

# HEARTMAN: Personal Decision Support for Heart Failure Management

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## BACKGROUND AND MOTIVATION

- Congestive heart failure (CHF) occurs when the heart cannot pump enough blood to meet the body's needs. The symptoms include shortness of breath, excessive tiredness and leg swelling. In developed countries, around 2 % of adults have heart failure, increasing to 6–10 % at ages over 65, when it becomes the leading cause of hospitalisation. There is no cure, and around 50 % of patients die within 5 years from diagnosis.
- Since CHF cannot be cured, its management is critical for survival and quality of life. In addition to taking medications, the patients must monitor their condition, exercise appropriately, watch what they eat and drink, and make other changes to their lifestyle.
- Since CHF management is complex and the patients mostly elderly, they often find it difficult to remember what exactly they need to do. We thus developed a mobile application that delivers personalized CHF management advice. Its heart is a personal decision support system using workflows, rules, DEX decision models and predictive models built with machine learning.

## WEEKLY EXERCISE PLANNING

- Endurance (e.g., walking) and resistance exercises (e.g., lifting)
- Exercise programme defines frequency and duration for each week
- Start with initial frequency and duration according to the programme
- Each week increase or decrease depending in patient's adherence to medications and his/her request to change the programme

**Model: endurance frequency (other models similar)**

Attribute	Scale
EnduranceFrequency	2x; 3x; 4x; 5x
Normative	2x; 3x; 4x; 5x
Category	low; normal
Week	1; 2; 3; 4; 5; 6; 7; 8; 9; 10; 11; 12; 13; 14; 15; 16; 17; 18; 19; 20; 21; 22; 23; 24; more
Current	2x; 3x; 4x; 5x
Transition	decrease; stay; increase; automatic
Adherence	no; yes
PatientsRequest	decrease; stay; increase; automatic

According to the exercise programme

Depends on patient physical capacity

As actually done (can be ahead or behind the plan)

Whether to change the frequency from one week to another

**Decision table: normative frequency (defined by the exercise programme)**

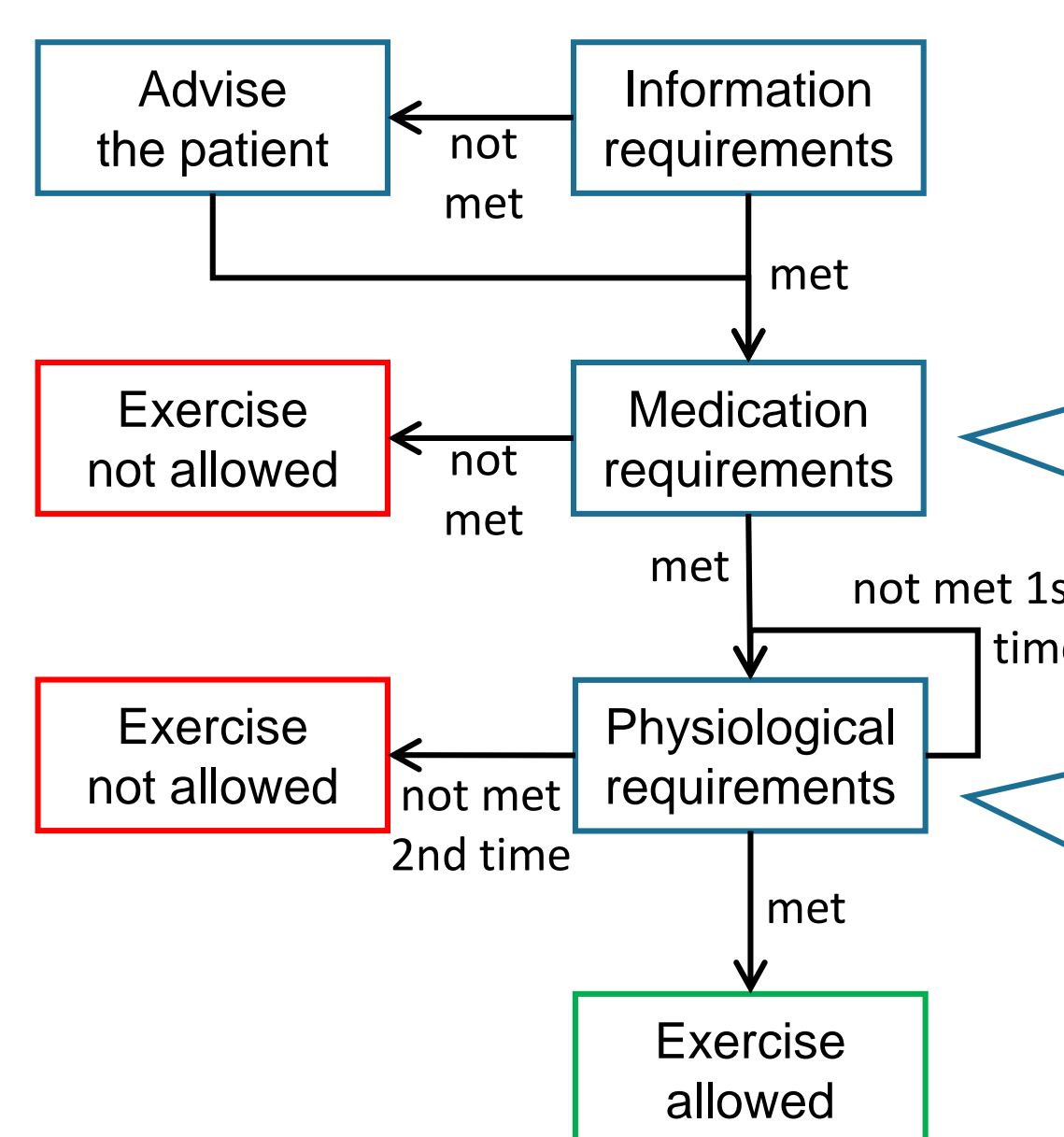
Category	Week	Normative
low	<=4	2x
low	5–12	3x
normal	<=6	3x
low	13–18	4x
normal	7–12	4x
low	>=19	5x
normal	>=13	5x

