Skaggs School of Pharmacy and Pharmaceutical Sciences

UNIVERSITY OF COLORADO
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Health Economics of T1D Screening

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Partners

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the early start study tess for pre-symptomatic T1D

Cost-effectiveness rapid primer

- Quantitative evidence synthesis method often calculated as the ratio of difference in cost to difference in effectiveness

$$ICER = \Delta C / \Delta E = (C_{new\ approach} - C_{usual\ care}) / (E_{new\ approach} - E_{usual\ care})$$

- As we add to the numerator, need continued spread in the denominator to achieve efficient use of limited resources

Status of Health Economics of T1D Screening

- Global investment in T1D screening driving evidence for the “numerator” (i.e., resources and associated costs) with varying degrees of clarity on the “denominator” (i.e., net health benefit)
- **How can we leverage evidence to address the question:**
  - *What is the most efficient way to combine screening, monitoring, and interventions to achieve the maximum health benefits?*

Clinical and Economic Optimization Platform

- Goal: develop a comprehensive, user-friendly, and publicly available clinical and economic type 1 diabetes screening platform
- Collaborators:
  - University of Exeter (Richard Oram, **Lauric Ferrat**, Jonathan Fieldsend, **Gonçalo Leiria**)
  - University of Washington and Pacific Northwest Diabetes Research Institute (Bill Hagopian)
  - University of Colorado (Marian Rewers, Conner Jackson)

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Key contributions to optimization platform

- Synthesis of real-world resource utilization and clinical evidence
  - Screening combinations: islet autoantibody and/or genetics based
  - Monitoring: parental education, glycemic monitoring (CGMs, HbA1c, etc.)
  - **DKA at diagnosis: higher DKA risk at baseline impacts both quality and quantity of life**
  - Therapeutic interventions: Delay and prevention of T1D

Cost and Cost-effectiveness of Large-scale Screening for Type 1 Diabetes in Colorado

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Based on Colorado data

Table 4—Incremental lifetime population-level cost and clinical outcomes on the basis of projected reductions in DKA events and resulting improved HbA_{1c} from screening and follow-up

Percent reduction in DKA events (screening vs. no screening)	Proportion of patients with DKA events in screening arm	Incremental population average HbA_{1c} for patients with type 1 diabetes	Incremental DKA treatment costs at diagnosis§	Incremental other diabetes complication costs over a lifetime†	Incremental effectiveness, QALYs	Incremental total costs (ASK screening vs. no screening)‡	Incremental total costs (routine screening vs. no screening)‡
0%	46%	0.0%	$0	$0	0	$560,000	$1,641,000
20%	37%	−0.1%	−$37,000	−$506,000	17	$18,000*	$1,098,000*
40%	28%	−0.3%	−$73,000	−$965,000	33	−$478,000**	$602,000*
60%	18%	−0.4%	−$110,000	−$1,384,000	49	−$934,000**	$147,000*
80%	9%	−0.5%	−$146,000	−$1,769,000	64	−$1,355,000**	−$274,000**

§All costs are in 2018 USD and rounded to the nearest $1,000. †Other diabetes complication costs include treatment and management of annual hypoglycemic events and long-run diabetes-related complications. ‡Total costs include screening costs for 10,029 children and adolescents, DKA treatment costs for case patients diagnosed with type 1 diabetes and experience a DKA event, and all other diabetes complication costs over a lifetime for the predicted case patients who convert to diabetes. *Costs of screening offset enough for screening to be cost-effective at ≤$150,000 per QALY. **Costs of screening offset completely, resulting in a cost savings scenario.

Input Generation Case Example:

Identifying DKA events among type 1 diabetes diagnoses in real-world all-payer claims data

