

EAGER: Detecting and Addressing Adverse Dependencies Across Human-in-the-Loop In-Home Medical Apps

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Goals of Project

- To make the simultaneous use of multiple medical and wellness apps safe
- To reduce the effort for medical and wellness app developers
- To improve the design and implementation process for apps to make them more robust and aware of inter-app dependencies
- To create personalized semantic-aware multilevel conflict detection
- To interact in the Global Cities Challenge

Innovative Contributions

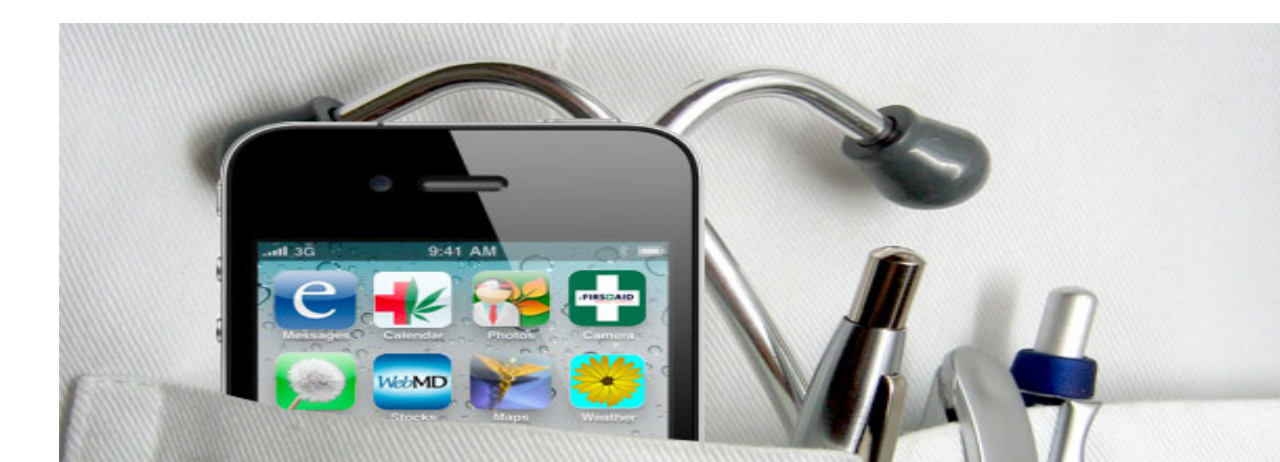
- A totally new approach to detecting primary and secondary dependencies across multiple in-situ, wellness, and medical apps
- Focused on human physiological parameters
- Using a personalized physiological simulator as part of a model predictive control loop
- Solutions consider personalized information and time dependent interventions
- New solutions for finding contradictory advice in textual outputs of apps
- Practical improvement to safety – people will use many apps

Research Challenges

- Development of a platform that supports construction of wireless and mobile medical apps that are conducive to dependency analysis
- Implementation of a set of apps with interventions
- Development of a runtime platform to support obtaining experience with running, detecting, and resolving dependencies to keep patients safe
- Develop solutions that can understand when advice (a major type of intervention) given by different apps is contradictory
- Develop solutions for addressing the very large numbers of secondary dependencies among the 7800 variables found in the HumMod simulator

Human-in-the-Loop Apps

- Smartphone Paradigm
- Medical apps are booming
 - US FDA expects 500M smart phone users downloading healthcare apps by 2015
 - By 2020, 157 million Americans predicted to have more than one chronic disorder



