Designing a Health Coach-Augmented mHealth System for the Secondary Prevention of Coronary Heart Disease among Women

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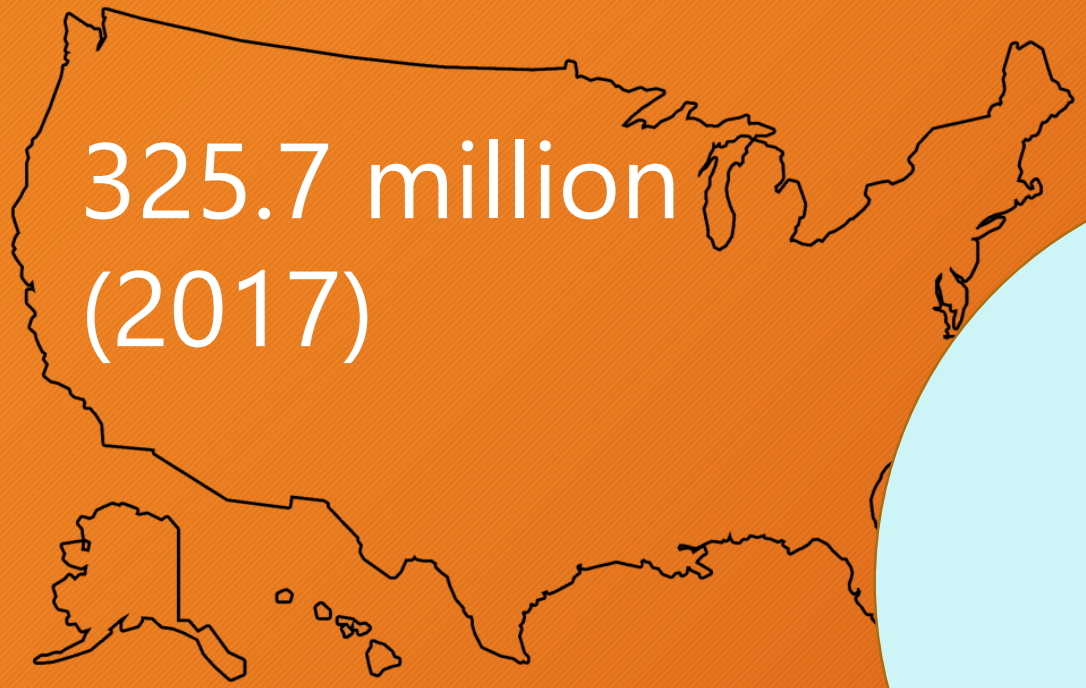
Motivation



CHD Affected People

16.5 Million Adults

5.06% Population

CHD Affected

7 Million Women

2.14% Population

CHD Affected People

16.5 Million Adults ♂ ♀

7 Million ♀

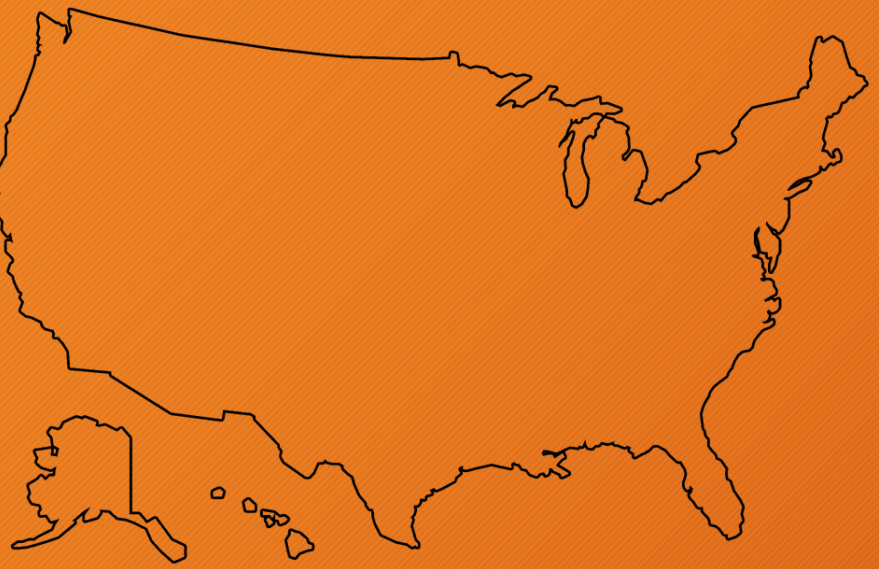
40% Increase

23.1 Million Adults ♂ ♀

9.8 Million ♀

2018

2035

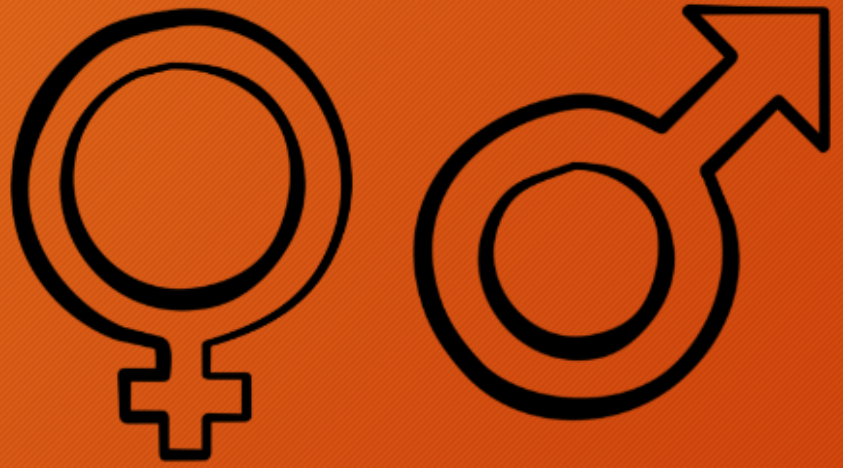


$182 Billions

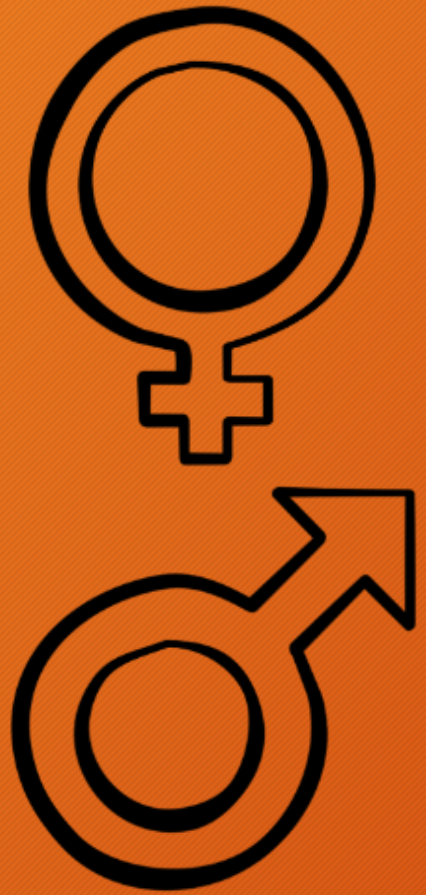
CHD Related Cost (2015)

Re-hospitalization within 30 days to 1 year of the cardiac event

30% More



In Research



Undertreated
Underrepresented

Rectifying sex-specific disparities in CHD

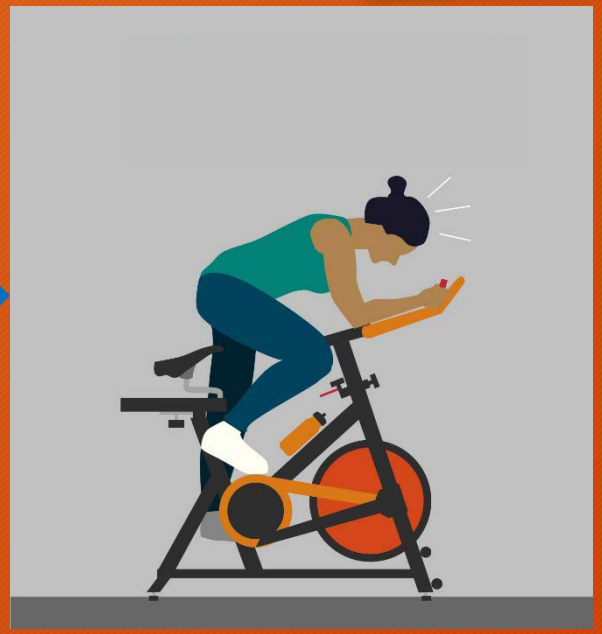
National Priority

Current Process: CBCR

Experience a Cardiac Event 💔

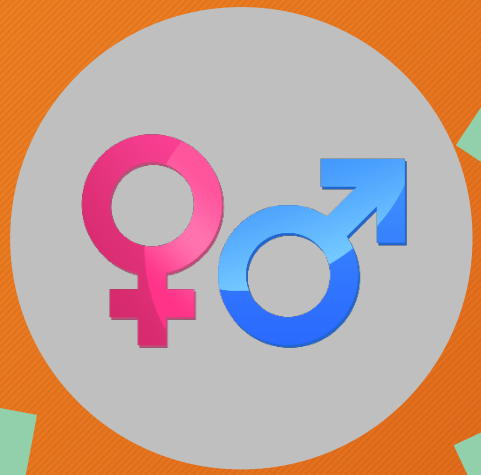
Diagnosed with CHD 💔

Cardiac Surgery



Center Based Cardiac Rehabilitation (CBCR)

