Addressing Modern Challenges to Truly Personalized Medicine

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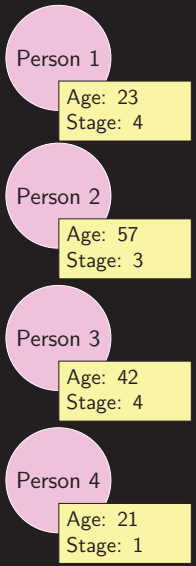
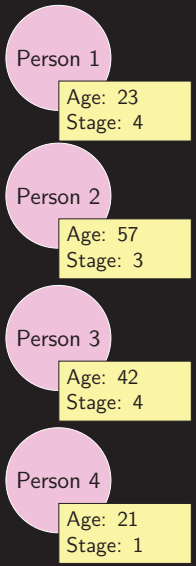
Tuesday October 3, 2023

Treat the patient, not the disease.



Experimental Treatment

Standard Treatment

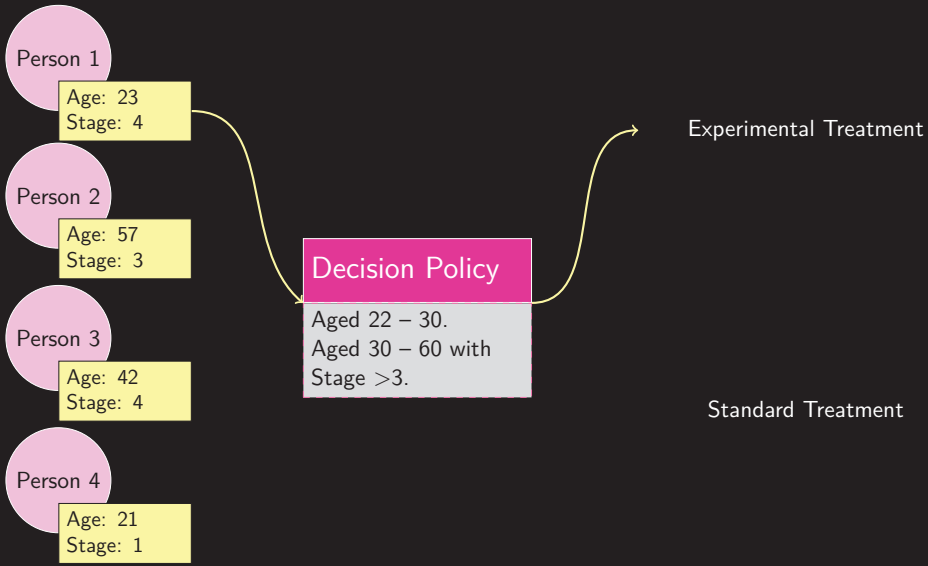


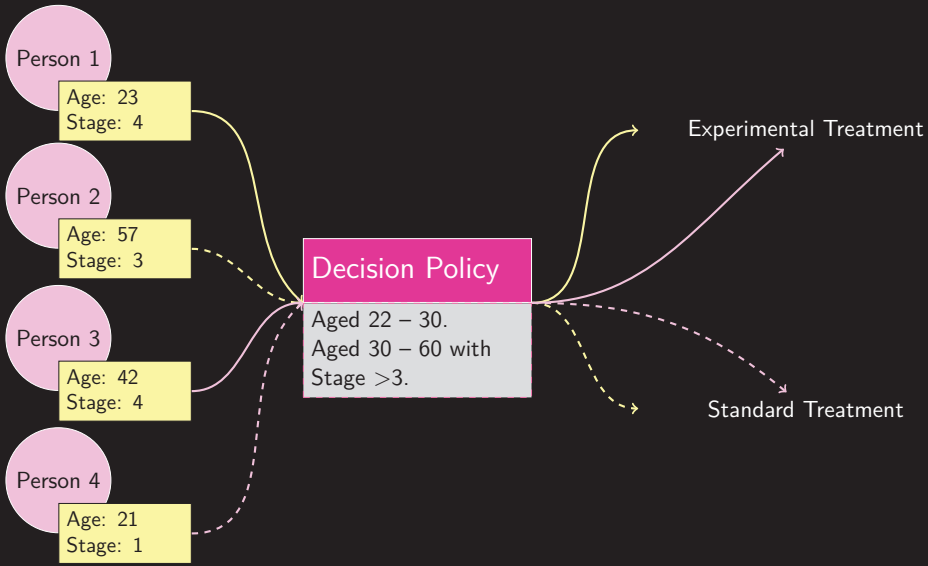
Decision Policy

Aged 22 – 30.
Aged 30 – 60 with Stage >3.

