

A DATA- AND EXPERT-DRIVEN DECISION SUPPORT FRAMEWORK FOR HELPING PATIENTS ADHERE TO THERAPY: PSYCHOBEHAVIORAL TARGETS AND ASSOCIATED INTERVENTIONS

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Motivation and Goal

- Non-adherence is one of the most significant barriers to effective treatment: 20-30% for short-term treatment, 50% for long-term and 70-80% for lifestyle changes [Jin et al., 2008]
- Interventions improving adherence have far greater impact on patient outcomes than those improving therapies [Haynes et al., 2008]
- Successful interventions combine patient education and behavior modification [Benjamin, 2012]

Our goal: to develop a decision support framework for providing most appropriate interventions to help patients with their treatment adherence

Proposed Decision Support Framework

1. Data-driven phase

- Identification of **psychobehavioral targets** → patterns in patient's psychological characteristics and behaviors that affect adherence
 - Application of dominance-based rough set approach (**DRSA**) to induce from data rules that capture patterns associated with adherence levels
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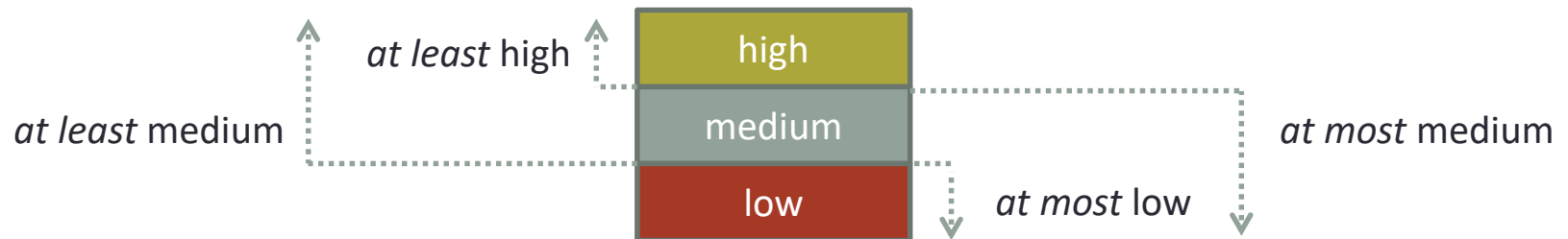
2. Expert-driven phase

- Construction and selection of **psychobehavioral interventions** → systematic plans of actions that affect patients' behaviors and psychological stance
- Application of predefined categories of generic interventions [Abraham, Michie, 2008] and domain knowledge (both clinical and psychological, e.g., behavioral economic principles)

DRSA:

Methodological Foundations

- Data analysis and knowledge discovery technique suitable for imperfect (incomplete, inconsistent) data
- Objects categorized into **ordered** classes (from worst to best) and described using features with (possibly) ordered values
- Analysis focused on unions of classes
 - *At least* and *at most* unions instead of individual classes



- Unions of classes also in consequences of discovered rules
→ *at least* and *at most* decision rules

DRSA:

Decision Rules

- Formally, r is a rule $\phi \rightarrow \psi$ derived from a set of objects U
 - ϕ is a premise (conjunction of conditions on selected features) and ψ is a consequence (union of decision classes)
 - r is also characterized by its confidence in U : $conf(r, U) = P_U(\psi|\phi)$
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- Classification- and **intervention-oriented** perspectives associated with decision rules
 - **Interventions** that may change values of object's features and affect its classification
 - ϕ defines the **intervention target** and ψ specifies the expected change in classification
 - $conf(r, U)$ gives a success rate of making the classification consistent with ψ after having attained target ϕ

DRSA:

Evaluation of Intervention-oriented Rules

- Target ϕ indicated in r can be evaluated using its **impact** on objects from set U' (different but homogeneous with U)

$$\delta(r) = \frac{|m(\neg\phi, U') \cap m(\neg\psi, U')|}{|U'|} \times \text{conf}(r, U)$$

where $m(\gamma, U')$ is a set of objects from U' that do satisfy γ

- Applicability profiles ϕ_i to limit the set objects that may achieve ϕ (\rightarrow additional “filters”)

$$\delta(r) = \frac{|[\bigcup_i m(\phi_i, U')] \cap m(\neg\phi, U') \cap m(\neg\psi, U')|}{|U'|} \times \text{conf}(r, U)$$

DRSA:

Types of Intervention Targets

- **Positive** targets
 - Associated with changes that improve class assignment, i.e., an object gets assigned to a better class after achieving the target
 - Given as premises of *at least* decision rules
- **Negative** targets
 - Associated with changes that result in deteriorated class assignment, i.e., an object gets assigned to a worse class after achieving the target
 - Given as premises of *at most* decision rules.