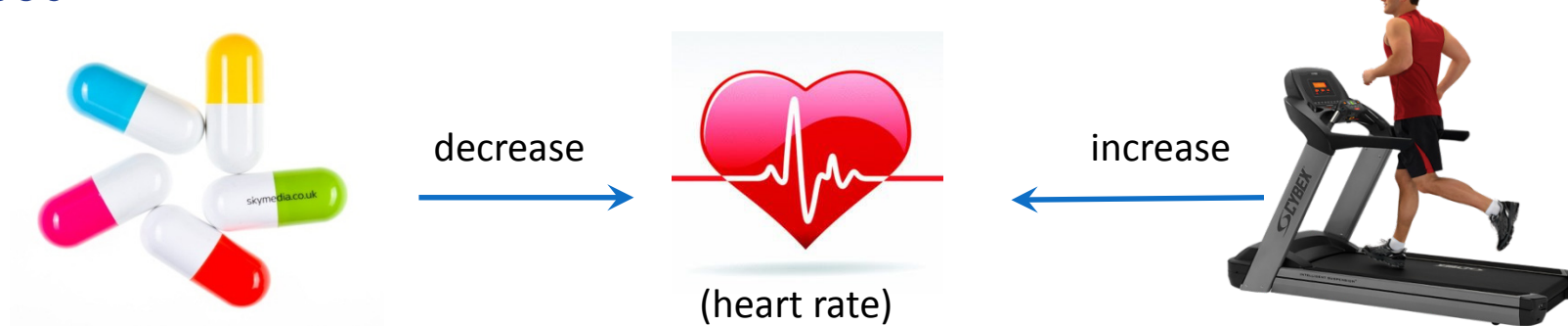
Conflicts in HiL CPSs

Very challenging!
Independently developed!

- Each app/system has its own assumption and strategy to control human physiological parameters

Multiple apps, multiple interventions : CONFLICTS

- Increase, decrease each others effects unwillingly
- Drug overdose



- Need to address a spectrum of (complex) dependencies

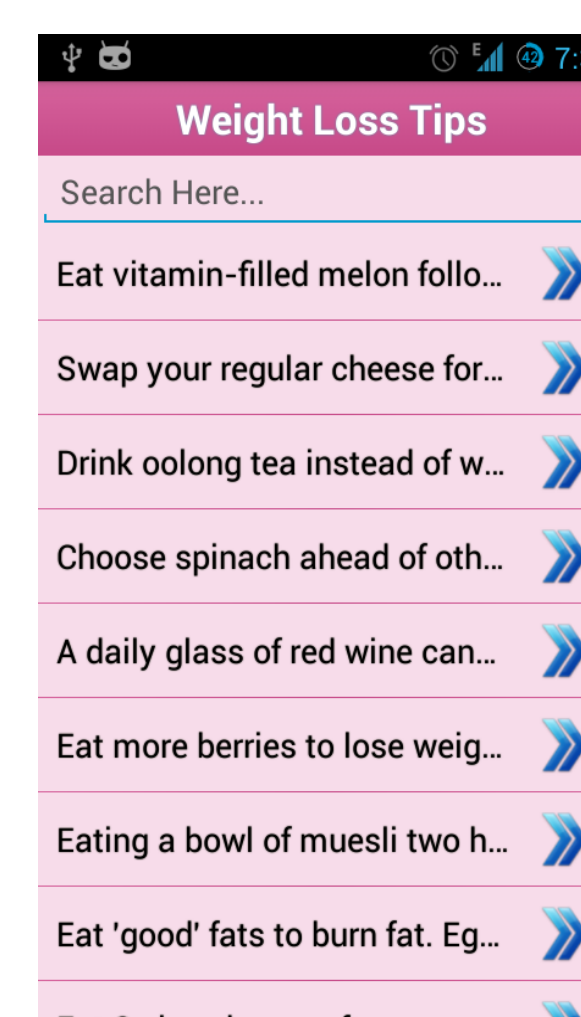
Conflicts in Textual Intervention

Majority of health apps provide interventions as formatted or free text

- Advice/recommendations

Detecting conflicts from pieces of text involve

- Understanding the intervention
- Inferring the implications of the intervention
- Using medical knowledge



