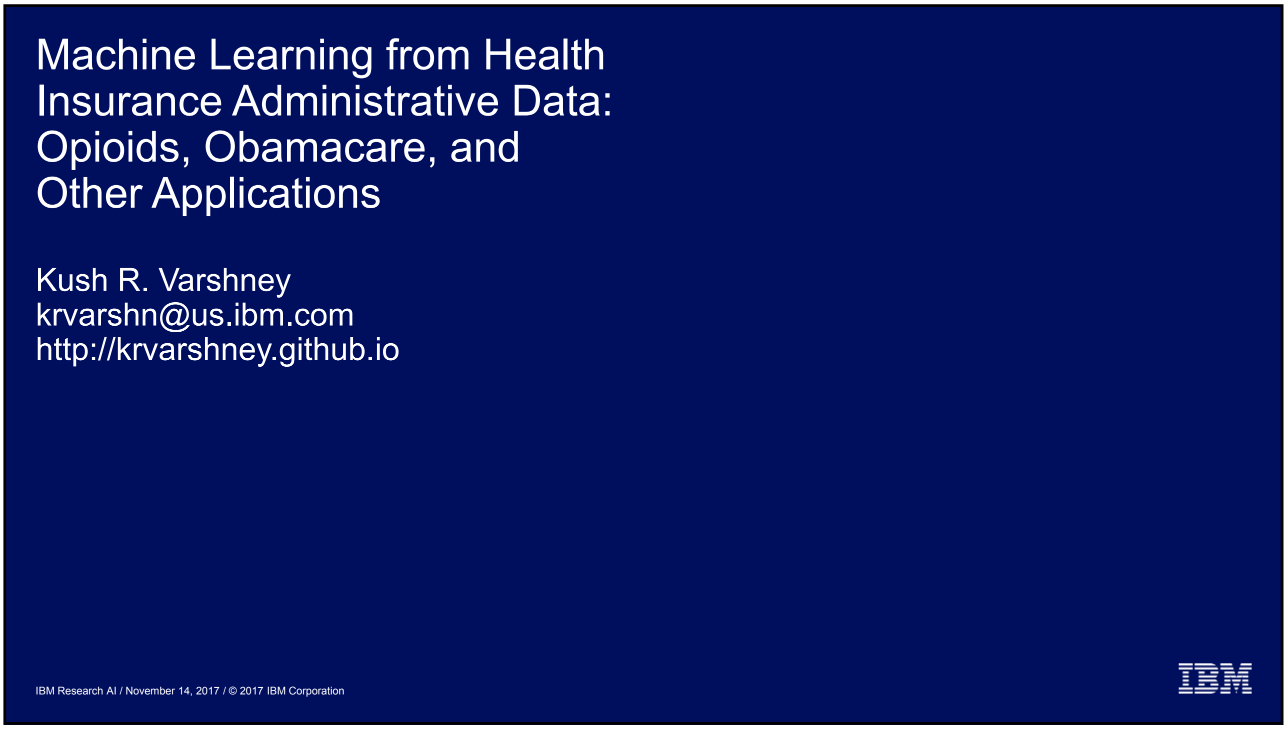
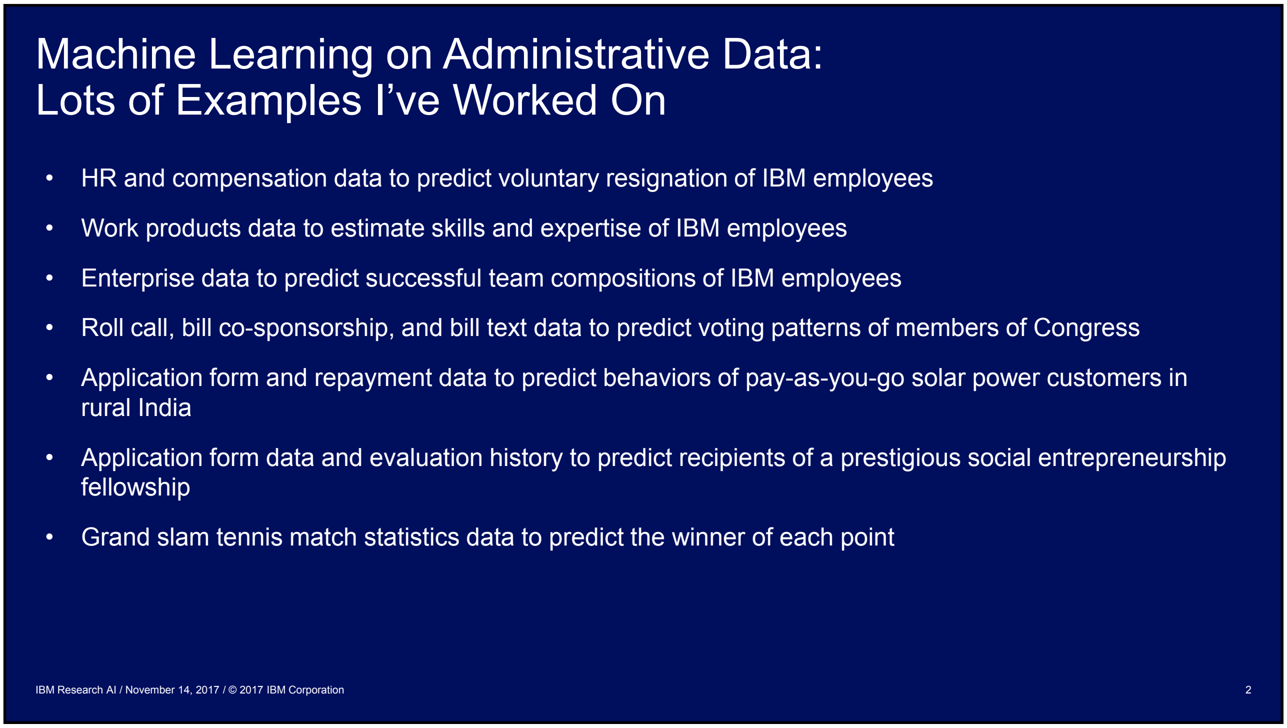