Experimental Treatment

Standard Treatment


Person 1
Age: 23
Stage: 4
Person 2
Age: 57
Stage: 3
Person 3
Age: 42
Stage: 4
Person 4
Age: 21
Stage: 1
Decision Policy
Aged 22 – 30.
Aged 30 – 60 with
Stage >3.
Experimental Treatment
Standard Treatment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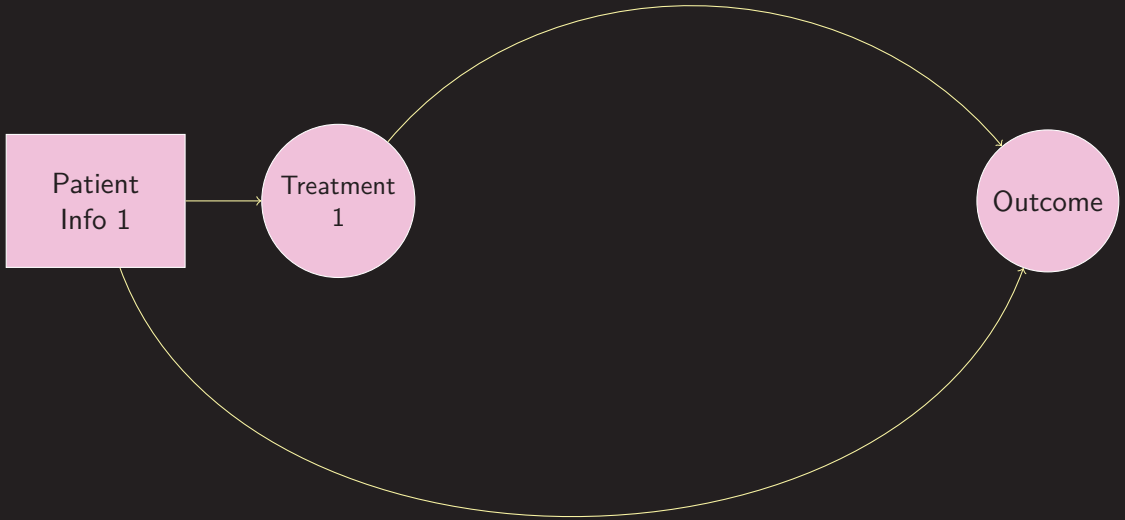
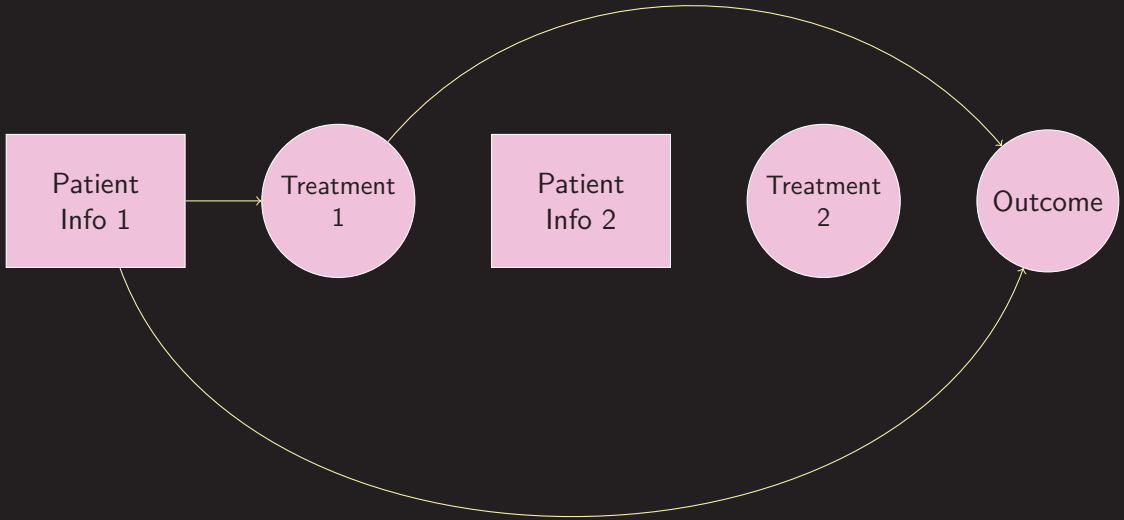
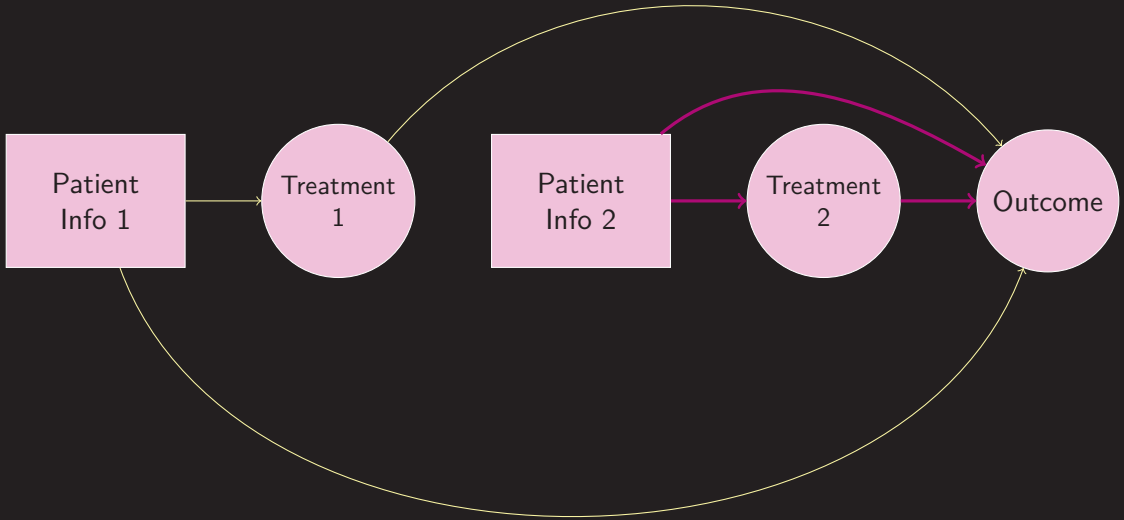
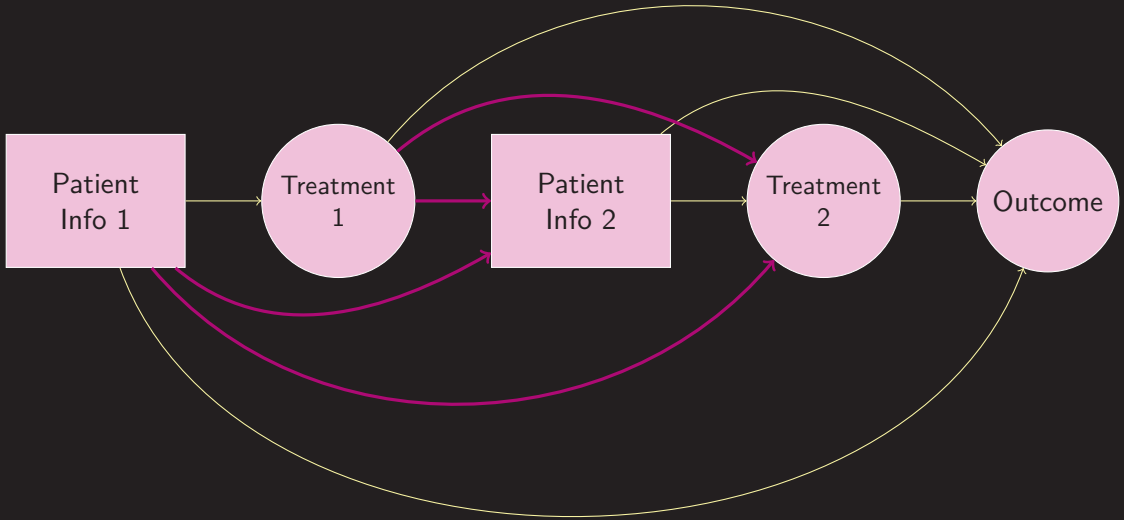