Parameter Classification

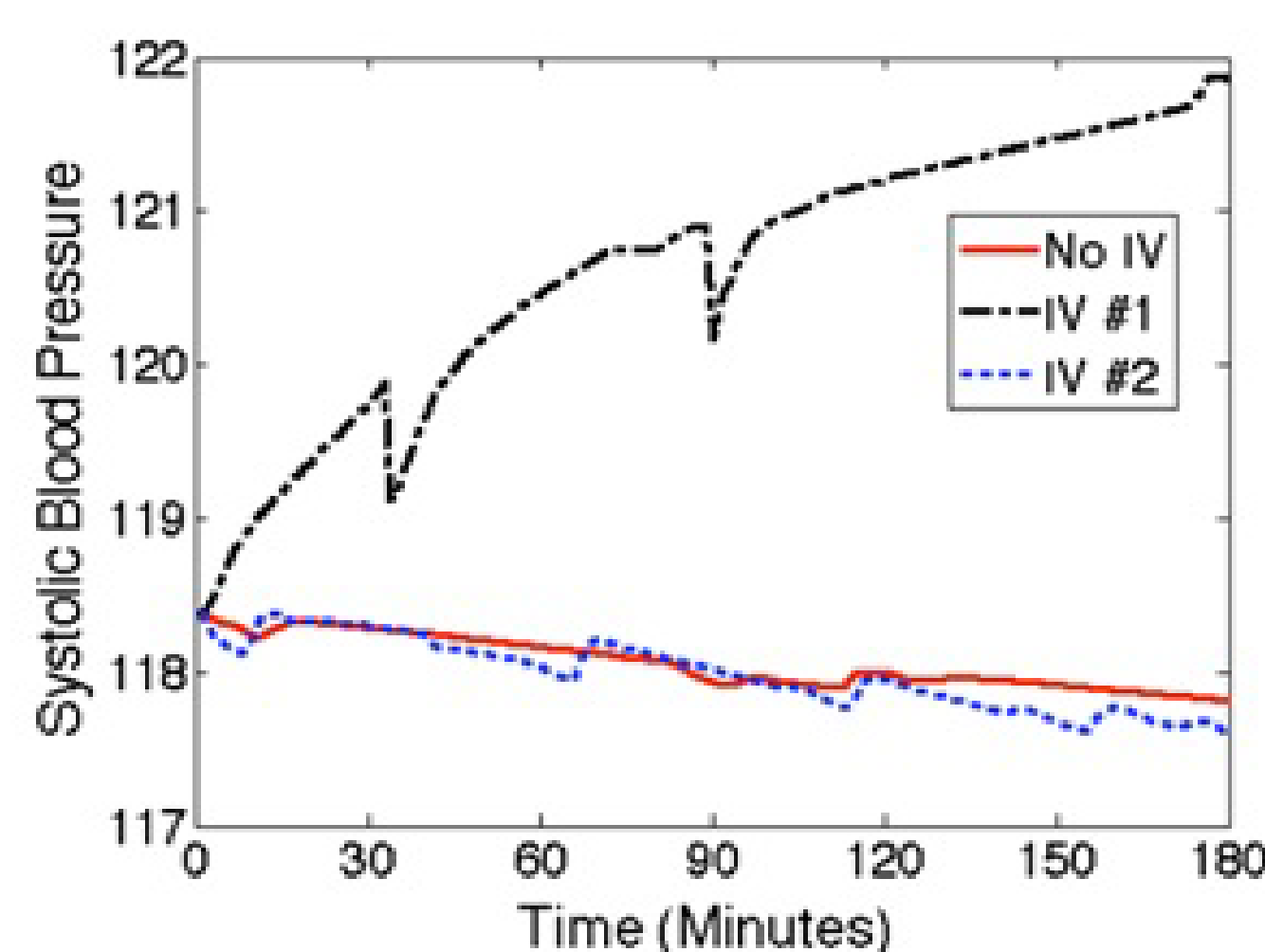
High Level Parameters (vital signs)

- Body temperature, heart rate, blood pressure, respiratory rate, glucose (normal range known) ✓ Extensible