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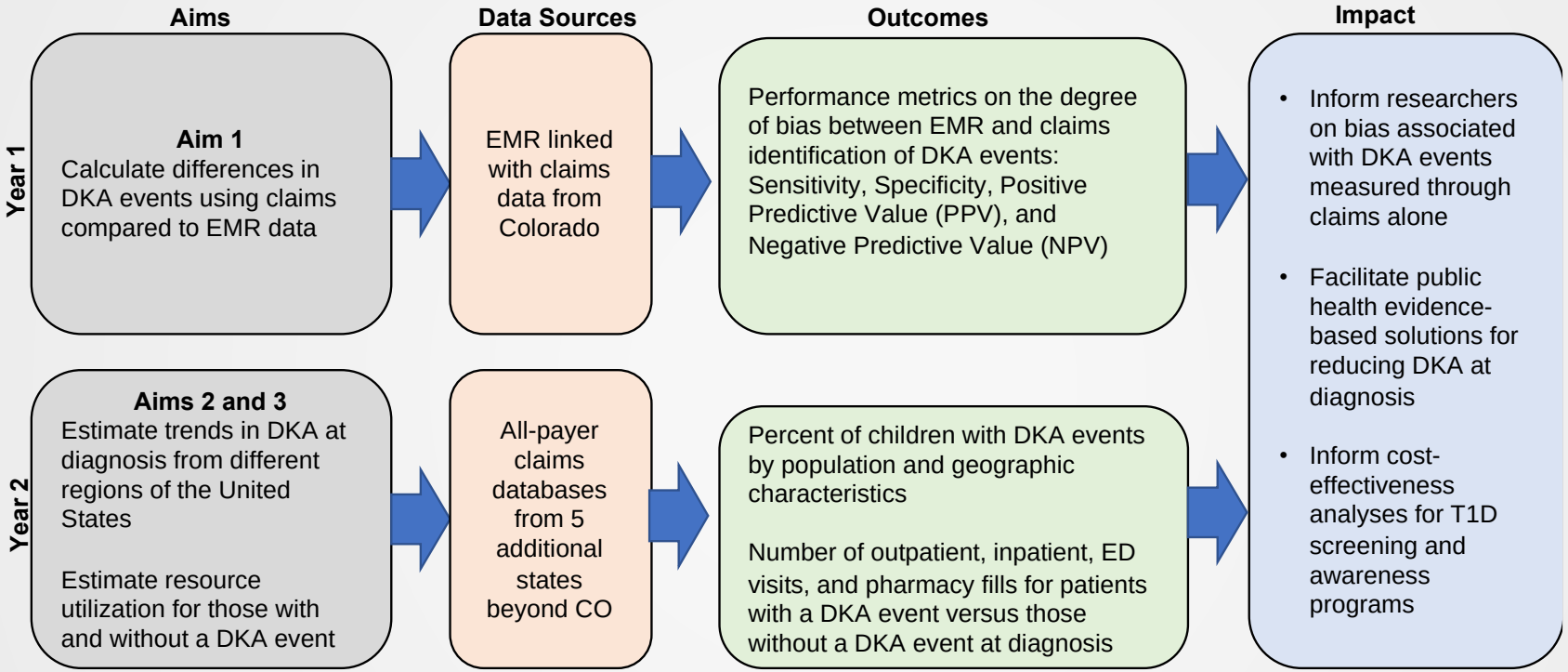
Specific Aims



- **Specific Aim 1: Calculate differences in DKA events identified using claims data compared to EMR data to develop an algorithm to estimate DKA rates only using administrative claims data.**