Patient
Info 1
Treatment
1
Outcome


Patient Info 1
Treatment 1
Patient Info 2
Treatment 2
Outcome


Patient Info 1
Treatment 1
Patient Info 2
Treatment 2
Outcome


Patient Info 1
Treatment 1
Patient Info 2
Treatment 2
Outcome

These models are referred to as dynamic treatment regimes.

Personalized Mental Health Care

Email Marketing Campaigns

Management of HIV/AIDS

Financial Portfolio Management

Push Notification Optimization

Resource Allocation

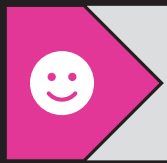
Modern data present certain challenges, limiting the uptake of dynamic treatment regimes.

Problem 1: Noisy Data

Measurement error refers to any situation where a quantity of interest is not, or cannot be, accurately observed.

Blood Pressure in Clinical Setting

Assessed Consumer Affect



Self-reported Caloric Consumption

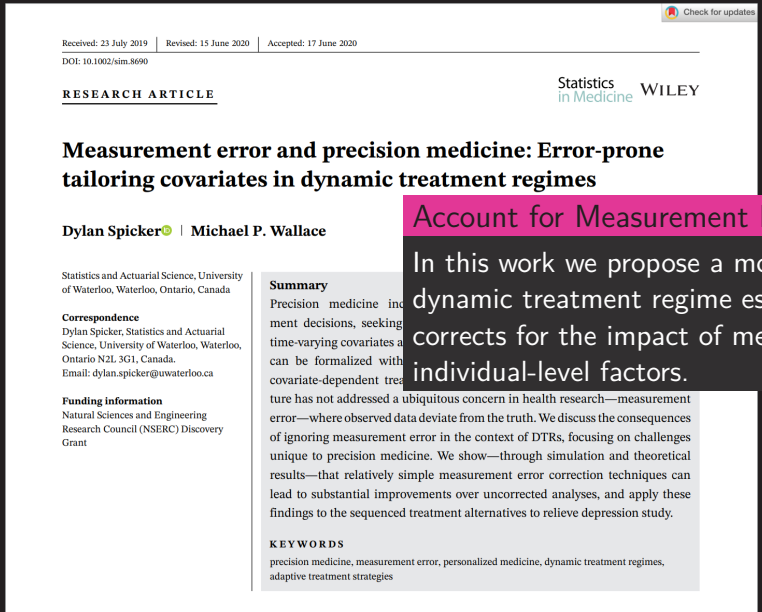
Customer Satisfaction Scores

User Demographic Information

Time Spent in Application

Measurement error renders the results of an analysis entirely unreliable if the effects are not corrected for.

Proposed Solution (Spicker and Wallace 2020)



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RESEARCH ARTICLE

Statistics in Medicine WILEY

Measurement error and precision medicine: Error-prone tailoring covariates in dynamic treatment regimes

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Funding information
Natural Sciences and Engineering Research Council (NSERC) Discovery Grant

Summary

Precision medicine inc
ment decisions, seeking
time-varying covariates a
can be formalized with
covariate-dependent trea
ture has not addressed a ubiquitous concern in health research—measurement error—where observed data deviate from the truth. We discuss the consequences of ignoring measurement error in the context of DTRs, focusing on challenges unique to precision medicine. We show—through simulation and theoretical results—that relatively simple measurement error correction techniques can lead to substantial improvements over uncorrected analyses, and apply these findings to the sequenced treatment alternatives to relieve depression study.