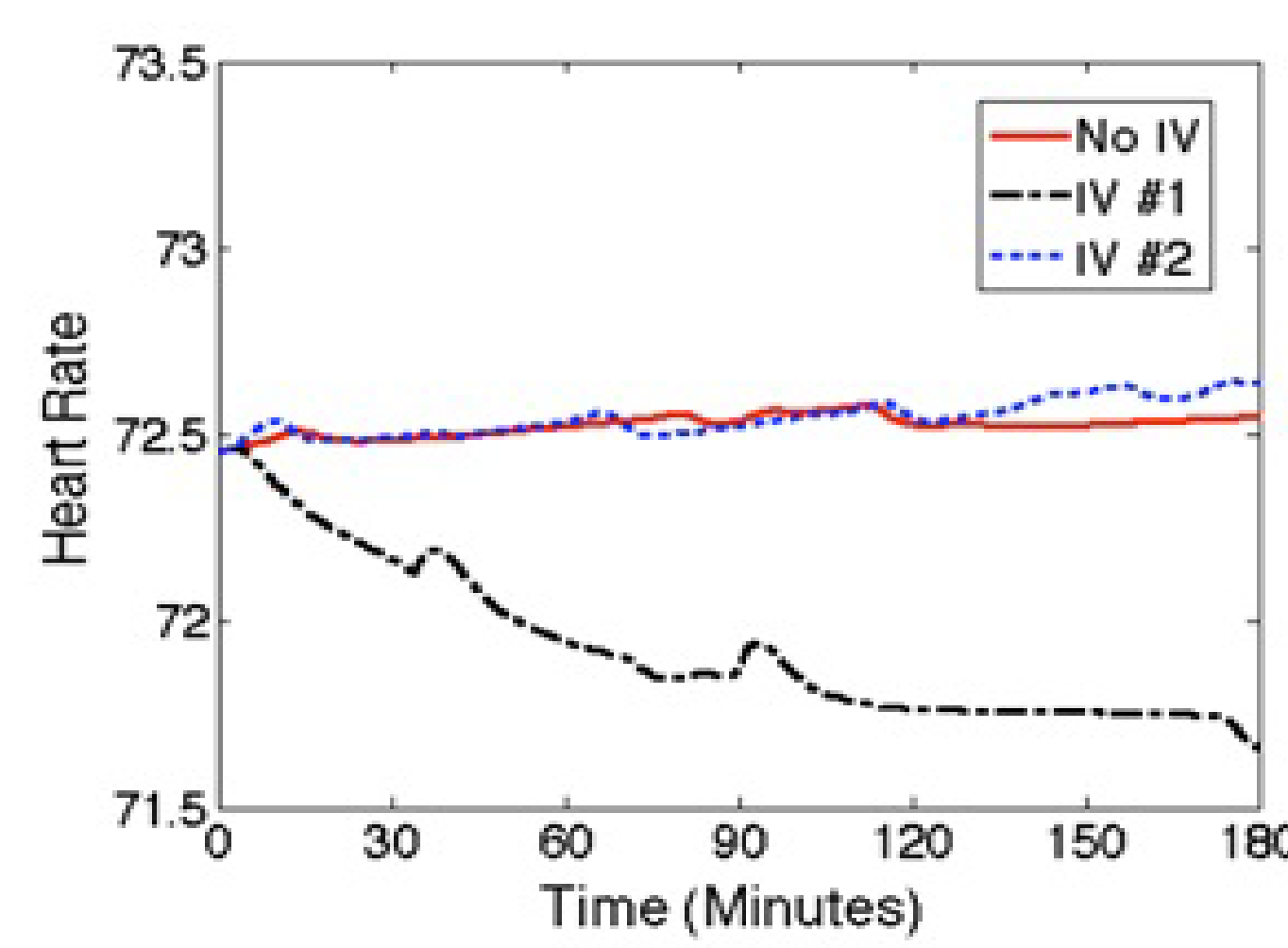
Low Level Parameters (secondary effects)

- Kidney-ArcuateArtery, BloodFlow, LeftHeart-Flow, BloodFlow, Liver-Fuel, GlucoseDelivered(Cals/Min)

Why do we need to worry about secondary effects (variables affected)?