CBCR Related Issues



- Low Family Income
- Inadequate Health Insurance
- Transportation Challenges
- Time Constraint
- Work Obligation

CBCR Relate Issues: Women

Dislike Mixed-Gender Exercise

Find Exercise Tiring and Painful

Unmet Emotional Needs in CR

CBCR Related Issues

Limited access to CBCR

Struggle with disease self-management

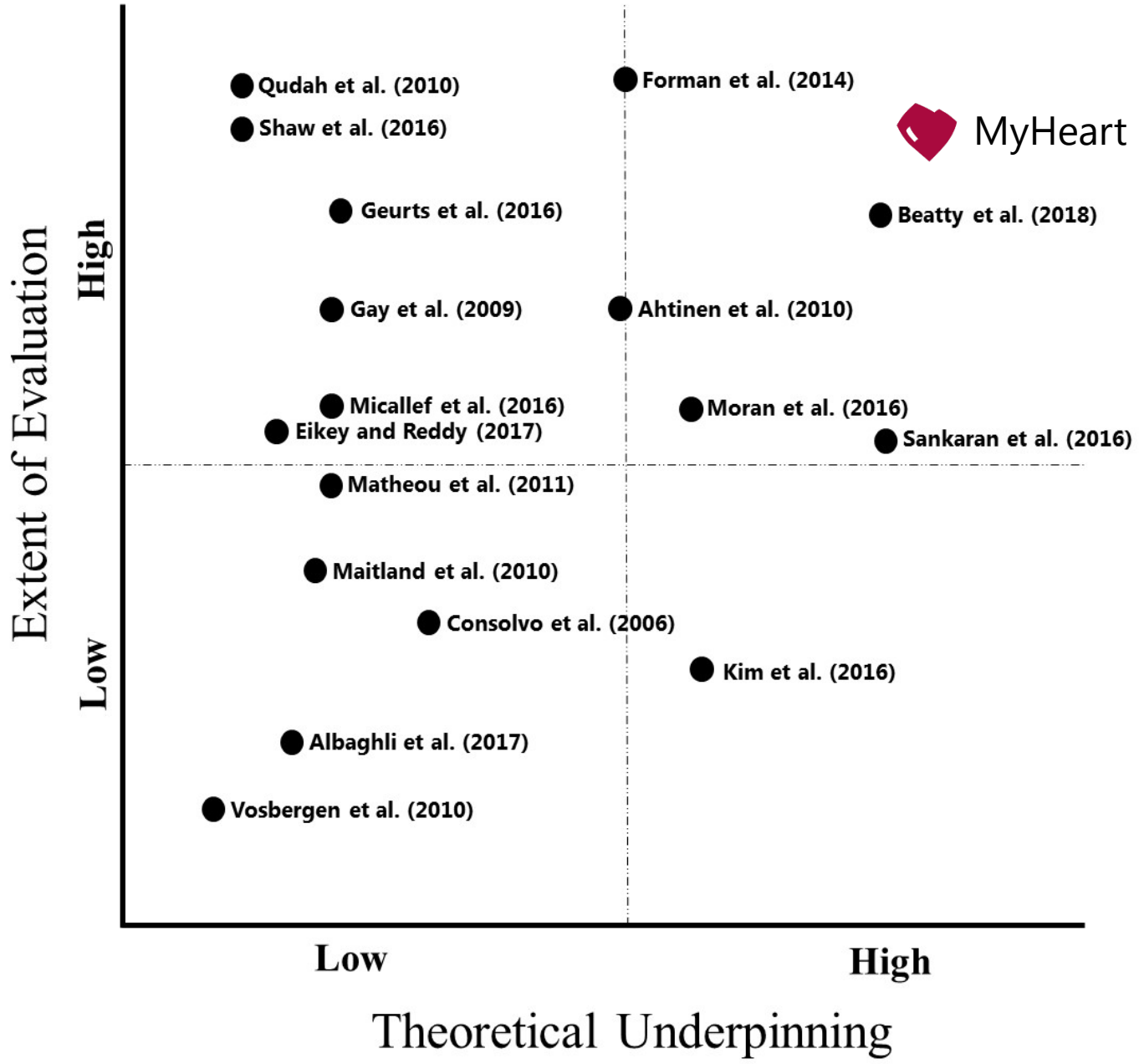
Research Questions

- What is feasible and required to develop a comprehensive mHealth home-based cardiac rehabilitation (HBCR) program for women with coronary heart disease?
- What is the impact of an mHealth HBCR program for women with CHD?

Existing Research

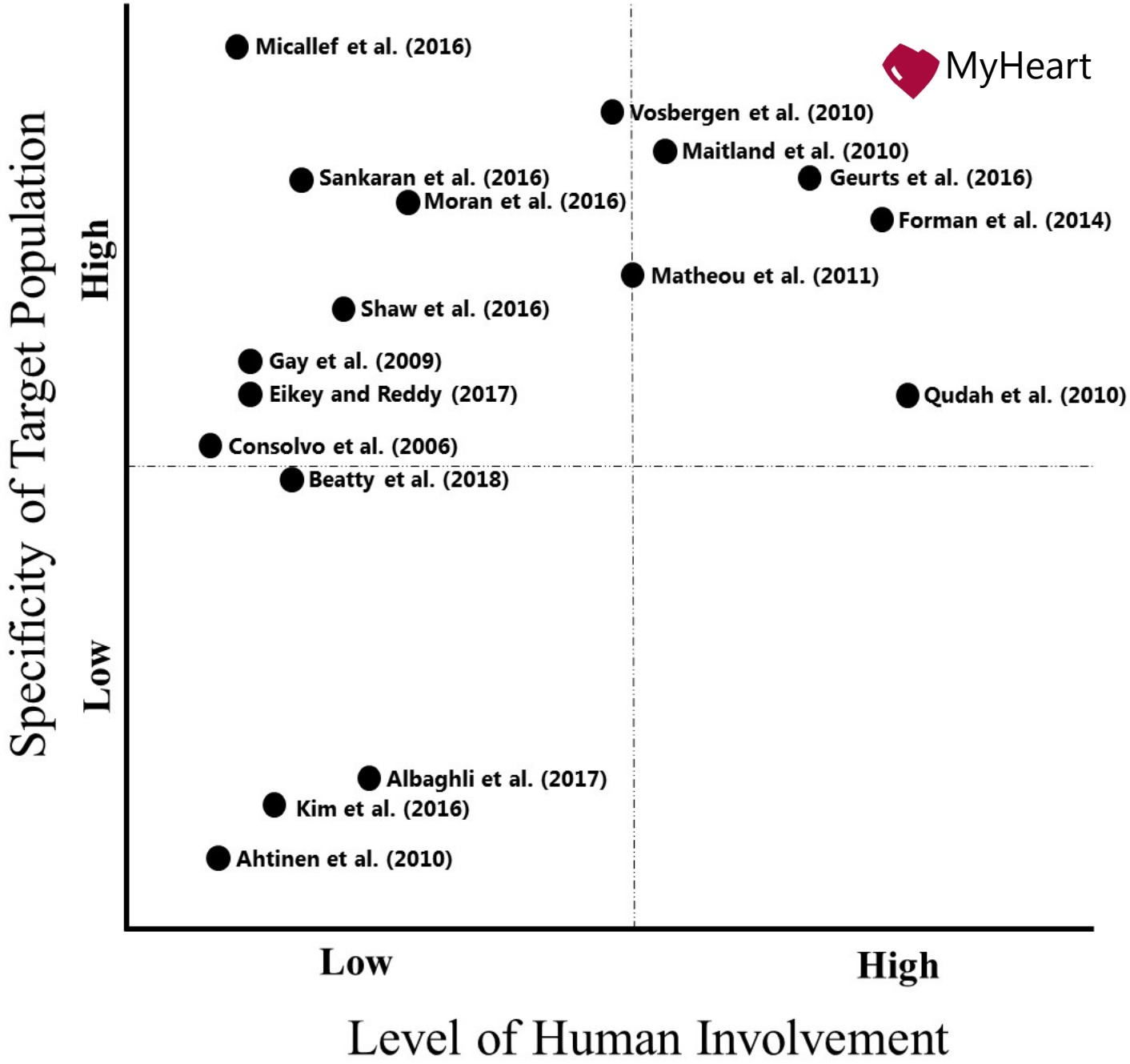
Existing Research

Theoretical Underpinning	extent to which the study uses single or multiple theories
Extent of Evaluation	number of different evaluation methods followed while evaluating a designed artifact