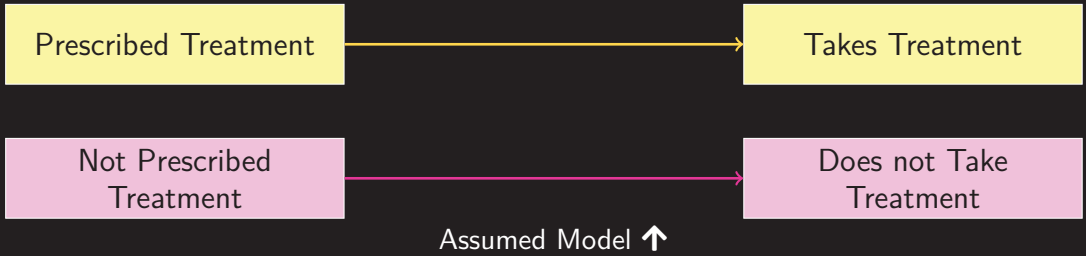
KEYWORDS

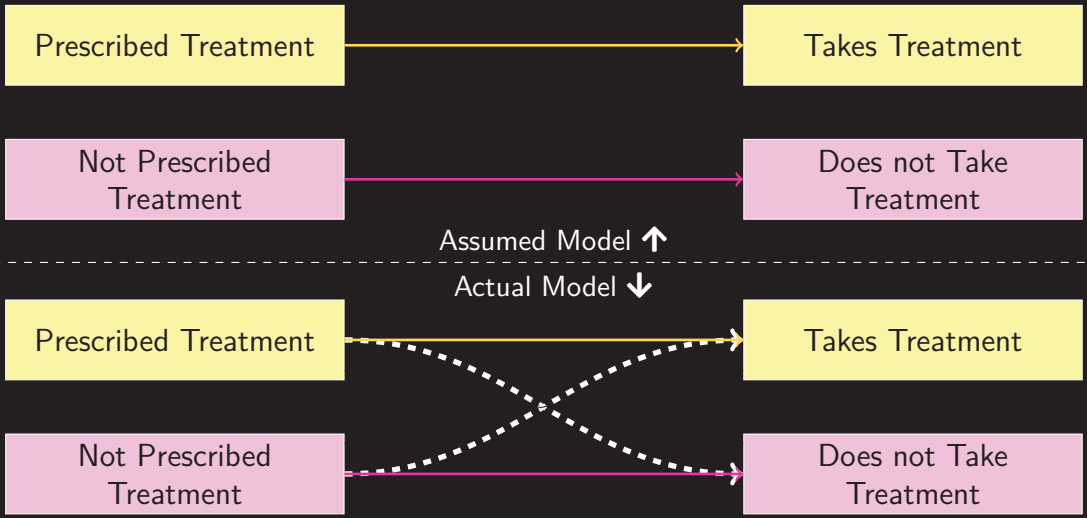
precision medicine, measurement error, personalized medicine, dynamic treatment regimes, adaptive treatment strategies

Account for Measurement Error from the Start

In this work we propose a modified version of an existing dynamic treatment regime estimation procedure which corrects for the impact of measurement error in individual-level factors.

Problem 2: Nonadherence


Prescribed Treatment
Takes Treatment
Not Prescribed Treatment
Does not Take Treatment
Assumed Model


Prescribed Treatment
Takes Treatment
Not Prescribed Treatment
Does not Take Treatment
Assumed Model ↑
Actual Model ↓
Prescribed Treatment
Takes Treatment
Not Prescribed Treatment
Does not Take Treatment

Proposed Solution (Spicker, Wallace, and Yi 2023)

CORRECTING FOR THE EFFECTS OF NON-ADHERENCE IN OPTIMAL DYNAMIC TREATMENT REGIME ESTIMATION USING G-ESTIMATION.