Positive targets should be achieved, while negative targets should be avoided

Framework – Phase 1:

Identification of Psychobehavioral Targets

- Patients described using sociodemographic, psychological and behavioral features [IOM, 2015] – interventions can be applied only to the latter two (\rightarrow psychobehavioral features)
 - Formal definition of rule changed to $\phi_{pb} \wedge \phi_{sd} \rightarrow \phi$, where
 - ϕ_{pb} is a psychobehavioral (intervention) target
 - ϕ_{sd} is a sociodemographic context (or sociodemographic characteristics)
 - ψ is a union of adherence levels
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- It is possible to obtain rules of no use with empty ϕ_{pb}
 - Feature selection \rightarrow all psychobehavioral features combined with the remaining relevant features (*reduct*)

Framework – Phase 1:

Evaluation of Psychobehavioral Targets

- Revised measure to evaluate the impact of ϕ_{pb} indicated by r (ϕ_{sd} acts as an applicability profile)

$$\delta(r) = \frac{|m(\phi_{sd}, U') \cap m(\neg\phi_{pb}, U') \cap m(\neg\psi, U')|}{|U'|} \times \text{conf}(r, U)$$

- Positive and negative psychobehavioral targets associated with improving and maintaining the level of adherence respectively

It is possible to capture correlation instead of causality between psychobehavioral targets and adherence levels → feedback loop and removal of rules with poor causality

Framework – Phase 2:

Construction of Psychobehavioral Interventions

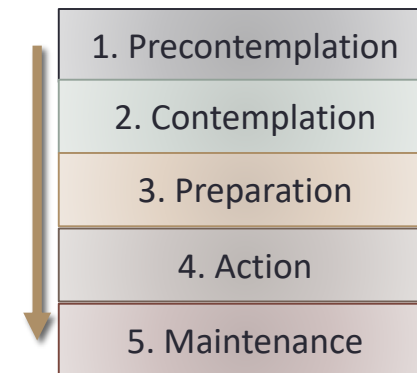
- Two major components of psychobehavioral interventions: **educational** and **behavior change** actions
- Educational actions should
 - Educate on disease manifestation, prognosis and management
 - Provide information about behavior-health links (benefits of a proper behavior and consequences of improper one)
 - Emphasize the key role of the patient in a successful therapy
- Behavior change actions should
 - Engage the patient in goal setting
 - Provide feedback on goal attainment
 - Encourage the patient for positive behavior

Critical role of self-reporting → “priming for honesty” to increase its reliability

Framework – Phase 2:

Selection of Psychobehavioral Interventions

- Predefined (static) associations between psychobehavioral targets and interventions (automatic matching in future)
- Additional constructs for more fine-grained and dynamic selection of a delivered intervention
 - **Transtheoretical model (TTM)** – classifies the patient according to where they are in their readiness of change
 - **Self-determination theory (SDT)** – evaluates the patient's level of autonomous (or intrinsic) motivation
- TTM and SDT employed also to define a stopping condition for delivering specific psychobehavioral interventions



Case Study: Atrial Fibrillation Treatment

- One of the most prevalent types of cardiac arrhythmias → approximately 30% of hospitalizations for arrhythmias
- Oral anticoagulation therapy is often sub-optimal due to poor patient's adherence and limited behavioral change
- Limited support for patients to help with their adherence (MobiGuide as one of the most advanced available tools)



Case Study:

Analyzed Data and Selected Features

- 12 patient vignettes vetted and revised by the hematologist
 - Described by 10 features (consistent with recommendation of IOM for EHR) – 2 psychobehavioral and 8 sociodemographic
 - Categorized into 3 adherence levels
- A set of features further limited to three features from a reduct (result confirmed by additional analysis using UTA method)

	Adherence_history	Smoking_or_alcohol	In_charge	Adherence_level
v1	(3) good	(2) moderate	(2) yes	(2) moderate
v2	(2) none_or_moderate	(1) none_or_light	(2) yes	(3) good
v3	(2) none_or_moderate	(1) none_or_light	(1) no	(2) moderate
v4	(1) poor	(1) none_or_light	(2) yes	(1) poor
v5	(2) none_or_moderate	(3) heavy	(1) no	(1) poor
v6	(1) poor	(2) moderate	(1) no	(1) poor
v7	(3) good	(1) none_or_light	(2) yes	(3) good
v8	(2) none_or_moderate	(1) none_or_light	(1) no	(2) moderate
v9	(2) none_or_moderate	(1) none_or_light	(1) no	(2) moderate
v10	(3) good	(2) moderate	(2) yes	(2) moderate
v11	(2) none_or_moderate	(1) none_or_light	(2) yes	(3) good
v12	(1) poor	(3) heavy	(1) no	(1) poor