Machine Learning from Health Insurance Administrative Data: Opioids, Obamacare, and Other Applications

Kush R. Varshney
krvarshn@us.ibm.com
http://krvarshney.github.io



Machine Learning on Administrative Data: Lots of Examples I've Worked On

- HR and compensation data to predict voluntary resignation of IBM employees
- Work products data to estimate skills and expertise of IBM employees
- Enterprise data to predict successful team compositions of IBM employees
- Roll call, bill co-sponsorship, and bill text data to predict voting patterns of members of Congress
- Application form and repayment data to predict behaviors of pay-as-you-go solar power customers in rural India
- Application form data and evaluation history to predict recipients of a prestigious social entrepreneurship fellowship
- Grand slam tennis match statistics data to predict the winner of each point

Medical Claims

Used by payers (insurance companies) to reimburse health providers (physicians, hospitals, etc.)

Date of service

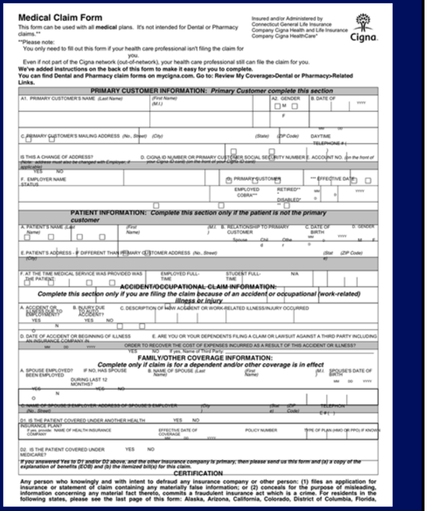
Diagnosis codes (ICD-10), procedure codes (CPT), drug codes (NDC)

Billed amount and paid amount

Provider and patient information (demographics)

Useful for many different machine learning tasks

- Cost prediction, e.g. Obamacare
- Understanding health patterns, e.g. opioid addiction



Medical Claim Form

This form can be used with all **medical** plans. It's not intended for Dental or Pharmacy claims.**

Insured and/or Administered by Connecticut General Life Insurance Company Cigna Health and Life Insurance Company Cigna HealthCare*

Cigna.

**Please note:

You only need to fill out this form if your health care professional isn't filing the claim for you.

Even if not part of the Cigna network (out-of-network), your health care professional still can file the claim for you.

We've added instructions on the back of this form to make it easy for you to complete.

You can find Dental and Pharmacy claim forms on mycigna.com. Go to: Review My Coverage>Dental or Pharmacy>Related Links.