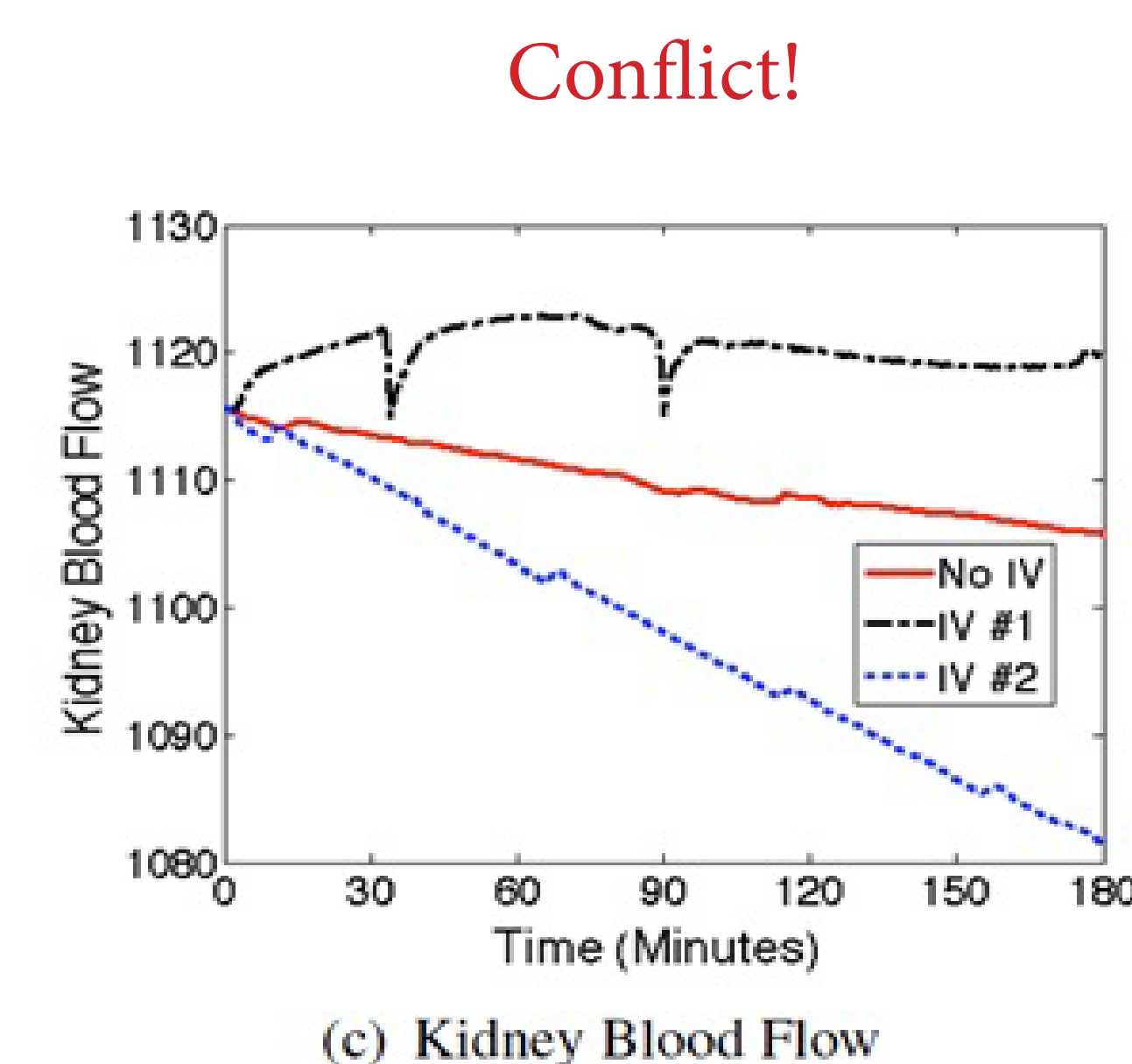


(a) Systolic Blood Pressure



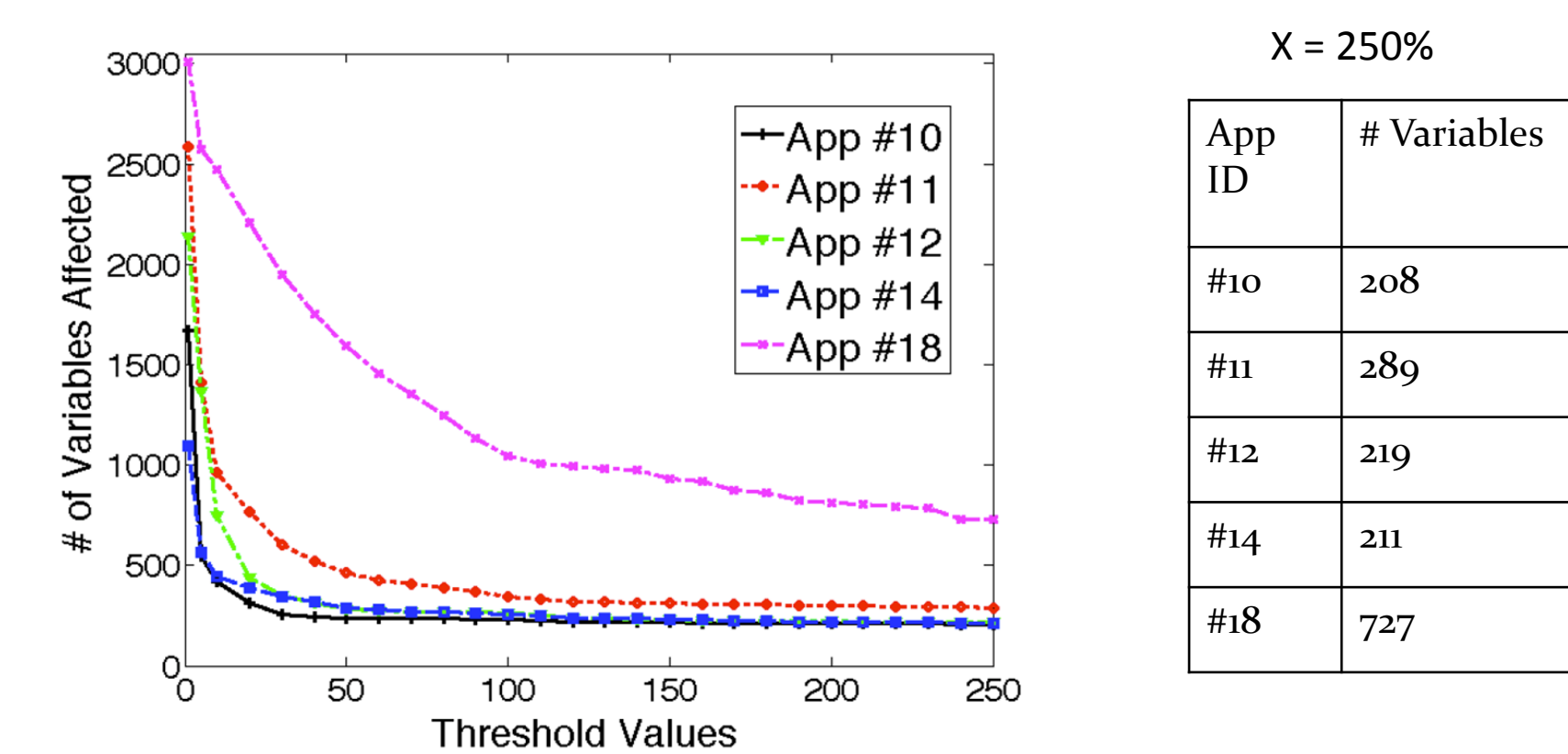
(b) Heart Rate

IV #1 = Administer Digoxin,
IV #2 = Administer Spironolactone



(c) Kidney Blood Flow

of Variables Affected



Finding: App developers can not specify all the effects!

Use App Meta Data

App Developers Specify

- Only the high level parameters (just 5 parameters)
- Allowed to specify low level parameters, if known
 - Specify effect: *increase, decrease, null*

<intervention> MidodrineSingleDose.Dose </intervention>

<dosage> 10 </dosage>

<param> Heart-Rate.Rate </param>

<effect> increase </effect>

Types of Conflicts in Text Advice

	Advice 1	Advice 2
Antonym	Soy is a miracle food.	Soy is terrible for you!
Negation	Olive oil is perfectly ok for frying.	Don't use olive oil for cooking as it has a low smoke point and can become toxic.
Numeric	Don't drink more than 4 cups of coffee per day, as it can increase the risk of death from all causes.	3 to 5 cups of coffee per day may lower heart attack risk.
Subject specific	Advice differs based on gender, age, health condition, ethnicity of the subject	
Contradictory effects	Red wine can inhibit the growth of breast cancer cells.	Avoid drinking as even one drink a day increases risk of breast cancer.
Different effects	Tea consumption can lower one's risk of hypertension and heart disease.	Prostate cancer risk is higher for heavy tea drinkers.

