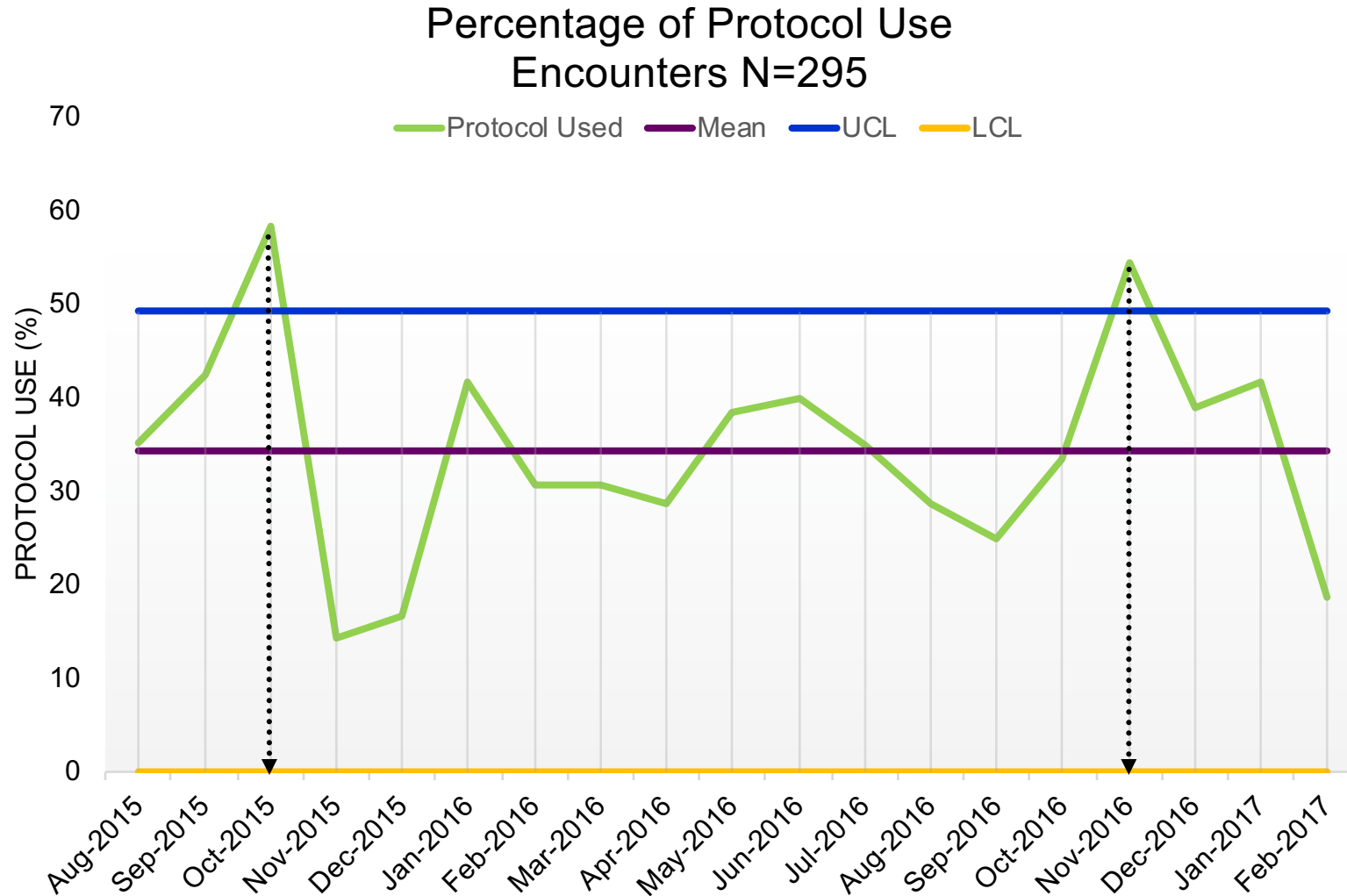
Aug 1, 2015-Feb 28, 2017

Percentage of DKA Protocol Use
Encounters N=295



Post Protocol Implementation

Aug 1, 2015-Feb 28, 2017



Qualitative Data

Front Line Provider Interviews (N=11)

- ▶ Knowledge, Workflow, Improvements
 - ▶ Endocrinology (3)
 - ▶ Medicine (1)
 - ▶ Emergency Department (3)
 - ▶ Management (1)
 - ▶ Lurie Children's ED(3)

GO UPSTREAM: ED Specific Needs

- ▶ Delay in Protocol Initiation
 - ▶ ED lab confirmation (estimated 45min-1hr)
 - ▶ Leads to MD workarounds to initiate insulin
- ▶ Protocol Suggestion Tool
 - ▶ EMR “nudge” for DKA protocol use connected to chief complaint

Diagnosis: DKA Status Classification

- ▶ Classification of Protocols
 - ▶ Clinical status vs. location based
- ▶ Mild or Moderate DKA