PRIMARY CUSTOMER INFORMATION: ***Primary Customer complete this section***

A1. PRIMARY CUSTOMER'S NAME *(Last Name)* *(First Name)* *(M.I.)*

A2. GENDER □ M □ F

B. DATE OF MM DD YYYY

C. PRIMARY CUSTOMER'S MAILING ADDRESS *(No., Street)* *(City)* *(State)* *(ZIP Code)* DAYTIME TELEPHONE # ( )

IS THIS A CHANGE OF ADDRESS? *(Note: address must also be changed with Employer, if applicable)* YES □ NO □

D. CIGNA ID NUMBER OR PRIMARY CUSTOMER SOCIAL SECURITY NUMBER *(on the front of your Cigna ID card)*

E. ACCOUNT NO. *(on the front of your Cigna ID card)*

F. EMPLOYER NAME

G. PRIMARY CUSTOMER STATUS □ EMPLOYED □ RETIRED*** □ COBRA*** □ DISABLED***

*** EFFECTIVE DATE MM DD YYYY

PATIENT INFORMATION: ***Complete this section only if the patient is not the primary customer***

A. PATIENT'S NAME *(Last Name)* *(First Name)* *(M.I.)*

B. RELATIONSHIP TO PRIMARY CUSTOMER □ Spouse □ Child □ Other

C. DATE OF BIRTH MM DD YYYY

D. GENDER □ M □ F

E. PATIENT'S ADDRESS - IF DIFFERENT THAN PRIMARY CUSTOMER ADDRESS *(No., Street)* *(City)* *(State)* *(ZIP Code)*

F. AT THE TIME MEDICAL SERVICE WAS PROVIDED WAS THE PATIENT: □ EMPLOYED FULL-TIME □ STUDENT FULL-TIME □ N/A

ACCIDENT/OCCUPATIONAL CLAIM INFORMATION:

Complete this section only if you are filing the claim because of an accident or occupational (work-related) illness or injury

A. ACCIDENT OR ILLNESS DUE TO EMPLOYMENT? YES □ NO □

B. INJURY DUE TO AUTO ACCIDENT? YES □ NO □

C. DESCRIPTION OF HOW ACCIDENT OR WORK-RELATED ILLNESS/INJURY OCCURRED

D. DATE OF ACCIDENT OR BEGINNING OF ILLNESS MM DD YYYY

E. ARE YOU OR YOUR DEPENDENTS FILING A CLAIM OR LAWSUIT AGAINST A THIRD PARTY INCLUDING AN INSURANCE COMPANY IN ORDER TO RECOVER THE COST OF EXPENSES INCURRED AS A RESULT OF THIS ACCIDENT OR ILLNESS? YES NO If yes, Name of Third Party:

FAMILY/OTHER COVERAGE INFORMATION:

Complete only if claim is for a dependent and/or other coverage is in effect

A. SPOUSE EMPLOYED? YES NO IF NO, HAS SPOUSE BEEN EMPLOYED DURING LAST 12 MONTHS? YES NO

B. NAME OF SPOUSE *(Last Name)* *(First Name)* *(M.I.)* SPOUSE'S DATE OF BIRTH MM DD YYYY

C. NAME OF SPOUSE'S EMPLOYER ADDRESS OF SPOUSE'S EMPLOYER *(No., Street)* *(City)* *(State)* *(ZIP Code)* TELEPHONE # ( )

D1. IS THE PATIENT COVERED UNDER ANOTHER HEALTH INSURANCE PLAN? YES NO

If yes, provide: NAME OF HEALTH INSURANCE COMPANY EFFECTIVE DATE OF COVERAGE MM DD YYYY POLICY NUMBER TYPE OF PLAN (HMO OR PPO) IF KNOWN

D2. IS THE PATIENT COVERED UNDER MEDICARE? YES NO

If you answered Yes to D1 and/or D2 above, and the other insurance company is primary, then please send us this form and (a) a copy of the explanation of benefits (EOB) and (b) the itemized bill(s) for this claim.