Data sources and study population

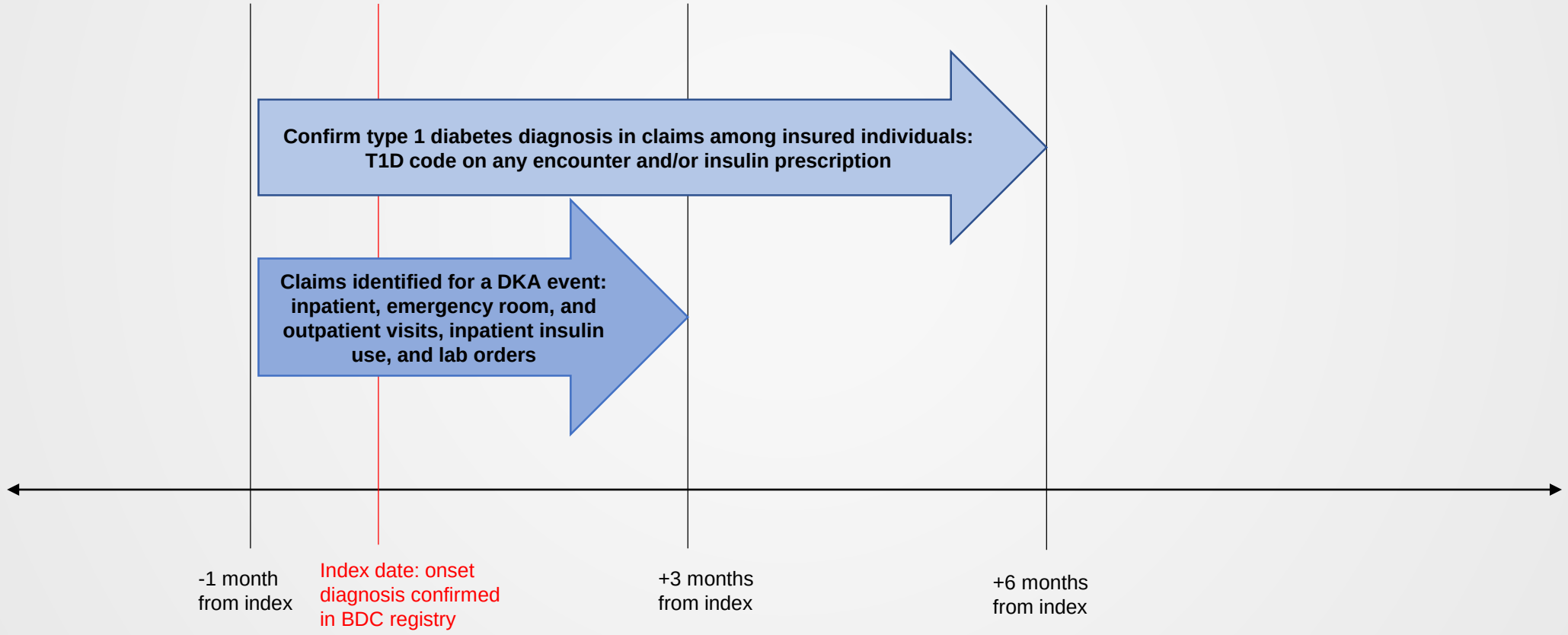
- Barbara Davis Center Registry (EMR) on T1D patients with and without DKA events at diagnosis
- CO insured residents in all-payer claims database
- Inclusion criteria reflects distinguishing features of DKA events at diagnosis
  - T1D diagnosis (claims + EMR)
  - Sufficient medical records to rule in or out the presence of DKA at diagnosis (EMR only)
  - **<18 years of age at diagnosis during a time window of 2014 – 2019 (claims + EMR)**
  - Laboratory values for DKA including pH or HCO_3 (EMR only)
  - **Insulin within 6 months following diagnosis date** (claims + EMR)
  - **Insurance flag for enrollment for 6 months post diagnosis (claims only) with no T1D diagnosis prior to index date**

Methods

- Previous work identified T1D cases with sensitivity, specificity, and PPV of greater than 90%*
  - Extend to include billing codes for DKA, IV insulin, and additional lab orders (e.g., metabolic panel)
- DKA event timeline in claims: -1 month and +3 months from EMR diagnosis
- Maximize performance metrics between combinations of setting and billing codes

*Zhong VW, Pfaff ER, Beavers DP, et al. Use of administrative and electronic health record data for development of automated algorithms for childhood diabetes case ascertainment and type classification: the SEARCH for Diabetes in Youth Study. Pediatr Diabetes 2014;15:573-84.

Capturing claims: timeline for T1D diagnosis and DKA events



Claims match

- N=1407 matched to APCD on N=2564 patients in BDC registry
  - N=232 without any claims + or – 12 months from onset date
- N=1,175 total patients with EMR and any non-zero claim
  - N= 447 without insurance and/or T1D + insulin prescription within 6 months of diagnosis
- *N=728 with confirmed T1D in claims and medical and pharmacy insurance 6 months from diagnosis*