Existing Research

Level of Human Involvement	extent to which the designed artifact involve human being while performing a specific task
Specificity of Target Population	extent to which the designed solution is cater to the need of a specific population



MyHeart Design Characteristics

Health Coach needs to be involved

Safeguard against random or systematic malfunction

Identification of meaningful behavioral pattern

Interventions need to be dynamic

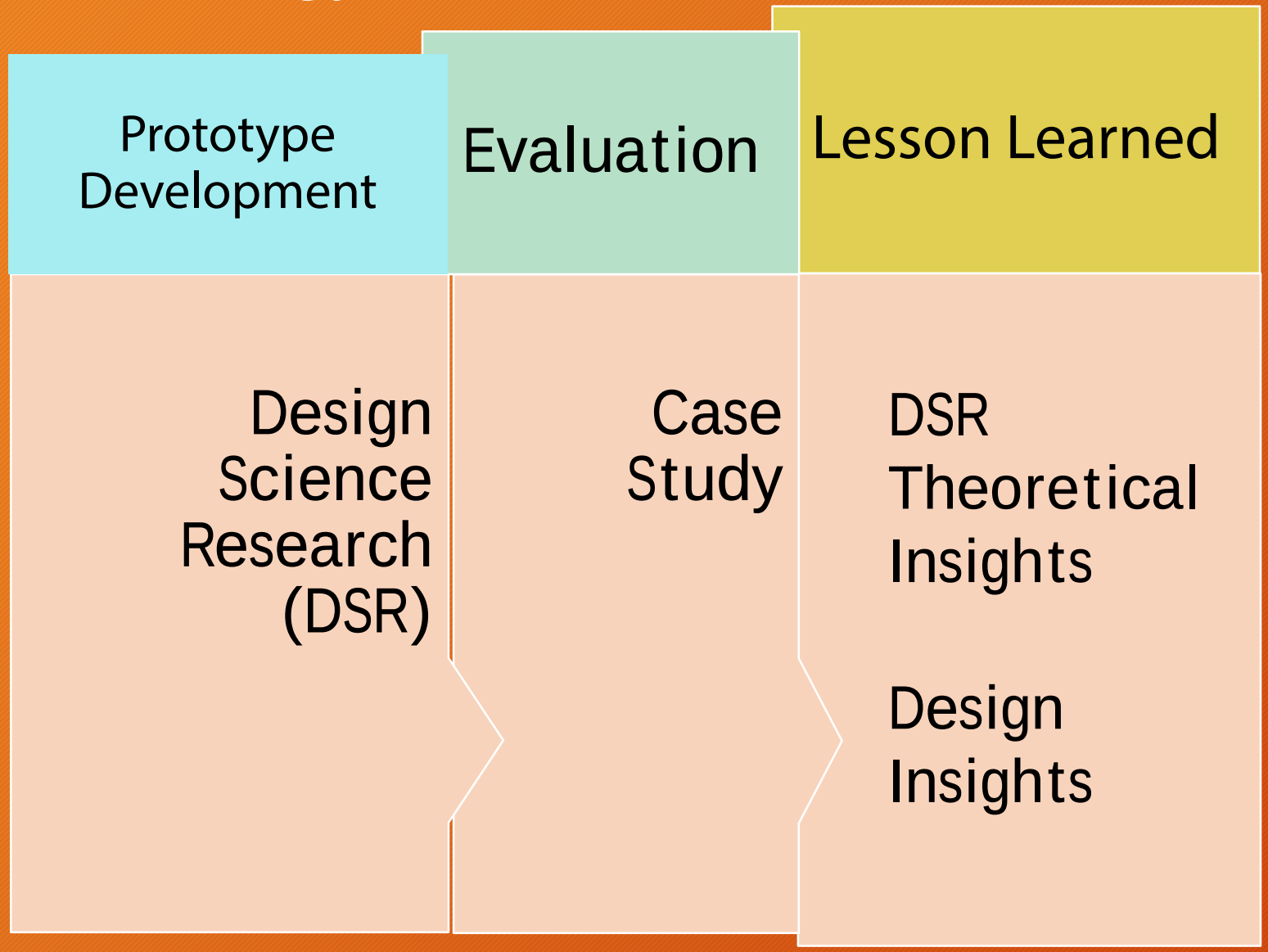
MyHeart Design Characteristics

Uses EMA to design interventions to target the unwarranted behavior

Dashboard gives unique opportunities to track both proximal and distal outcome

Research Methodology

Research Methodology



MyHeart Design

MyHeart: Design of System Architecture

Machine Learning Algorithm & Activity Recognition

Gyro (X,Y,Z)
Accel (X,Y,X)
Activity
Step Count
Heart Rate

BlueTooth

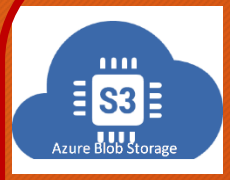
Smart Phone App

Receive Activity from Smart-Watch, Accept EMA Responses and Trigger Interventions