CERTIFICATION

Any person who knowingly and with intent to defraud any insurance company or other person: (1) files an application for insurance or statement of claim containing any materially false information; or (2) conceals for the purpose of misleading, information concerning any material fact thereto, commits a fraudulent insurance act which is a crime. For residents in the following states, please see the last page of this form: Alaska, Arizona, California, Colorado, District of Columbia, Florida,

A Tale of Two Laws

PATIENT PROTECTION AND AFFORDABLE CARE ACT

Changed the landscape of the health insurance market in the United States

Health insurance companies had to decide which new markets to enter

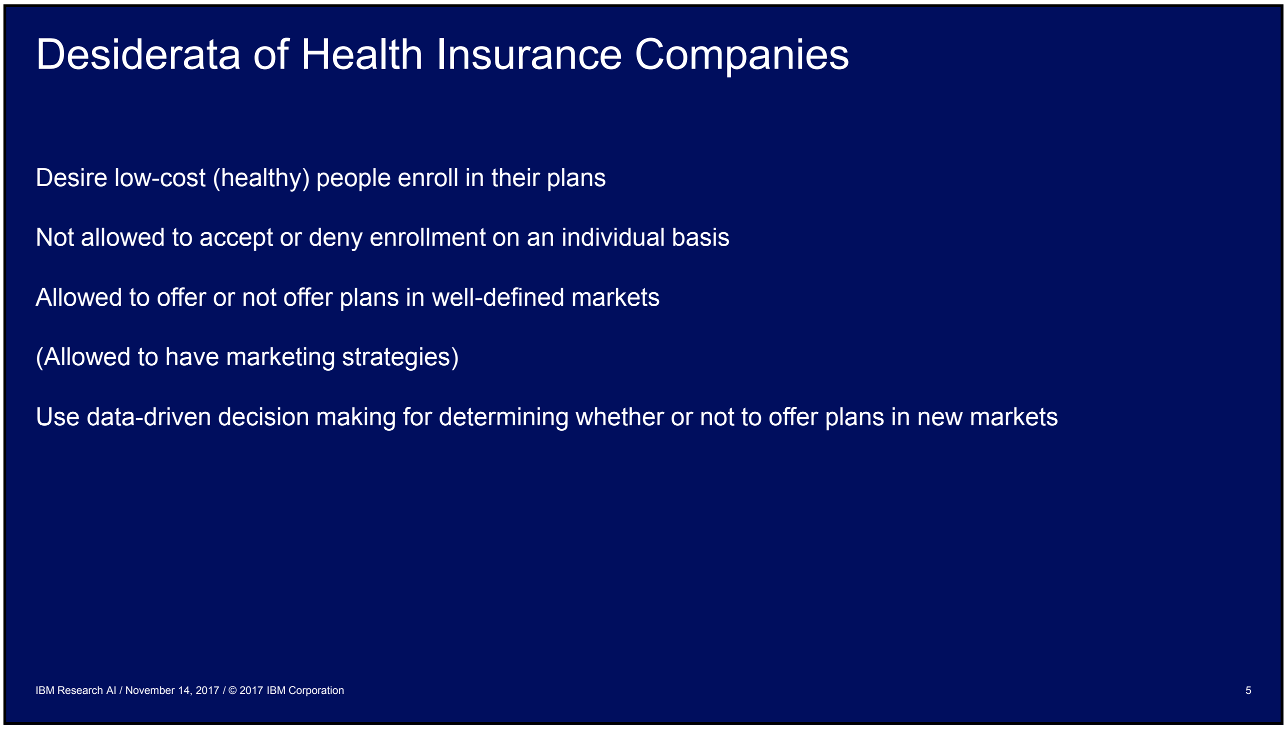
– New markets defined by geography, age group, and other prospect base criteria

HEALTH INSURANCE PORTABILITY AND ACCOUNTABILITY ACT

Required all releases of health-related information about individuals to protect their privacy