Structure of Advice

Free text:

- "Drink around 1.5 to 2 liters of water, every day."
- Sentence can be imperative or declarative
- Source: general health app that provides bulk of tips

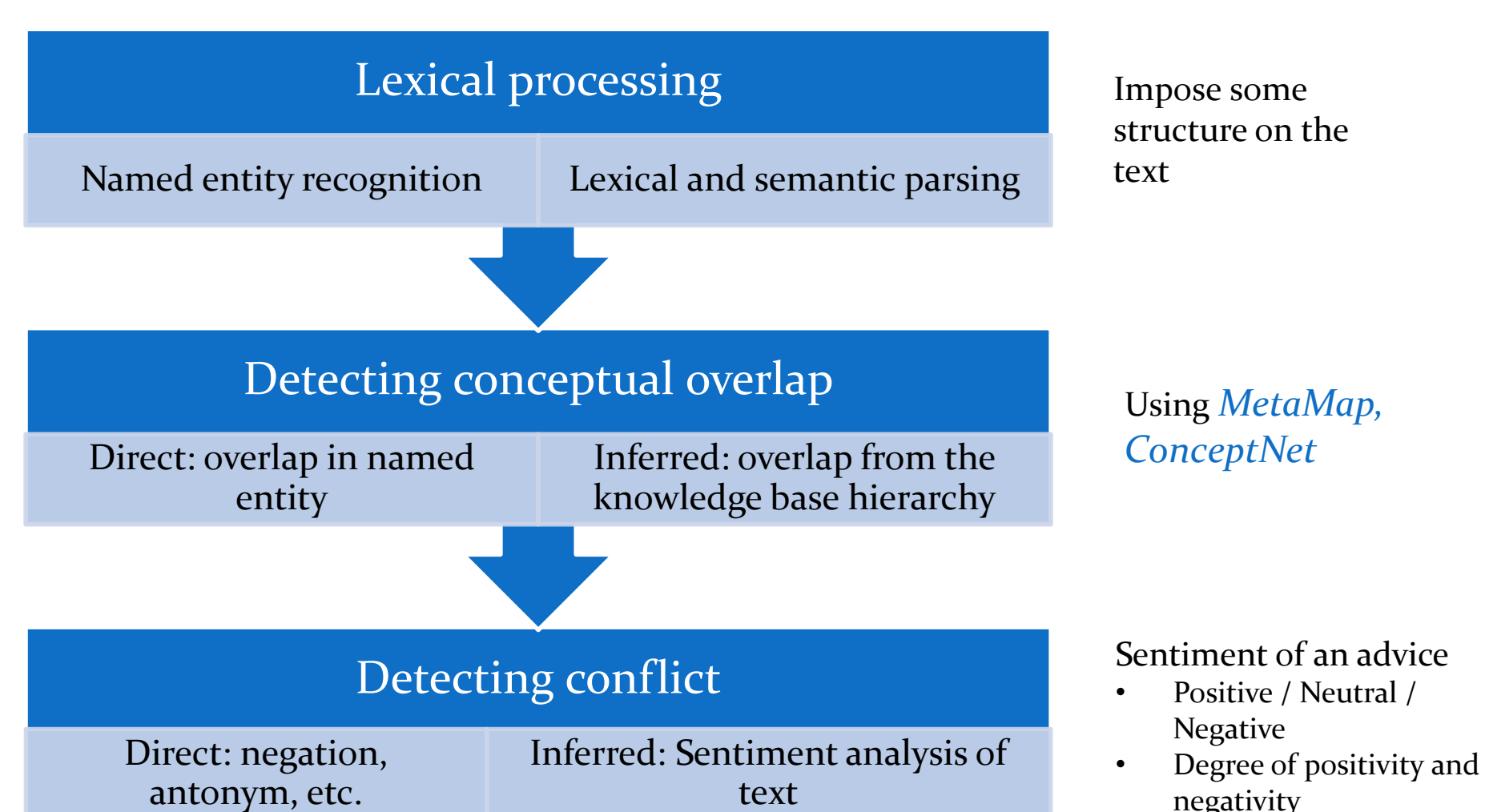
Semi-structured

- Something between the other 2 types
- Source: created by app developers, partial personalization

Structured

- <age: any><sex: any><condition: >...<task: drinking water><amount: 1.5L-2L><frequency: daily>...<affect: kidney><prevent: urinary infection>
- Source: personalized apps, thoroughly maintained by developers

Solution Approach



Smart Cities: Action Cluster Being Created

Title: Support for Safety of the Elderly Population

Participants

- Academia
 - University of Virginia
 - Stonybrook
 - University of Pennsylvania
 - DGIST, S. Korea
 - William and Mary
 - University of Minnesota
 - University of North Carolina
 - Virginia Tech
 - Texas A & M
- Industry - in progress
- Municipalities - in progress