Patient Interaction with App + EMA

Intervention

Wi-Fi / 4G

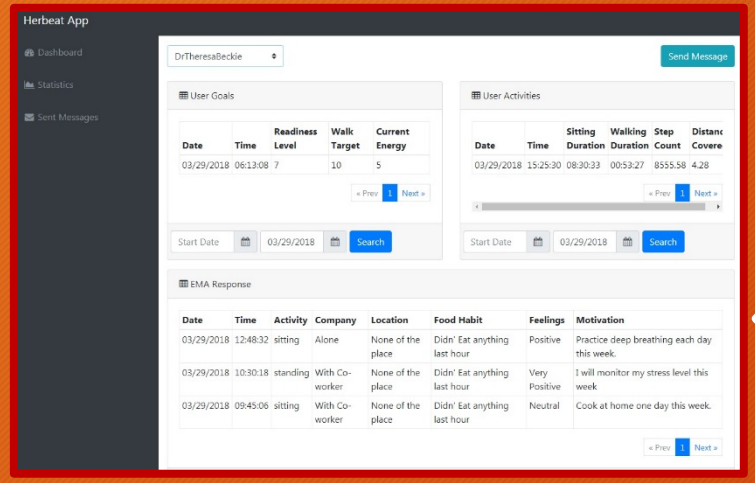


Analytic Processing

Servers

Summary Data

Azure HIPPA Compliant Private Cloud

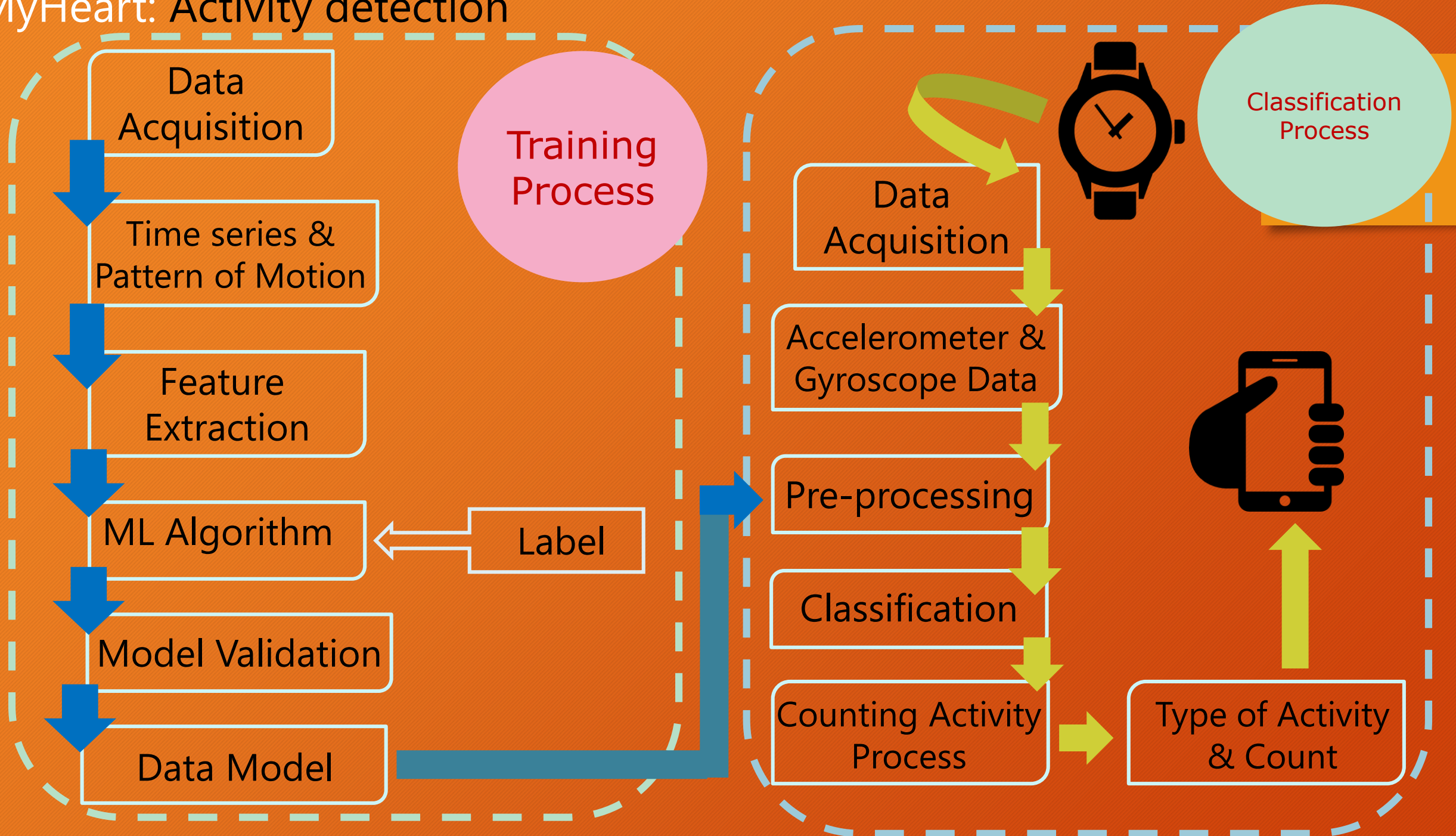


Dashboard for Health Coach

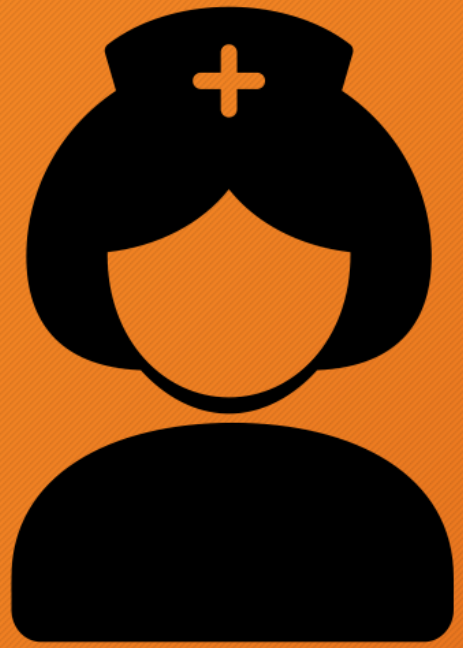
Health Coach Feedback to Patients

Health Coach Interaction with Dashboard

MyHeart: Activity detection



MyHeart: Decision Rule System



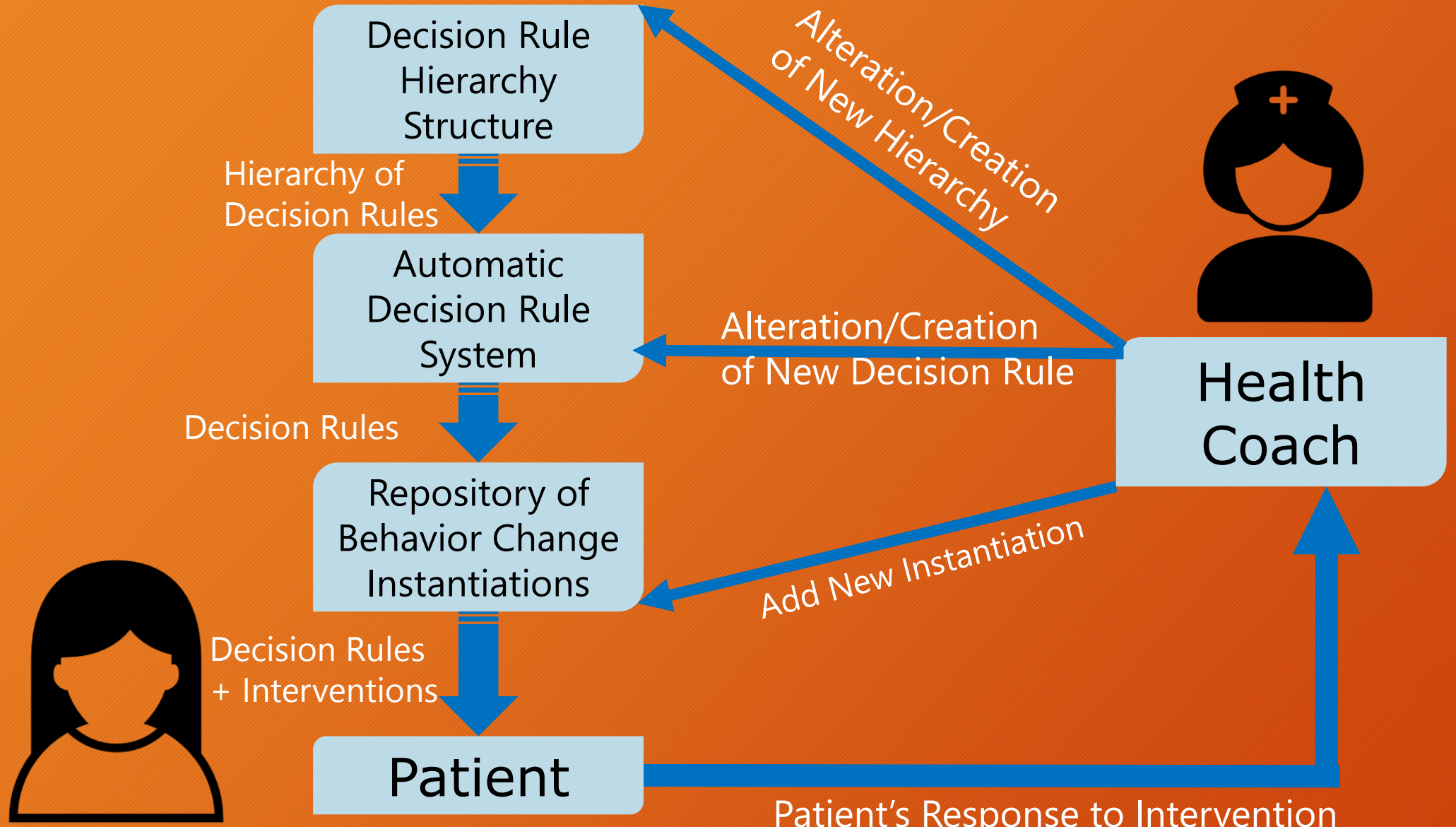
Preprogrammed Decision Rules

- Automated system with the help of health coach

Impromptu, Personalized Decision Rules

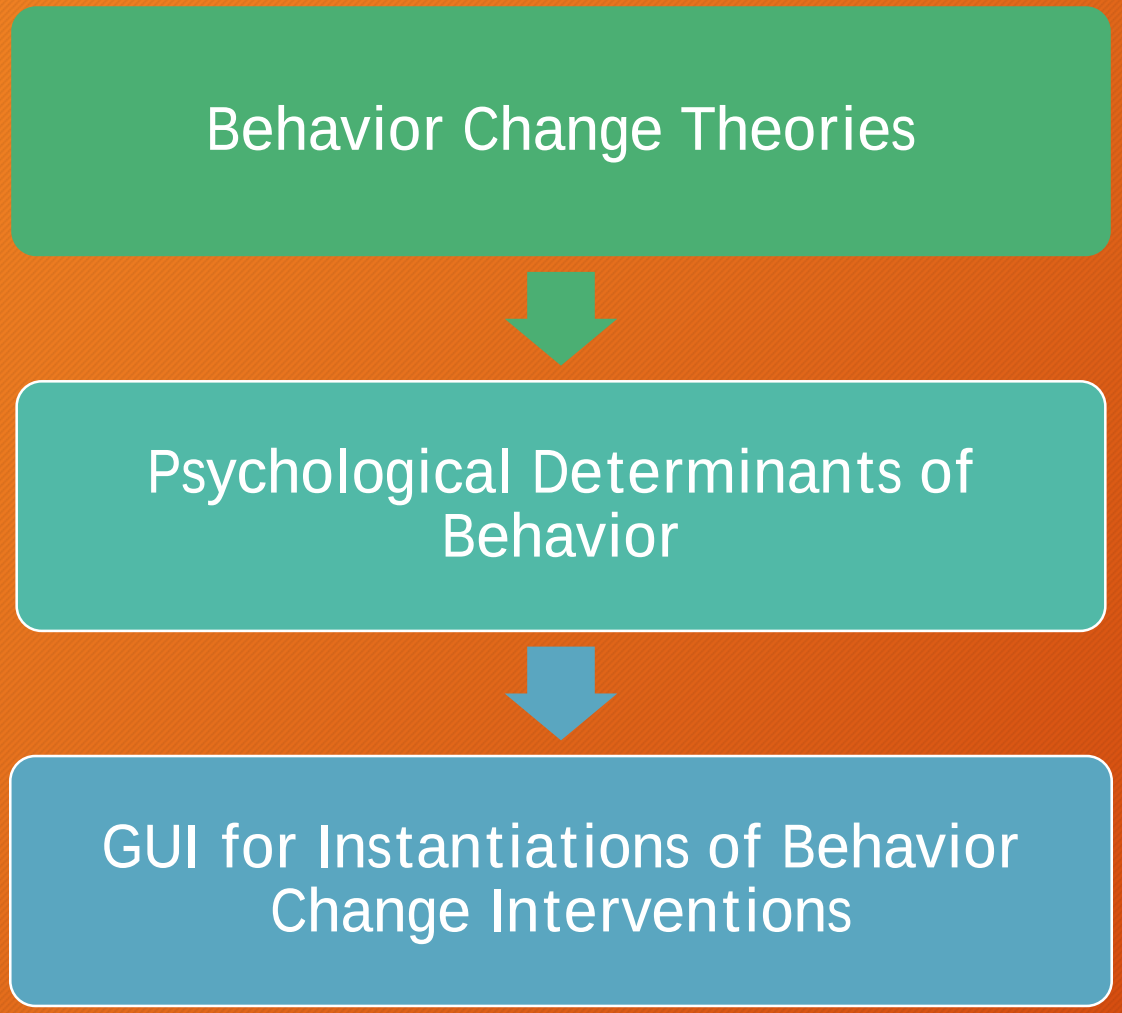
- Health coach only

MyHeart: Automatic Decision Rule System



MyHeart:

Theory-Based Behavior Change Techniques (BCTs) and Interventions



Evaluation

Evaluation: Case Study

Test the high fidelity system prototype with the help of 6 CHD patents through a field trial spanning 12 weeks

Evaluation: Data

Pre-test Survey Data

.Physiological data

.Self-Efficacy for managing chronic disease

.Perceived stress scale

.Exercise confidence survey

.Eating behavior confidence survey

Patient Usage Log Data

.Physical activity goal

.Activity readiness

.Energy level

.Physical activity

.Heart rate

. EMA survey responses

.Viewing educational videos

Post-test Survey and Interview Data

.Physiological data

.Self-Efficacy for managing chronic disease

.Perceived stress scale

.Exercise confidence survey