– Even for health insurance companies' internal planning uses

k-Anonymity is a common mathematical interpretation of the privacy condition



Desiderata of Health Insurance Companies

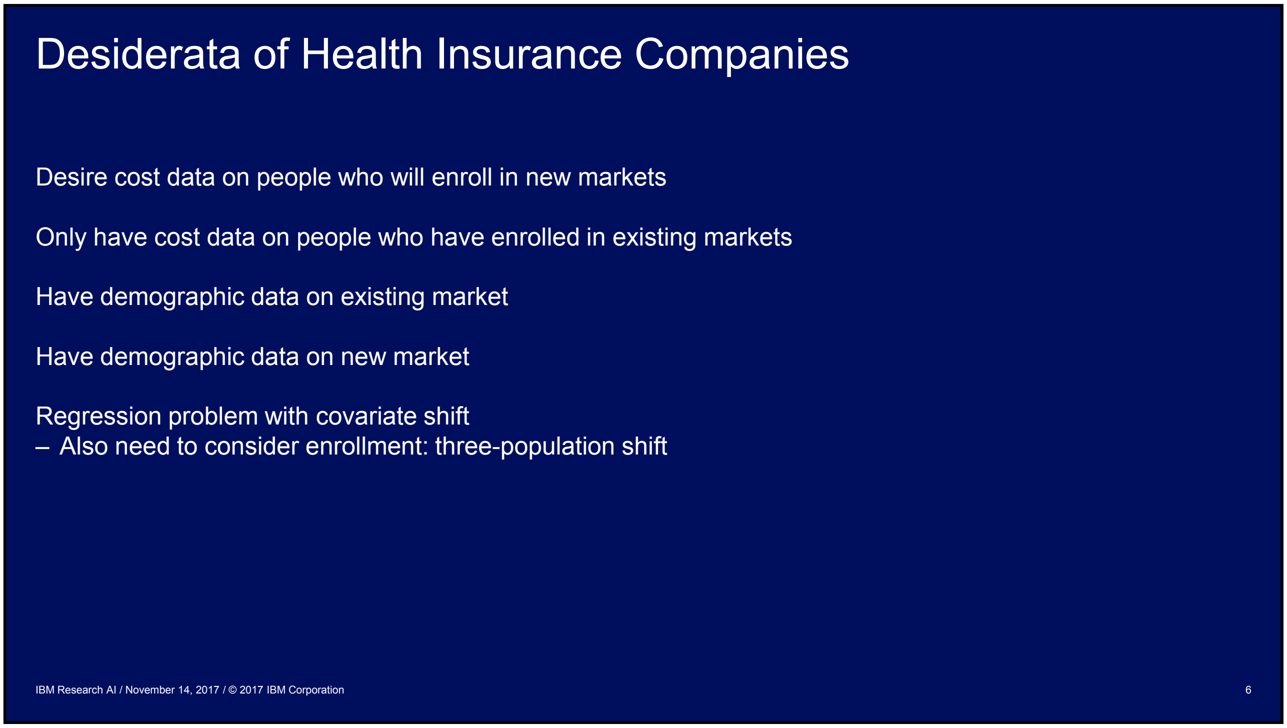
Desire low-cost (healthy) people enroll in their plans

Not allowed to accept or deny enrollment on an individual basis

Allowed to offer or not offer plans in well-defined markets

(Allowed to have marketing strategies)

Use data-driven decision making for determining whether or not to offer plans in new markets



Desiderata of Health Insurance Companies

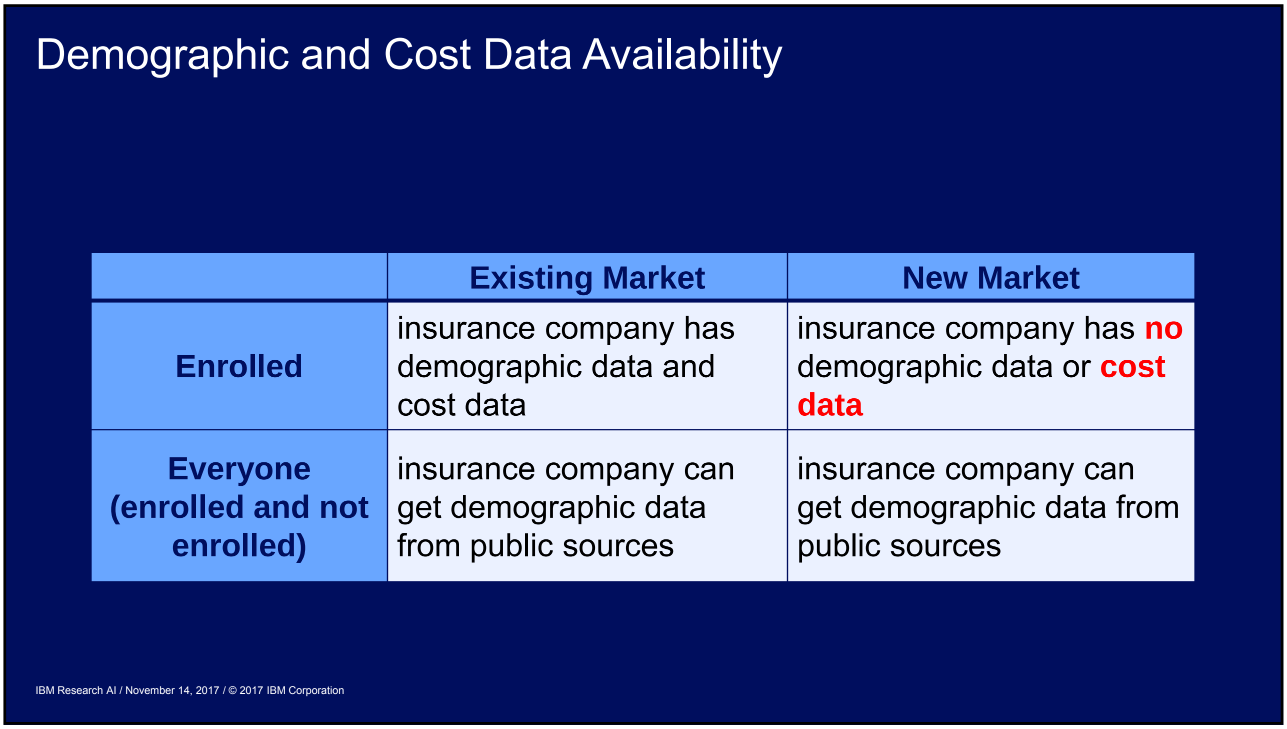
Desire cost data on people who will enroll in new markets