Willingness to be in charge of one's health → **engagement**

Case Study:

Identified Psychobehavioral Targets

- Leaving-one-out schema for reliable identification and evaluation of psychobehavioral targets

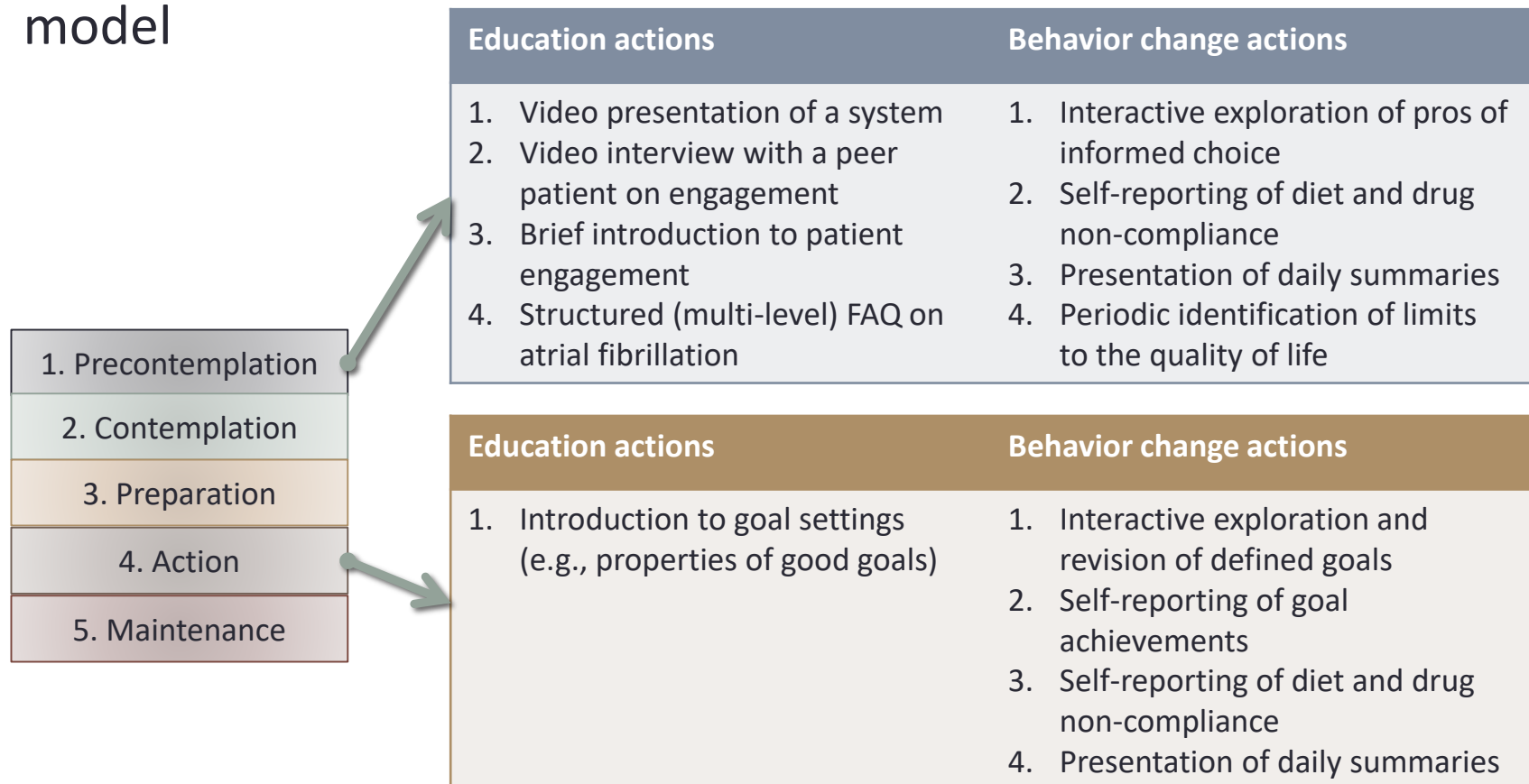
	Sociodemographic context	Psychobehavioral target			Impact [%]
	Adherence_history	Smoking_or_alcohol	In_charge	Adherence_level	
r1	>= none_or_moderate	<= none_or_light	>= yes	>= good	54.9
r2	>= good			>= moderate	
r3	>= none_or_moderate	<= none_or_light		>= moderate	9.1
r4	<= poor			<= poor	
r5		>= heavy		<= poor	66.7
r6			<= no	<= moderate	25.0
r7		>= moderate		<= moderate	25.0