.Eating behavior confidence survey

.Interview transcripts

Results

Survey : Physiological Attribute Scores

	Difference between Post-test Score and Pre-test Score		
Patient	Waist (in cm)	Weight (in Kg)	Body Mass Index (BMI)
P1	-1.6	-1	-0.36731
P2	-1.27	-0.4	-0.13411
P3	-1.27	-0.74	-0.2799
P4	-1.3	-1.4	-0.54687
P5	-1.6	0	0
P6	-1.27	-0.9	-0.3875

Survey : Self-Efficacy for Managing Chronic Disease

[Lorig, K. R., Sobel, D. S., Ritter, P. L., Laurent, D., & Hobbs, M. , 2001]

Patient	Pre-Test Total Score [Lowest Score can be 6 and maximum score can be 60]	Post-Test Total Score [Lowest Score can be 6 and maximum score can be 60]
P1	38	46
P2	59	60
P3	48	32
P4	58	54
P5	47	53
P6	18	46
Mean	44.66	48.5
Standard Dev	13.87	8.82

Survey: Exercise Confidence Scores

[Sallis, J. F., Pinski, R. B., Grossman, R. M., Patterson, T. L., and Nader, P. R.,1988]

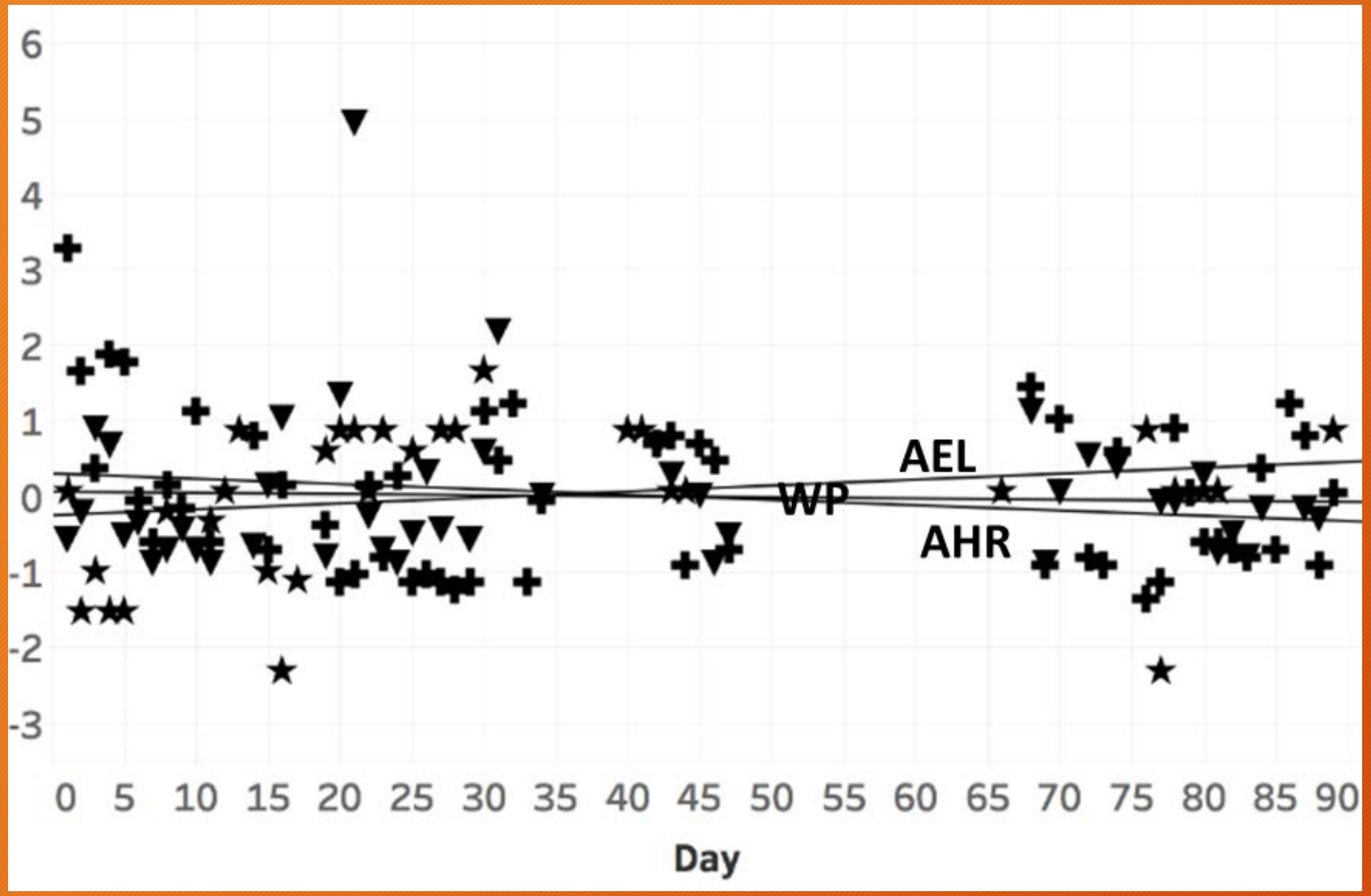
Patient	Total Score Pre-Test [Lowest Score can be 12-Highest score can be 60]	Total Score Post-Test [Lowest Score can be 12-Highest score can be 60]
P1	47	50
P2	54	55
P3	23	49
P4	59	58
P5	52	60
P6	30	44
Mean	44.16	52.66
Std Dev	13.13	5.52

Survey : Perceived Stress Scale

[Cohen and Williamson, 1998]

Patient	Total Score Pre-Test [Lowest Score can be 0 –Highest Score can be 40]	Total Score Post-Test [Lowest Score can be 0 –Highest Score can be 40]
P1	22	17
P2	22	20
P3	24	27
P4	23	18
P5	18	19
P6	18	21
Mean	21.16	20.33
Std. Dev	2.33	3.24