Only have cost data on people who have enrolled in existing markets

Have demographic data on existing market

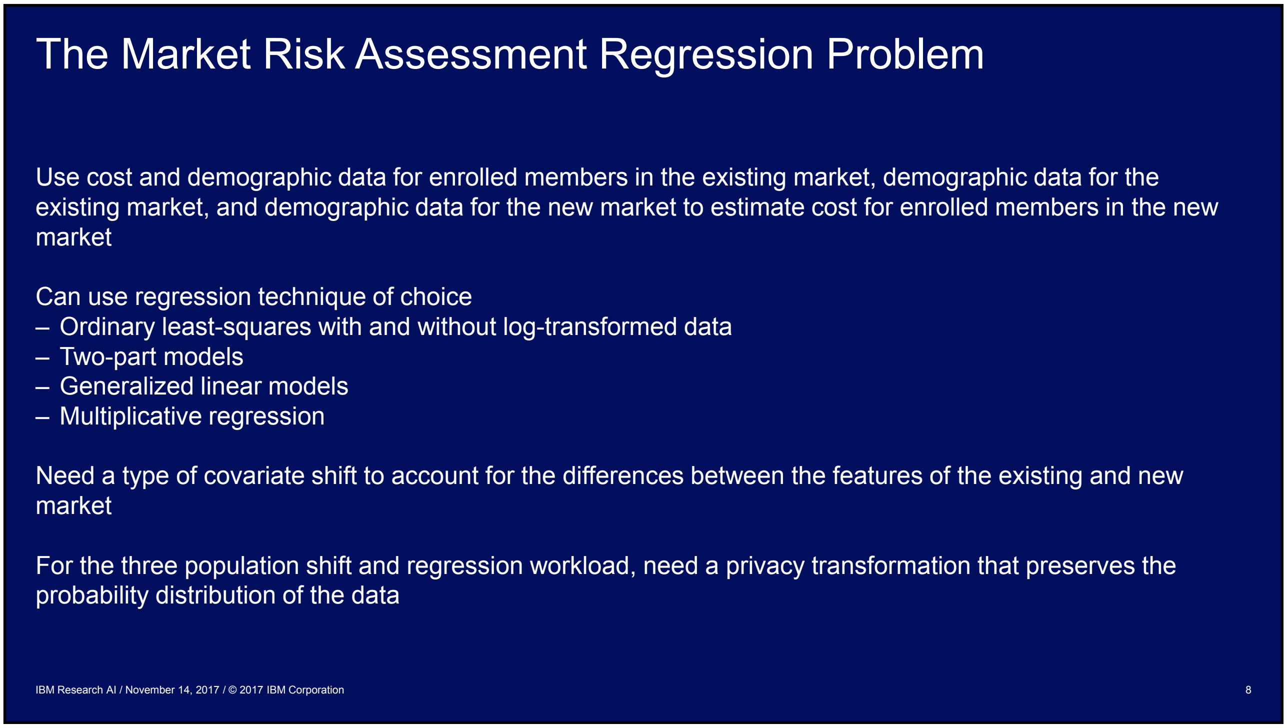
Have demographic data on new market

Regression problem with covariate shift
– Also need to consider enrollment: three-population shift