A PREPRINT

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Separate the Impact of Adherence and Treatment

Model separately the effects of adherence and of treatment efficacy to correctly estimate the true optimal dynamic treatment regime, and the propensity of adherence, which can be combined as required by clinical decision makers.

September 23, 2023

ABSTRACT

Precision medicine is method for evidence-based medicine predicated on determining optimal treatments based on individual-level characteristics. In longitudinal settings, precision medicine can be formalized through the use of dynamic treatment regimes (DTRs). DTRs are sequences of functions which take as input patient information and output treatment recommendations. A substantial focus of the DTR literature is on the estimation of optimal DTRs, those sequences of treatment rules which provide maximal benefit in expectation if they were to be applied across a population. While

Problem 3: Individual-Level Privacy

Patryk Palazzo

Birthyear: 1960
Status: HIV+
Sex: M
CD4 Count: 1014
% CD4 Positive: 48
WBC Count: 6400
RBC Count: 4.8
CD8 Count: 549
Systolic BP: 158
Diastolic BP: 102
Weight: 154lbs
Notes: MSM, 2 Week

Charles De León

Birthyear: 1985
Status: HIV+
Sex: M
CD4 Count: 1989
% CD4 Positive: 65
WBC Count: 10200
RBC Count: 5.2
CD8 Count: 520
Systolic BP: 135
Diastolic BP: 95
Weight: 160lbs
Notes: MSM, No Fever, H

Roman Ormond

Birthyear: 1951
Status: AIDS
Sex: M
CD4 Count: 508
% CD4 Positive: 25
WBC Count: 5800
RBC Count: 5.4
CD8 Count: 1076
Systolic BP: 110
Diastolic BP: 75
Weight: 143lbs
Notes: MSM, No Fever, Herpes

Proposed Solution (Spicker, Moodie, and Shortreed 2023)

ARTICLE TYPE

Differentially Private Outcome-Weighted Learning for Optimal Dynamic Treatment Regime Estimation

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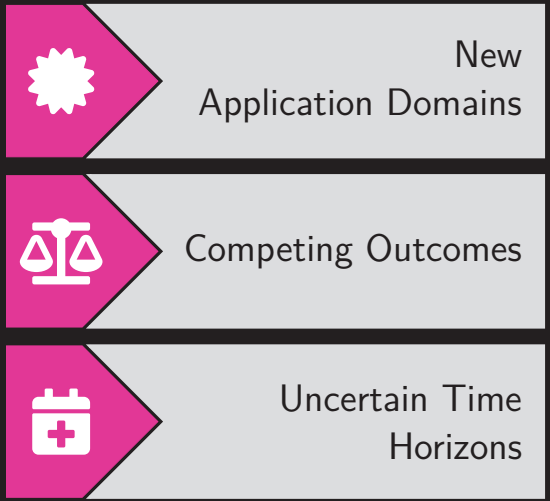
Email: dylan.spicker@unb.ca

Abstract

Precision medic
that seeks to d
vant patient-lev
highly sensitive
tance. Dynamic
in a longitudina
estimating opti
vector machine
fication based
classification rule produced by SVMs often requires direct access to the support vectors. Thus, releasing a treatment policy estimated with OWL requires the release of patient data for a subset of patients in the sample. As a result, the classification rules from SVMs constitute a severe privacy violation for those individuals whose data comprise the support vectors. This privacy violation is a major concern, particularly in light of the potentially highly sensitive medical data which are used in DTR estimation. Differential privacy has emerged as a mathematical framework for ensuring the privacy of individual-level data, with provable guarantees on the likelihood that individual characteristics can be determined by an adversary. We provide the first investigation of differential privacy in the context of

Apply the Standards of Differential Privacy

We produce a novel technique for estimating optimal dynamic treatment regimes, referred to as PrOWL, which achieves a rigorous mathematical standard of privacy (known as differential privacy) with provable accuracy compared with non-private estimation techniques.


New
Application Domains
Competing Outcomes
Uncertain Time
Horizons

Thank You!

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