Results : Patient 1

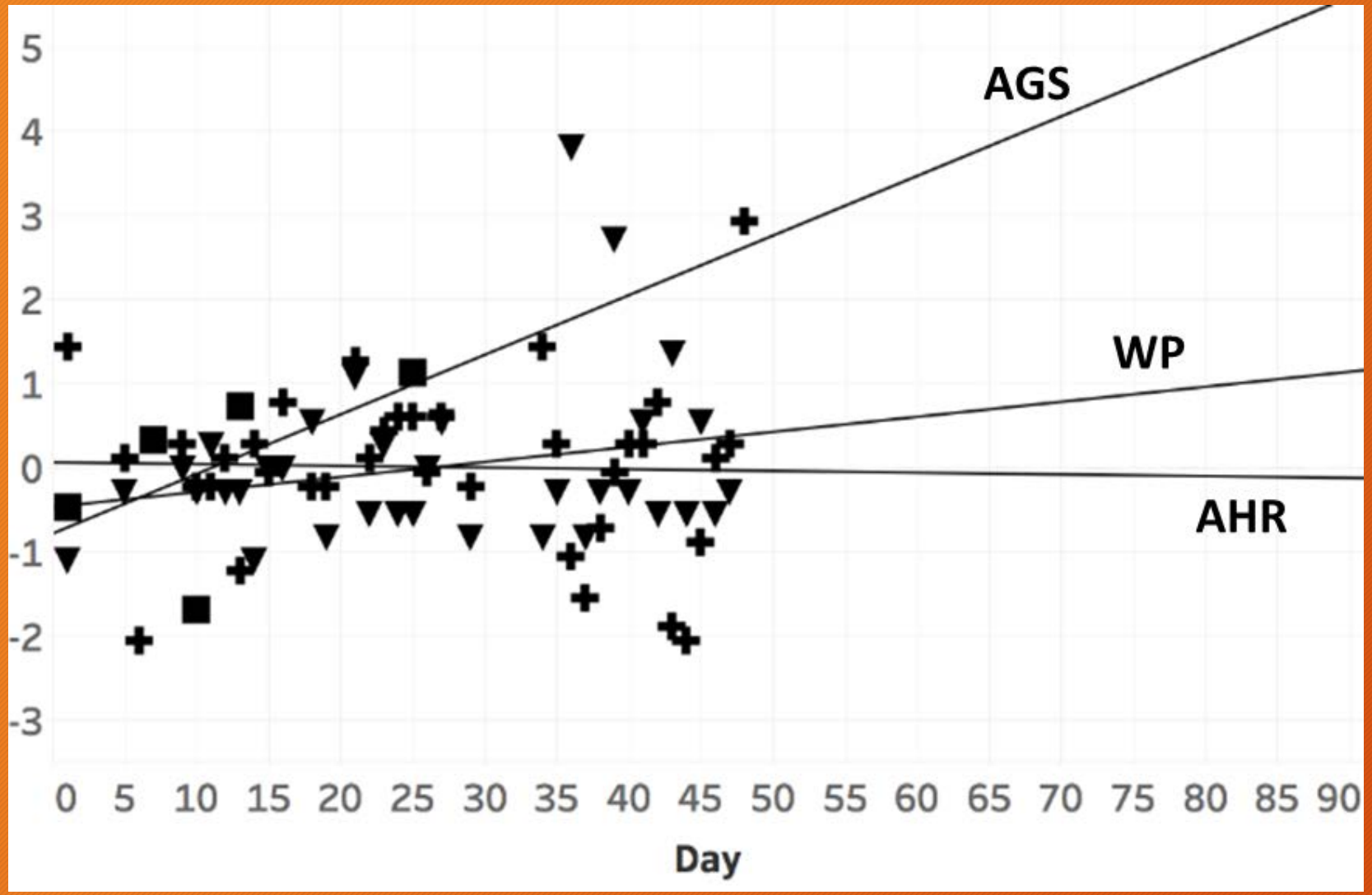


(WP) Walk Performance

(AHR) Average Heart Rate

(AEL) Average Energy Level

Results : Patient 3

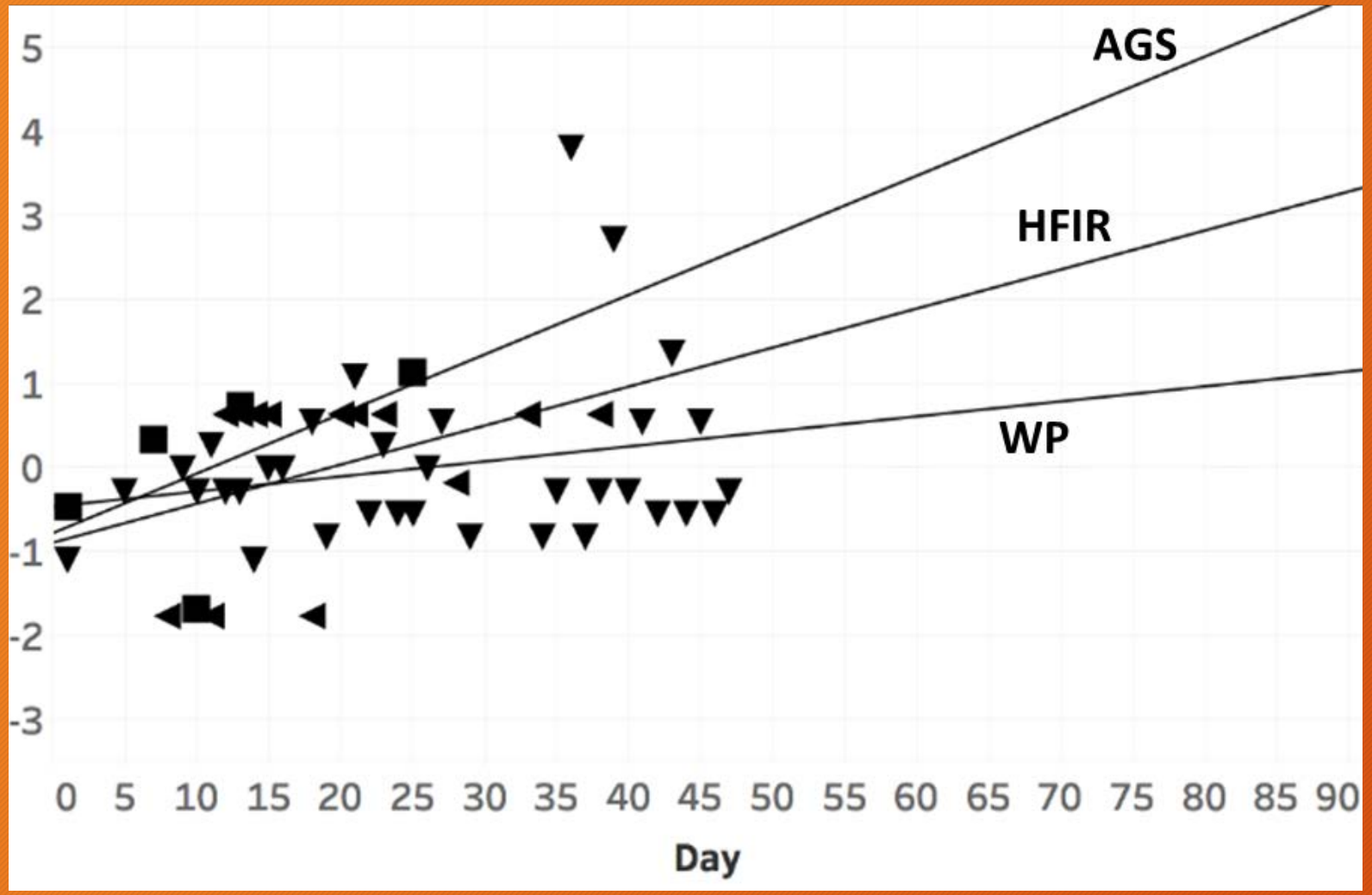


(AGS) Average Goal Set

(WP) Walk Performance

(AHR) Average Heart Rate

Results :Patient 3

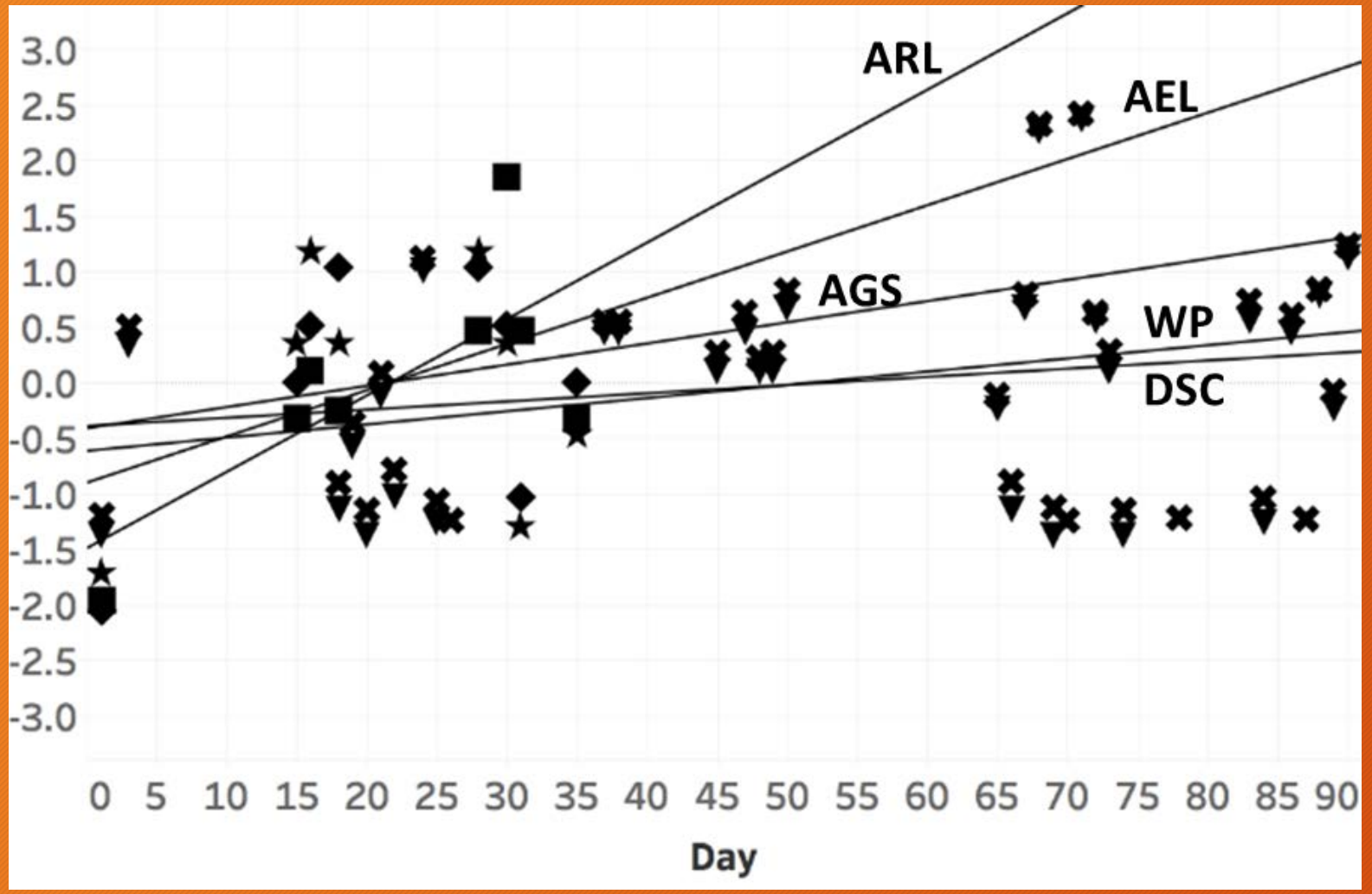


(AGS) Average Goal Set