Demographic and Cost Data Availability

	Existing Market	New Market
Enrolled	insurance company has demographic data and cost data	insurance company has **no** demographic data or **cost data**
Everyone (enrolled and not enrolled)	insurance company can get demographic data from public sources	insurance company can get demographic data from public sources



The Market Risk Assessment Regression Problem

Use cost and demographic data for enrolled members in the existing market, demographic data for the existing market, and demographic data for the new market to estimate cost for enrolled members in the new market

Can use regression technique of choice

- Ordinary least-squares with and without log-transformed data
- Two-part models
- Generalized linear models
- Multiplicative regression

Need a type of covariate shift to account for the differences between the features of the existing and new market

For the three population shift and regression workload, need a privacy transformation that preserves the probability distribution of the data

Results

Developed such an approach, which required a new privacy-preservation method

Excellent empirical performance

Successfully used by a large health insurance company

D. Wei, K. N. Ramamurthy, and K. R. Varshney, “Health Insurance Market Risk Assessment: Covariate Shift and k-Anonymity” SIAM International Conference on Data Mining, pp. 226-234, April-May 2015.

Best Research Paper Honorable Mention

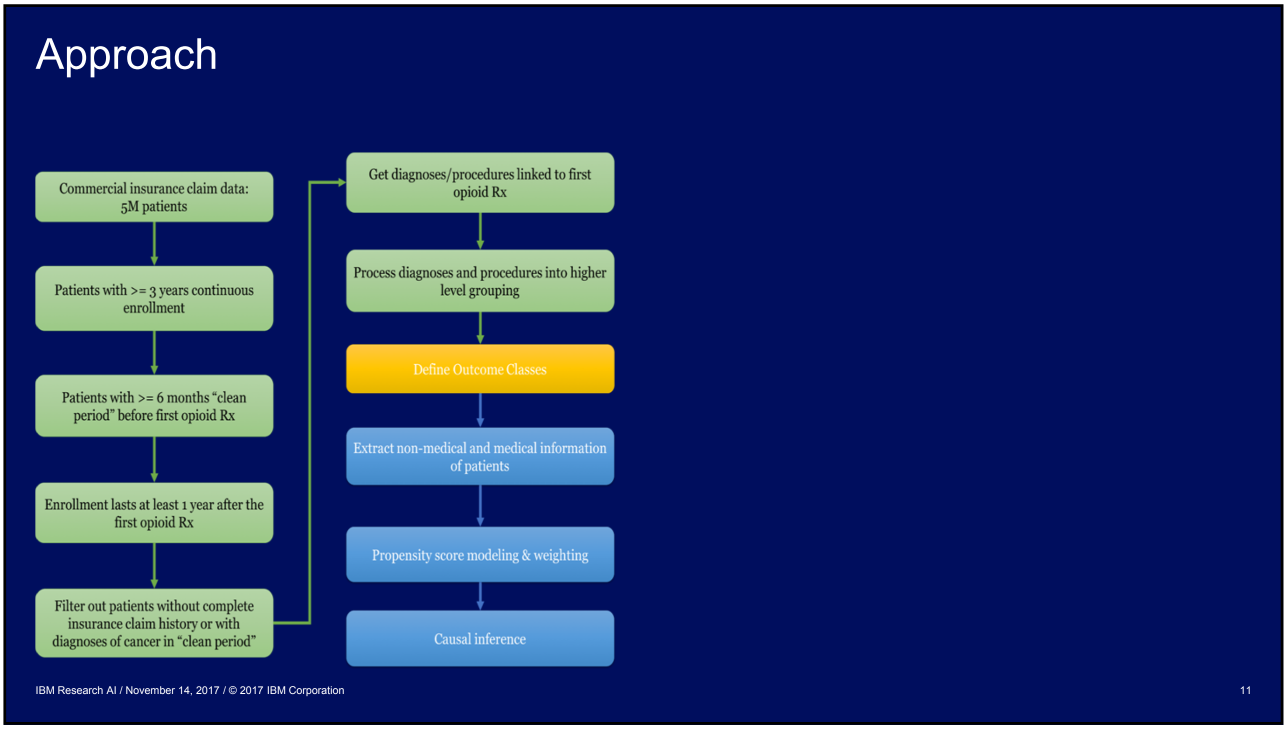
Opioid Epidemic

175 deaths per day due to opioid overdose in the United States

Physicians could be indirectly contributing to the epidemic by overprescription

One reason is because they have generally lacked data to guide opioid prescribing decisions

Use medical claims data to explore the causal relationships between the characteristics of the initial opioid prescriptions and outcomes