**Decision rules: transition (\* = any value)**

Adherence	PatientsRequest	Transition
*	decrease	decrease
no	>=stay	stay
*	stay	stay
yes	increase	increase
yes	automatic	automatic

## DAILY EXERCISE

- Each day the weekly exercise plan prescribes exercise, the patient is provided assistance to perform it safely
- Check if information on blood pressure and heart rate is available and the values are within prescribed boundaries, and check if there are any problematic interactions with medications



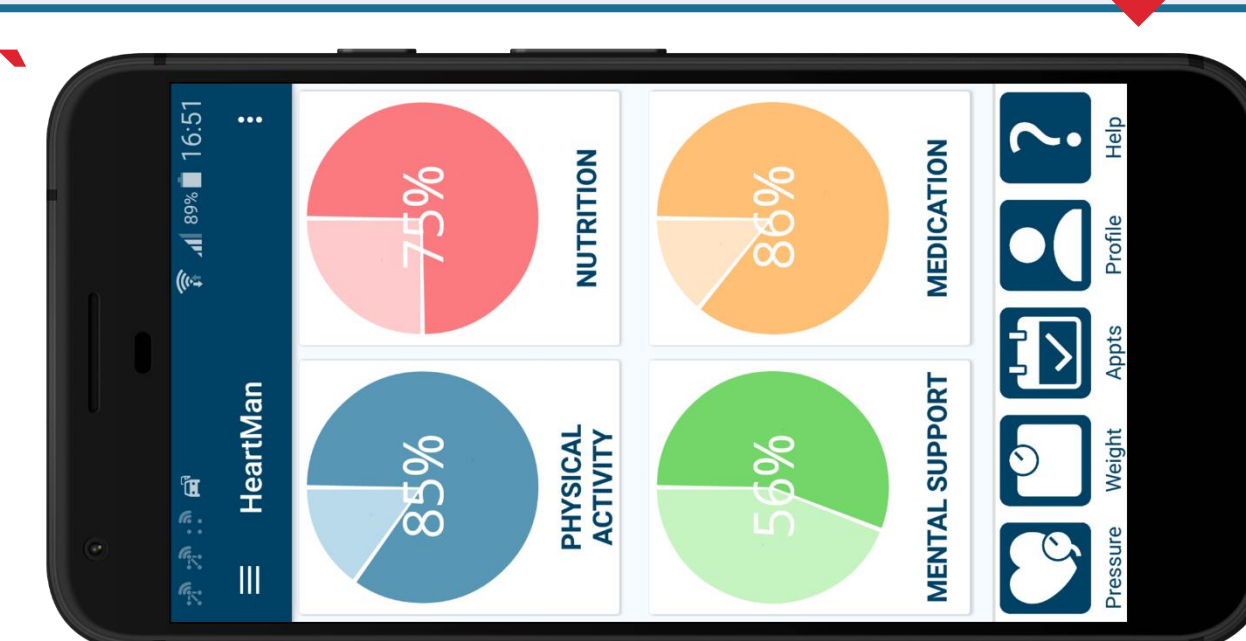
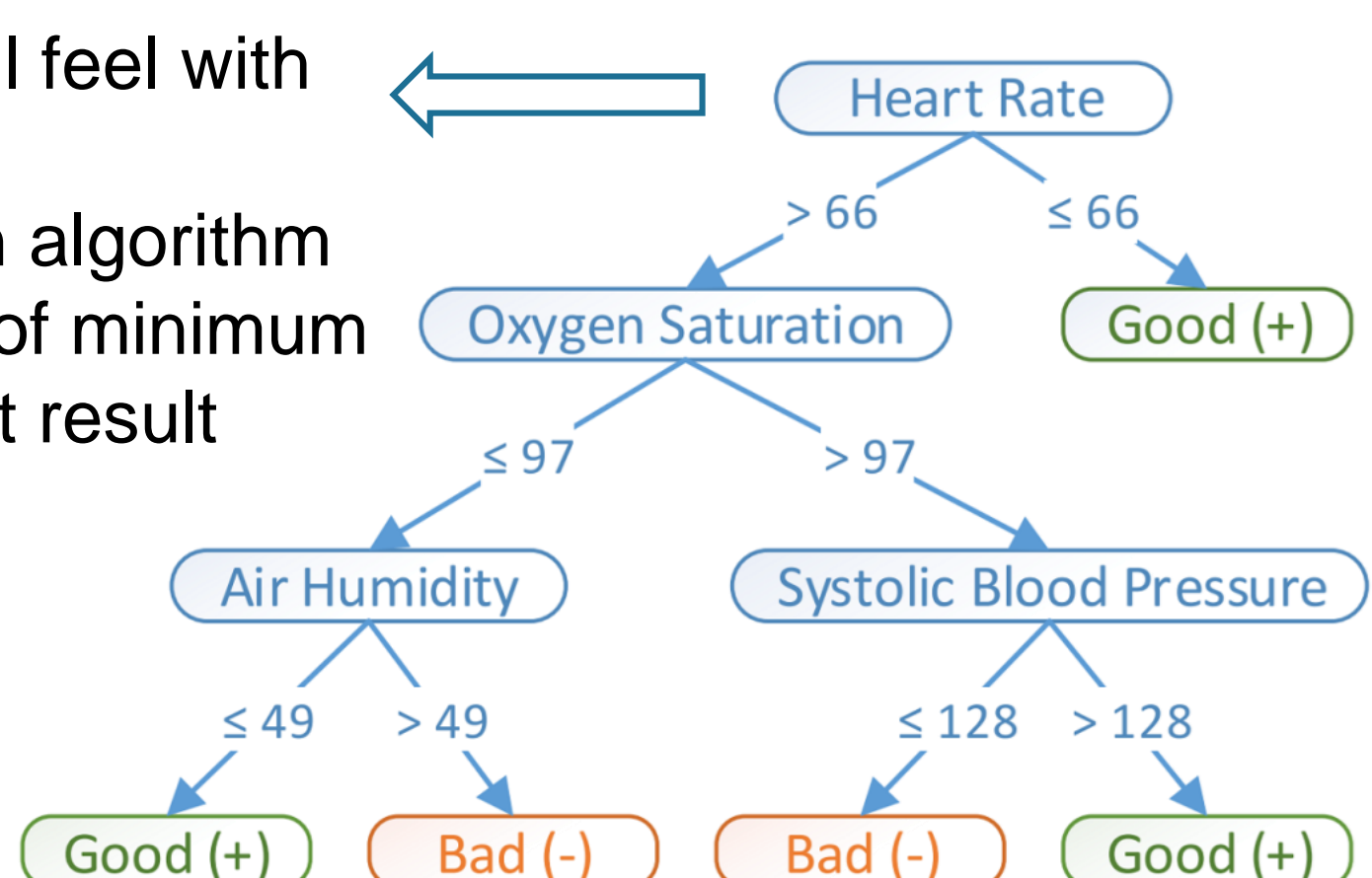
Attribute	Scale
PreExerciseRequirements	not_met; met
BloodCoagulationReasons	yes; no
TakesAnticoagulants	yes; no
PossibleBleeding	yes; no
Rash	yes; no
Hemorrhages	yes; no
NeurologicalSymptoms	yes; no
MedicationIntakeReasons	yes; no
Intake<2hours	yes; no
ExercisePreventionMedications	yes; no
TakesBetaBlockers	yes; no
TakesACEInhibitors	yes; no
TakesARBs	yes; no
TakesDiuretics	yes; no
TakesLoopDiuretics	yes; no
HeartRateReasons	yes; no
TakesDigitalis	yes; no
HR<40	yes; no
BloodPressureReasons	yes; no
HypertensionReasons	yes; no
TakesACEInhibitors	yes; no
TakesARBs	yes; no
PersistentLowBloodPressure	yes; no
PersistentCough	yes; no
SystolicPressureReasons	yes; no
TakesLoopDiuretics	yes; no
TookLoopDiuretics	yes; no
SYS<105	yes; no

## ENVIRONMENT

- We built models that predicts the feeling of health based on physiological and ambient parameters
- Since it is hard for the patients to modify their physiological parameters, the model is mainly used for decisions about ambient temperature and humidity

### Procedure

- Predict how the patient will feel with the current parameters
- If bad, use an optimisation algorithm to find minimum changes of minimum number of parameters that result in the patient feeling good
  - Change directly modifiable parameters
  - Compute parameters correlated with the directly modifiable ones using linear regression
  - Predict how the patient will feel with new parameters
  - Discard solutions in which the feeling remains bad
- Advise the patient to make the smallest modifications that result in feeling good



MOBILE APPLICATION + SENSING WRISTBAND



## MEDICATION

- Reminders for medications at appropriate times
- Instructions to fill a pill organiser once a week
- Questions about the number of pills remaining to estimate how many the patient skipped



## NUTRITION

- Nutrition knowledge questionnaire in week 1 (e.g., How much salt are you allowed to eat per day?)
- Nutrition behaviour questionnaire in week 2 (e.g., How much did you drink yesterday?)
- Repeat every three months
- In between, advice on topics identified as problematic in the questionnaires (inadequate knowledge or unhealthy behaviour)