(WP) Walk Performance

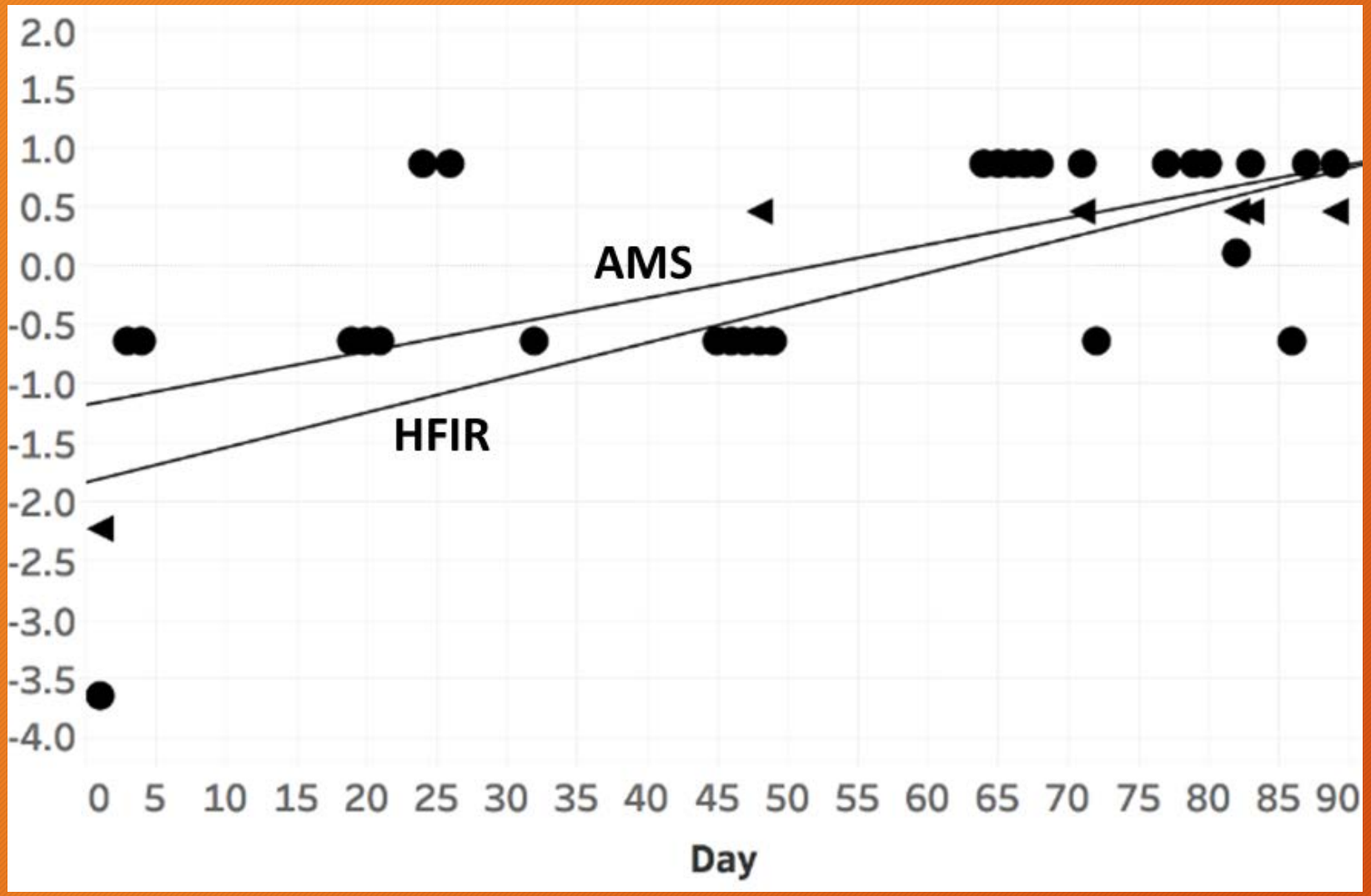
(HFIR) Healthy Food Intake Ratio
{ratio of the number of times healthy food intake is reported to the total number of times food intake is reported}

Results : Patient 4



(AGS) Average Goal Set
(AEL) Average Energy Level
(ARL) Average Readiness Level
(WP) Walk Performance
(DSC) Daily Step Count