Approach

Commercial insurance claim data: 5M patients

Patients with >= 3 years continuous enrollment

Patients with >= 6 months "clean period" before first opioid Rx

Enrollment lasts at least 1 year after the first opioid Rx

Filter out patients without complete insurance claim history or with diagnoses of cancer in "clean period"

Get diagnoses/procedures linked to first opioid Rx

Process diagnoses and procedures into higher level grouping

Define Outcome Classes

Extract non-medical and medical information of patients

Propensity score modeling & weighting

Causal inference

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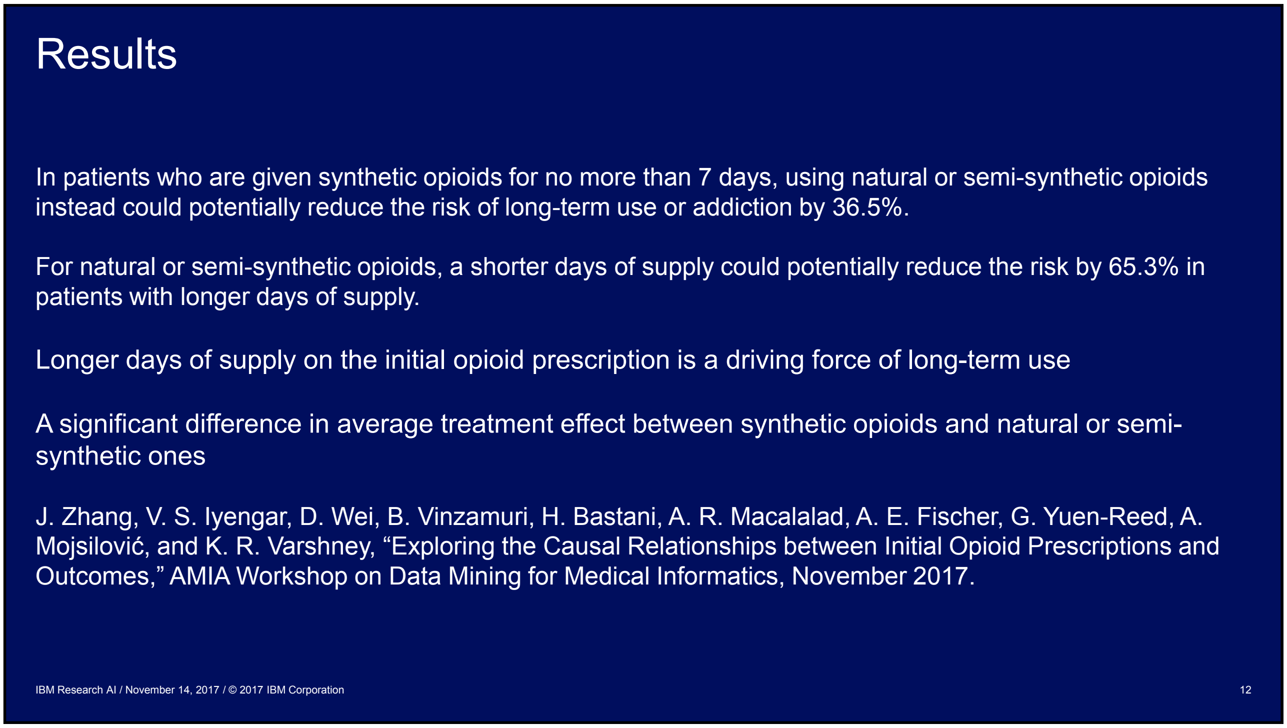
11



Results

In patients who are given synthetic opioids for no more than 7 days, using natural or semi-synthetic opioids instead could potentially reduce the risk of long-term use or addiction by 36.5%.

For natural or semi-synthetic opioids, a shorter days of supply could potentially reduce the risk by 65.3% in patients with longer days of supply.

Longer days of supply on the initial opioid prescription is a driving force of long-term use

A significant difference in average treatment effect between synthetic opioids and natural or semi-synthetic ones

J. Zhang, V. S. Iyengar, D. Wei, B. Vinzamuri, H. Bastani, A. R. Macalalad, A. E. Fischer, G. Yuen-Reed, A. Mojsilović, and K. R. Varshney, "Exploring the Causal Relationships between Initial Opioid Prescriptions and Outcomes," AMIA Workshop on Data Mining for Medical Informatics, November 2017.

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12