Insured population and DKA events

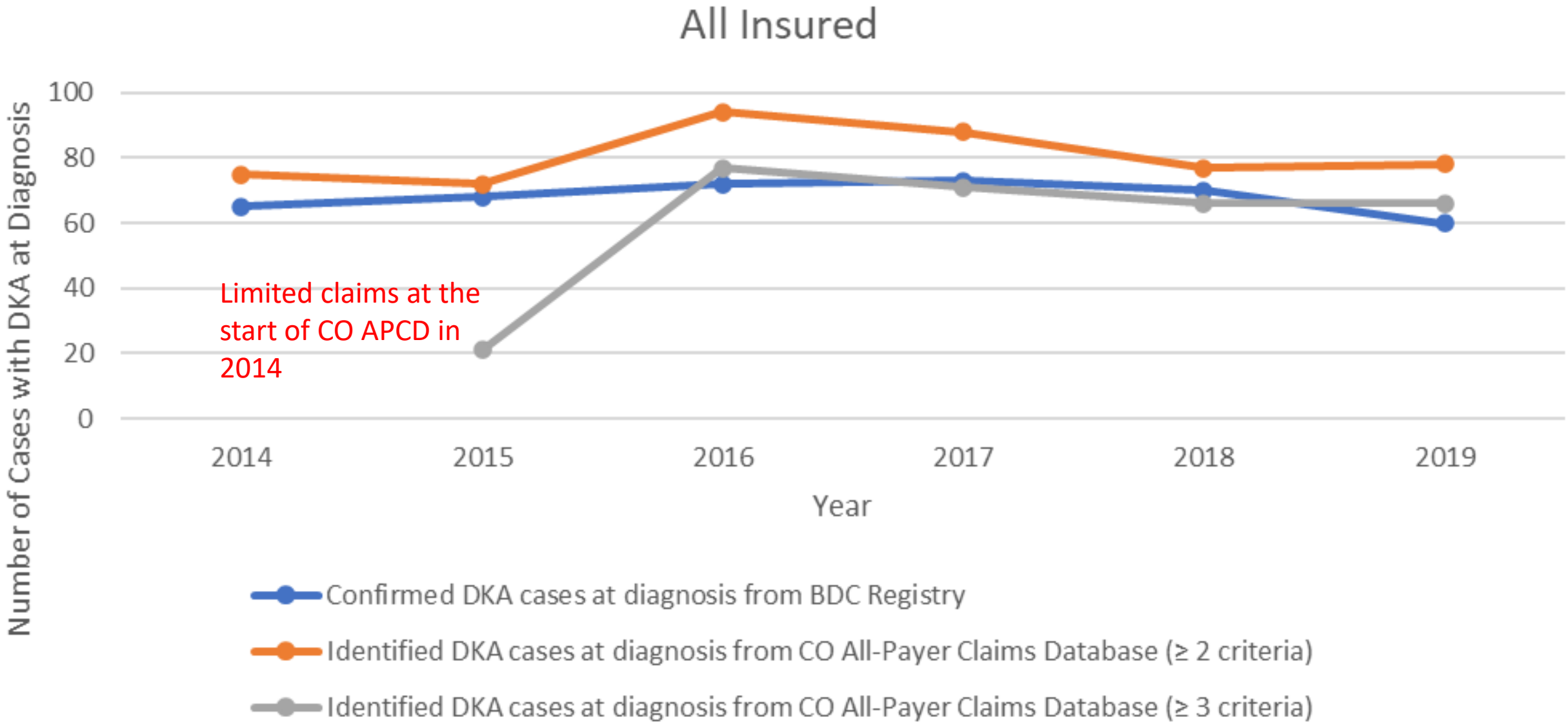
Characteristic		T1D Diagnoses		DKA at Diagnosis		No DKA at Diagnosis	
		n or mean	Frequency or standard error	n or mean	Frequency or standard error	n or mean	Frequency or standard error
Total		728	100%	408	56%	320	44%
Mean age		16	0.17	16	0.22	16	0.25
Sex							
	Female	353	48%	207	59%	146	41%
	Male	375	52%	201	54%	174	46%
Race and Ethnicity							
	Non-Hispanic White	438	60%	227	52%	211	48%
	Non-Hispanic African American	56	8%	34	61%	22	39%
	Hispanic	159	22%	99	62%	60	38%
	Other	75	10%	48	64%	27	36%
Insurance at Diagnosis							
	Medicaid	425	58%	257	60%	168	40%
	Private	269	37%	133	49%	136	51%
	Other	34	5%	18	53%	16	47%
Year of Diagnosis							
	2014	114	16%	65	57%	49	43%
	2015	116	16%	68	59%	48	41%
	2016	133	18%	72	54%	61	46%
	2017	124	17%	73	59%	51	41%
	2018	124	17%	70	56%	54	44%
	2019	117	16%	60	51%	57	49%

Performance results

Criteria	TP	TN	FP	FN	Sensitivity	Specificity	PPV	Proportion of DKA events predicted from claims
Inpatient (IP) and Emergency Room (ER) Specific								
IP or ER with at least one of DKA code, T1D code, or J-code for insulin use	385	106	214	23	94.4	33.1	64.3	64%
IP or ER with at least two of DKA code, T1D code, or J-code for insulin use	357	193	127	51	87.5	60.3	73.8	66%
IP or ER with three of DKA code, T1D code, and J-code for insulin use	235	254	66	173	57.6	79.4	78.1	41%
Inpatient (IP), Emergency Room (ER), and Outpatient Visits (OP)								
IP, ER, or OP with at least one of DKA code, T1D code, or J-code for insulin use	402	6	314	6	98.5	1.9	56.2	98%
IP, ER, or OP with at least two of DKA code, T1D code, or J-code for insulin use	394	32	288	14	96.6	10.0	57.8	94%
IP, ER, or OP with three of DKA code, T1D code, and J-code for insulin use	356	98	222	52	87.3	30.6	61.6	79%