- Positive target in r_1 → limit smoking or drinking (to none or light) and improve patient's engagement
- Negative target in r_5 → maintain current (at most moderate) smoking or drinking level

Case Study:

Possible Psychobehavioral Interventions

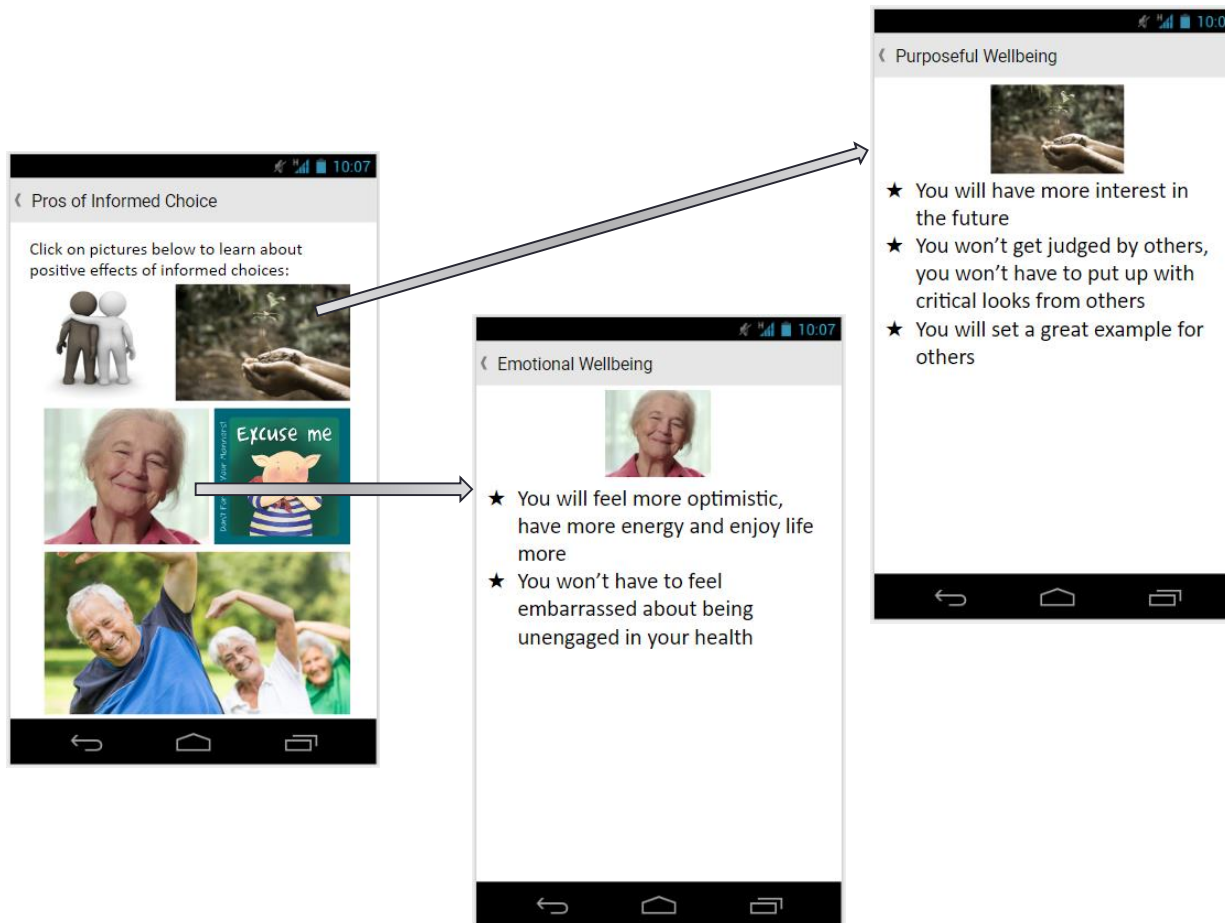
- Interventions aimed at improving patient's engagement
- Fine-grained selection based on the patient's stage in the TTM model



Case Study:

Possible Psychobehavioral Interventions

- Selected interventions implemented in a mobile system



Conclusions

- A framework for identification of psychobehavioral targets and construction and selection of appropriate interventions
- Combination of data-driven and expert-driven phases
- Implementation of the framework within the Motivational Patient Assistant (MPA) system
 - Extension of MobiGuide with support for adherence
 - A specialized version (AF-MPA) aimed at atrial fibrillation
 - Planned limited evaluation of AF-MPA with patients and physicians

Ultimate goal is to provide **end-to-end support for management of complex patients** from the office of a primary care physician to the patient's home

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Thank you for your attention
Questions?