Moderate or Mild DKA Defined

Table 1—Diagnostic criteria for DKA and HHS

	DKA		Severe (plasma glucose >250 mg/dl)	HHS
	Mild (plasma glucose >250 mg/dl)	Moderate (plasma glucose >250 mg/dl)		Plasma glucose >600 mg/dl
Arterial pH	7.25–7.30	7.00 to <7.24	<7.00	>7.30
Serum bicarbonate (mEq/l)	15–18	10 to <15	<10	>18
Urine ketone*	Positive	Positive	Positive	Small
Serum ketone*	Positive	Positive	Positive	Small
Effective serum osmolality†	Variable	Variable	Variable	>320 mOsm/kg
Anion gap‡	>10	>12	>12	Variable
Mental status	Alert	Alert/drowsy	Stupor/coma	Stupor/coma

*Nitroprusside reaction method. †Effective serum osmolality: $2[\text{measured Na}^+ \text{ (mEq/l)}] + \text{glucose (mg/dl)}/18$. ‡Anion gap: $(\text{Na}^+) - [(\text{Cl}^- + \text{HCO}_3^- \text{ (mEq/l)})]$. (Data adapted from ref. 13.)

Protocol Used in Sicker Patients

	Protocol Eligible Protocol Used	Protocol Eligible Protocol NOT Used
Encounters	100	195
Glucose*	520.6 ± 547.5	343.1 ± 122.0
Bicarbonate*	10.8 ± 4.4	14.9 ± 3.7
VBG pH	7.1 ± 0.1	7.1 ± 0.1
A1c*	10.9 ± 1.9	8.5 ± 2.5
*p value <0.0001		

Protocol not used in mild/moderate DKA

	Protocol Used		Protocol	NOT Used
	DKA Dx N= 97	DM Dx + Lab Criteria N= 3	DKA Dx N= 49	DM Dx + Lab Criteria N= 146
Inpt LOS	2.9 ± 4.2	7.21 ± 3.9	4.9 ± 19.6	5.9 ± 6.3
Glucose	411.4 ± 184.0	949.3 ± 667.4	430.7 ± 158.2	313.7 ± 89.7
Bicarbonate	13.0 ± 4.6	14 ± 1.63	12.5 ± 4.3	15.7 ± 3.1
VBG pH	7.1 ± 0.1	7.2 ± 0.1	7.1 ± 0.1	7.1 ± 0.1
A1c	9.8 ± 2.5	-	10.0 ± 2.6	7.7 ± 2.0
Endo Consult	68 (70.0)	0	35 (71.4)	82 (56.1)
CDE Consult	49 (50.5)	1 (33.3)	19 (38.8)	10 (6.8)

Areas of Improvement

- ▶ Delay in initiation of DKA protocol
- ▶ Electronic prompts and easy access
- ▶ Further define appropriateness of DKA protocol use

Potential Protocol Updates

Endocrine MD Input

Goal:

- Increase use of DKA protocol appropriately in those with “Moderate DKA”
- Ensure provider knowledge about those eligible for DKA protocol
- Expedite labs (bicarbonate, glucose) if possible

Chief Complaint → DKA

1. ED labs drawn
 - If VBG ≤ 7.24 → draw accurate bicarbonate ASAP
2. Draw ABG
 - If Bicarbonate value is < 15

VBG(reminder) expedited

- pH ✓
- bicarbonate ✗
- pCO₂ ✗

Look for low hanging fruit...

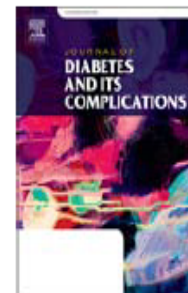
- ▶ **New rapid assay for Beta Hydroxybutyrate – assay to help identification for those with diabetic ketoacidosis**
- ▶ **Worked towards publication of preliminary findings**



Contents lists available at ScienceDirect

Journal of Diabetes and Its Complications

journal homepage: WWW.JDCJOURNAL.COM



Validation of data from electronic data warehouse in diabetic ketoacidosis: Caution is needed[☆]



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Thank you

- ▶ Students
 - ▶ Teresa (Derby) Pollack
 - ▶ Jennifer Vander Weele
- ▶ Project Mentors
 - ▶ Dr. Jane Holl
 - ▶ Dr. Kevin O'Leary
- ▶ Endocrinology
 - ▶ Dr. Grazia Aleppo
 - ▶ Dr. Mark Molitch
 - ▶ Colleen Smyrniotis, CDE, APN
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- ▶ NM Quality
 - ▶ Joanne Prinz
 - ▶ Ming Zang
- ▶ ED Team
 - ▶ Dr. Emilie Powell
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 - ▶ Dr. Aashish Didwania
- ▶ AQSI
 - ▶ Ross Ewin-York
 - ▶ Dr. Kevin O'Leary