IP: inpatient visit; ER: emergency room visit; OP: outpatient visit; TP: true positive; TN: true negative; FP: false positive; FN: false negative; PPV: positive predictive value; DKA: diabetic ketoacidosis; T1D: type 1 diabetes

RESULTS SUBJECT TO CHANGE



RESULTS SUBJECT TO CHANGE

Next steps

- Develop encounters in claims to estimate cost pre- and post-diagnosis with and without DKA events
- Resource use identified in 4 other state APCDs will directly inform optimization platform

Summary

- Inpatient and emergency room visits ≥ 2 among T1D diagnosis codes, DKA codes, and insulin use maximized performance
  - Among sample of N=1,175 total patients with EMR and any non-zero claim, sensitivity = 76%, specificity = 76%, and PPV = 73%
- What happened to patients that dropped out?
  - Chart review shows majority out of state residents
- Implications for state-by-state investments in screening and monitoring

Future research and collaborations

- Global evidence generation on T1D screening demonstrates the need for collaboration and sharing of information
- Proposal: consortium for the health economics of T1D screening
  - Objectives: efficiently use evidence to achieve country-specific objectives for the uptake of screening and monitoring
  - Multi-stakeholder group of health economists, biostatisticians, endocrinologists, patients, and policy makers

Discussion

Cost-benefit and Cost-effectiveness

- Cost-effectiveness and cost-benefit use the same analytic approach and used interchangeably in the field of health economics. True or false?
- A: False.
  - Cost-effectiveness analysis incrementally compares both the costs and health effects to estimate the efficiency of resources used when a new intervention is introduced against at least one existing intervention.
  - Cost-benefit analysis quantifies health effects and costs to produce one monetary number.

Appendix

Codes

- ICD-9-CM codes (for years 2014-2015) 250.01, 250.03, 250.11, 250.13, 250.21, 250.23, 250.31, 250.33, 250.41, 250.43, 250.51, 250.53, 250.61, 250.63, 250.71, 250.73, 250.81, 250.83, 250.91, and 250.93; ICD-10 codes E10.8, E10.9, E10.2, E10.3, E10.32, E10.33, E10.34, E10.25, E10.36, E10.37, E10.4, E10.5, E10.5, E10.6; and ICD-10 codes specific to ketoacidosis or hyperglycemia: E10.10. E10.11, E10.65

Labs and insulin

Blook gas, venous	82803
Metabolic panel	80053
IV Hydration	96360
IV Hydration	96361

J1811	Injectable insulin
J1812	Injectable insulin
J1813	Injectable insulin
J1814	Injectable insulin
J1815	Injectable insulin
J1817	Injectable insulin
S5550	Injectable insulin
S5571	Injectable insulin

Code Type	Code	Description	Insulin Type	Include/Exclude from T1DM
HCPCS	A4225	Supplies for external insulin infusion pump, syringe type cartridge, sterile, each	Not insulin	Include - Insulin Pump-Related Supplies
HCPCS	A4226	Supplies for maintenance of insulin infusion pump with dosage rate adjustment using therapeutic continuous glucose sensing, per week	Not insulin	Include - Insulin Pump-Related Supplies
HCPCS	A4230	Infusion set for external insulin pump, non needle cannula type	Not insulin	Include - Insulin Pump-Related Supplies
HCPCS	A4231	Infusion set for external insulin pump, needle type	Not insulin	Include - Insulin Pump-Related Supplies
HCPCS	A4232	Syringe with needle for external insulin pump, sterile, 3 cc	Not insulin	Include - Insulin Pump-Related Supplies
HCPCS	A9274	External ambulatory insulin delivery system, disposable, each, includes all supplies and accessories	Short	Include - Disposble Insulin Pump (contains short acting insulin)
HCPCS	E0784	External ambulatory infusion pump, insulin	Not insulin	Include - Insulin Pump
HCPCS	E0787	External ambulatory infusion pump, insulin, dosage rate adjustment using therapeutic continuous glucose sensing	Not insulin	Include - Insulin Pump
HCPCS	J1815	Injection, insulin, per 5 units	Short	Include - Short acting insulin for T1DM ID. May be used in an acute episode for patients without diabetes.
HCPCS	J1817	Insulin for administration through dme (i.e., insulin pump) per 50 units	Short	Include - Short acting insulin for T1DM ID
HCPCS	K0601	Replacement battery for external infusion pump owned by patient, silver oxide, 1.5 volt, each	Not insulin	Include - Insulin Pump-Related Supplies
HCPCS	K0602	Replacement battery for external infusion pump owned by patient, silver oxide, 3 volt, each	Not insulin	Include - Insulin Pump-Related Supplies

HCPCS	K0603	Replacement battery for external infusion pump owned by patient, alkaline, 1.5 volt, each	Not insulin	Include - Insulin Pump-Related Supplies
HCPCS	K0604	Replacement battery for external infusion pump owned by patient, lithium, 3.6 volt, each	Not insulin	Include - Insulin Pump-Related Supplies
HCPCS	K0605	Replacement battery for external infusion pump owned by patient, lithium, 4.5 volt, each	Not insulin	Include - Insulin Pump-Related Supplies
HCPCS	S1034	Artificial pancreas device system (e.g., low glucose suspend (lgs) feature) including continuous glucose monitor, blood glucose device, insulin pump and computer algorithm that communicates with all of the devices	Not insulin	Include - Insulin Pump
HCPCS	S1035	Sensor; invasive (e.g., subcutaneous), disposable, for use with artificial pancreas device system	Not insulin	Include - Insulin Pump-Related Supplies
HCPCS	S1036	Transmitter; External, For Use With Artificial Pancreas Device System	Not insulin	Include - Insulin Pump-Related Supplies
HCPCS	S1037	Receiver (Monitor); External, For Use With Artificial Pancreas Device System	Not insulin	Include - Insulin Pump-Related Supplies
HCPCS	S5550	Insulin, rapid onset, 5 units	Short	Include - Short acting insulin for T1DM ID. May be used in an acute episode for patients without diabetes.
HCPCS	S5551	Insulin, most rapid onset (lispro or aspart); 5 units	Short	Include - Short acting insulin for T1DM ID. May be used in an acute episode for patients without diabetes.
HCPCS	S5552	Insulin, intermediate acting (nph or lente); 5 units	Intermediate	Exclude from T1DM ID - Intermediate acting insulin. May be used in an acute episode for patients without diabetes.
HCPCS	S5553	Insulin, long acting; 5 units	Long	Exclude from T1DM ID - Long acting insulin. May be used in an acute episode for patients without diabetes.
HCPCS	S5560	Insulin delivery device, reusable pen; 1.5 ml size	Not insulin	Include - Insulin-Related Supplies
HCPCS	S5561	Insulin delivery device, reusable pen; 3 ml size	Not insulin	Include - Insulin-Related Supplies
HCPCS	S5565	Insulin cartridge for use in insulin delivery device other than pump; 150 units	Short	Include - Short acting insulin for T1DM ID
HCPCS	S5566	Insulin cartridge for use in insulin delivery device other than pump; 300 units	Short	Include - Short acting insulin for T1DM ID
HCPCS	S5570	Insulin delivery device, disposable pen (including insulin); 1.5 ml size	Short	Include - Short acting insulin for T1DM ID
HCPCS	S5571	Insulin delivery device, disposable pen (including insulin); 3 ml size	Short	Include - Short acting insulin for T1DM ID
HCPCS	S8490	Insulin syringes (100 syringes, any size)	Not insulin	Include - Insulin-Related Supplies
HCPCS	G9147	Outpatient intravenous insulin		

Other key themes with claims and EMR matching

Theme	Problem	Chart review sampling	Implications	Potential impact
Confirming no diagnosis present in claims pre-onset in EMR	We found n=31 patients with a T1D diagnosis between -1 mo and -12 mo from onset in EMR	1) Bad charting which would influence coding in claims and dates recorded; 2) Screening study participants	Both themes indicate that gaps in claims may exist that impact dates used to identify an "index" in claims later used to compare resource utilization	Small impact given only 31 of 728 people had a code not correspond with their original diagnosis date
Missing claims for those seen at BDC	We found nearly N=500 patients with no claims history yet have a health plan number in the APCD	1) Most resided out of state but sought care in CO temporarily; 2) Screening study participants; 3) There were unknowns as well	When comparing an insured population against a broader population of all treated in a hospital and ER setting, we will miss some T1D diagnoses	Large impact if the objective is to estimate complete T1D diagnoses across the entire state, including uninsured. But this is a well known limitation of APCDs. We are still able to distinguish DKA events