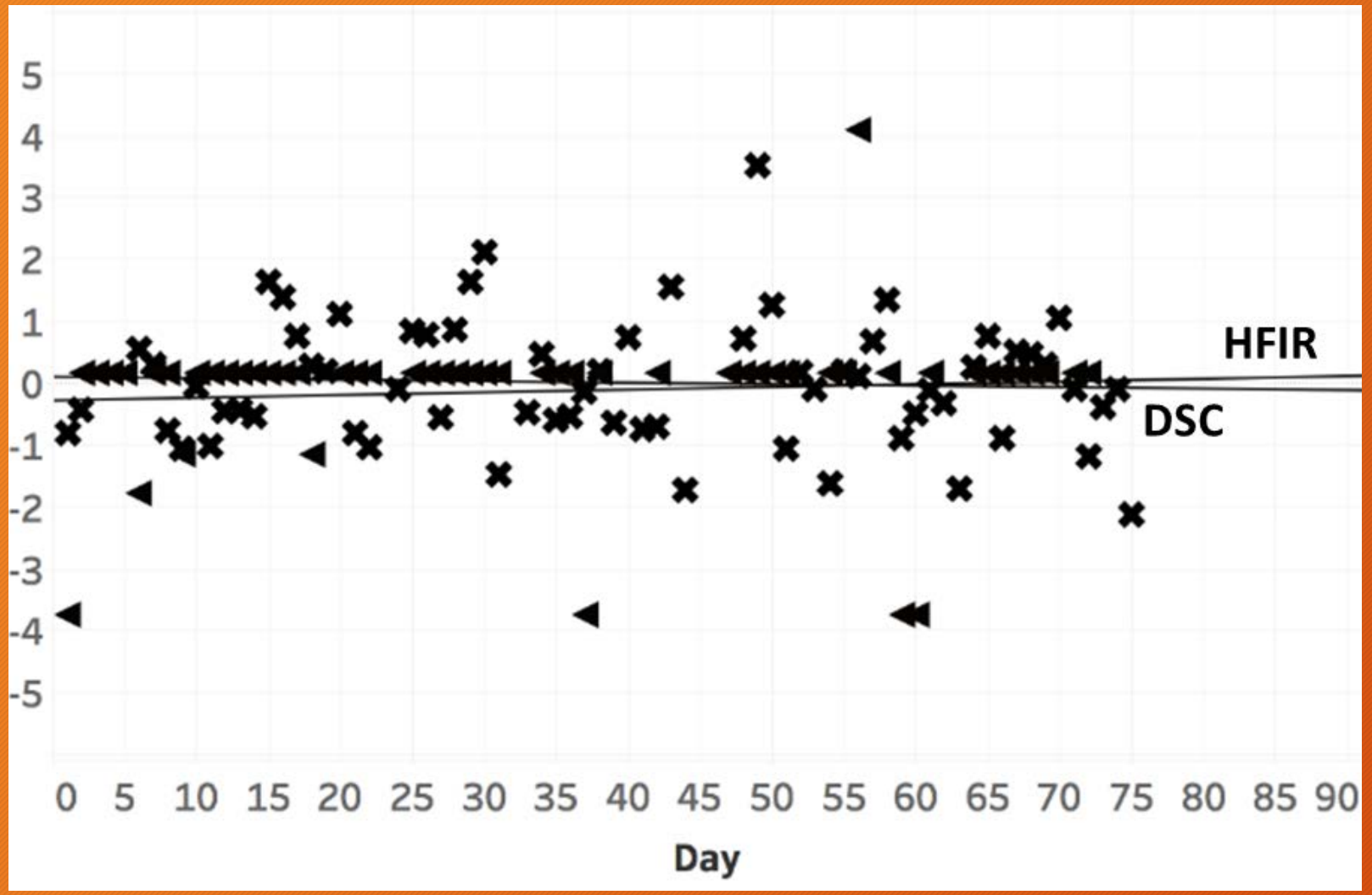
Results : Patient 4



(HFIR) Healthy Food Intake Ratio

(AMS) Average Mood Score

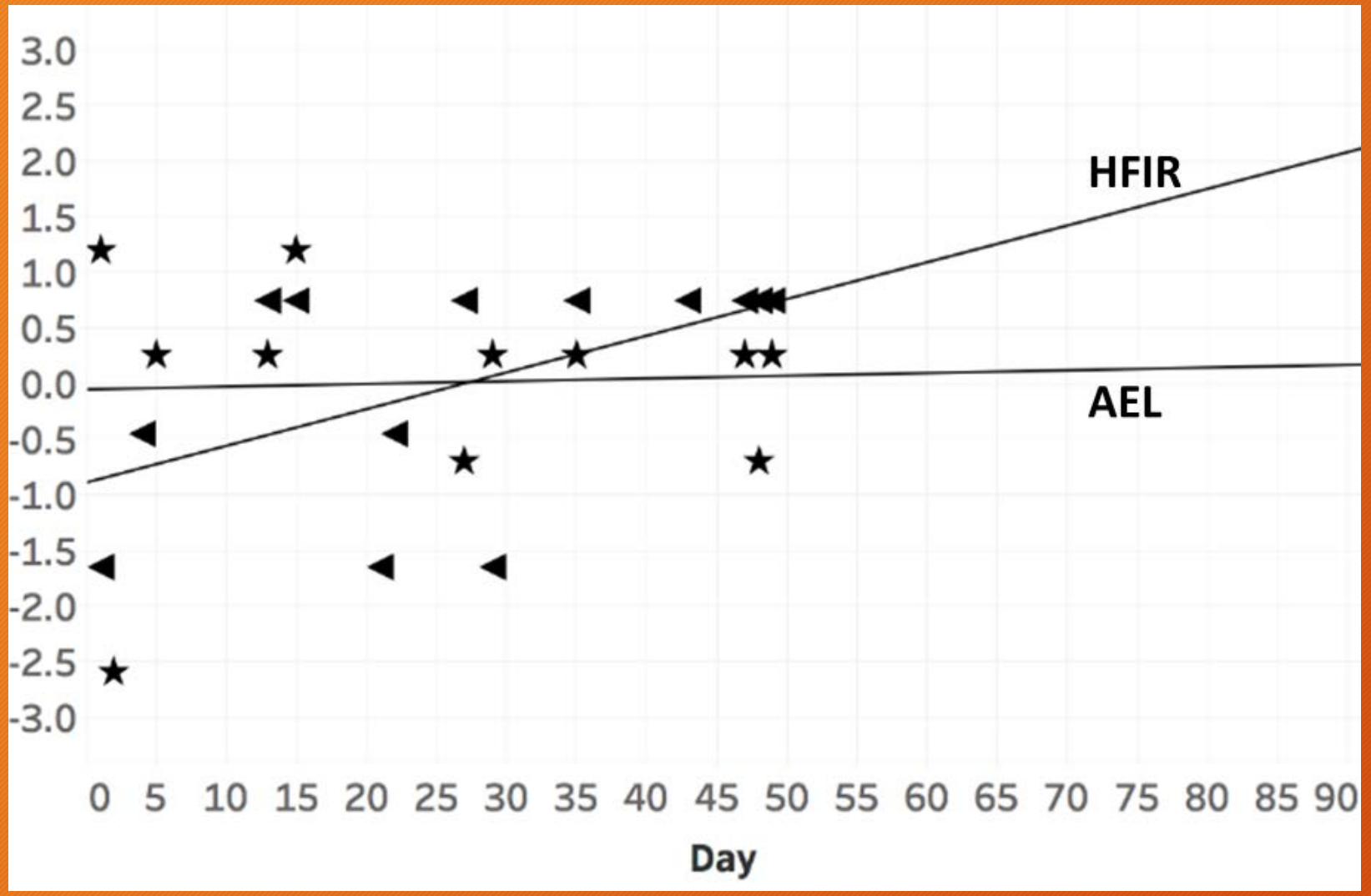
Results : Patient 5



(DSC) Daily Step Count

(HFIR) Healthy Food Intake Ratio

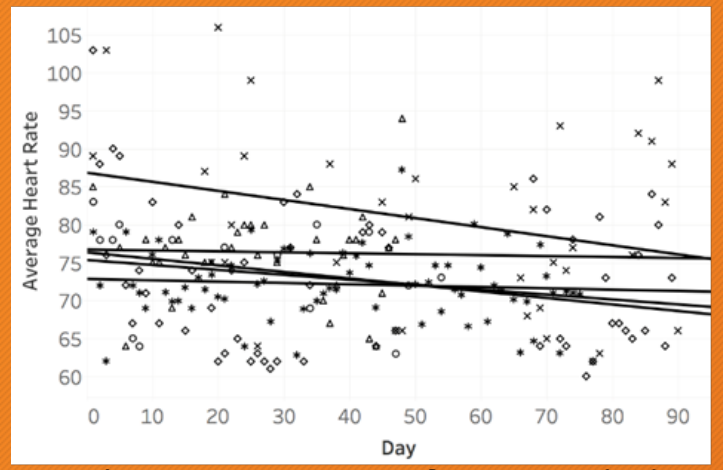
Results : Patient 6



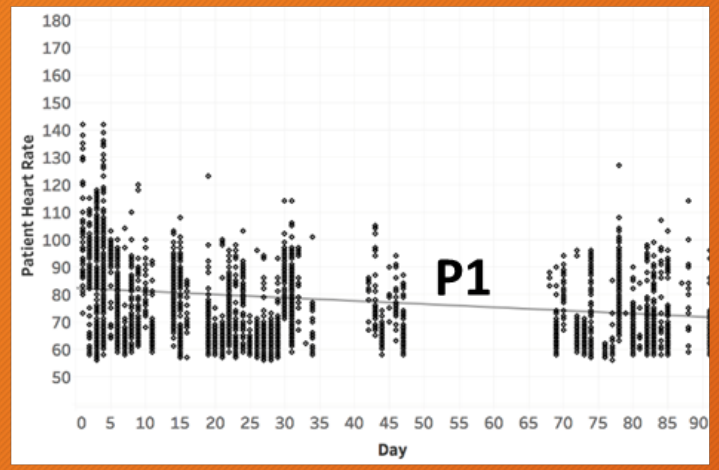
(AEL) Average Energy Level

(HFIR) Healthy Food Intake Ratio

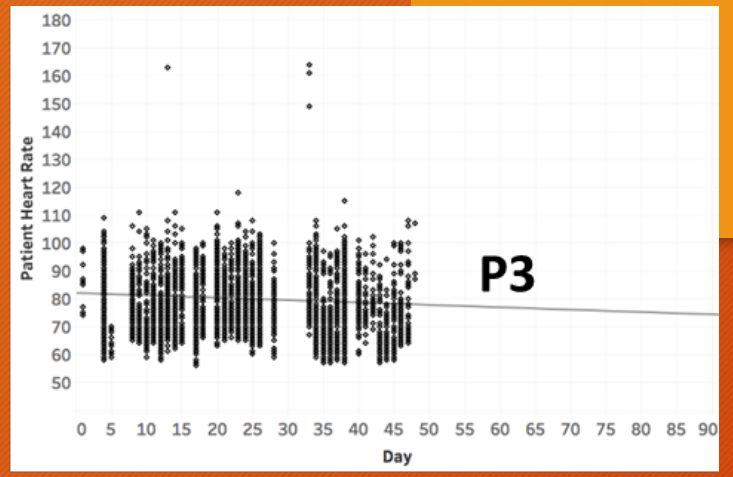
Results : Heart Rate



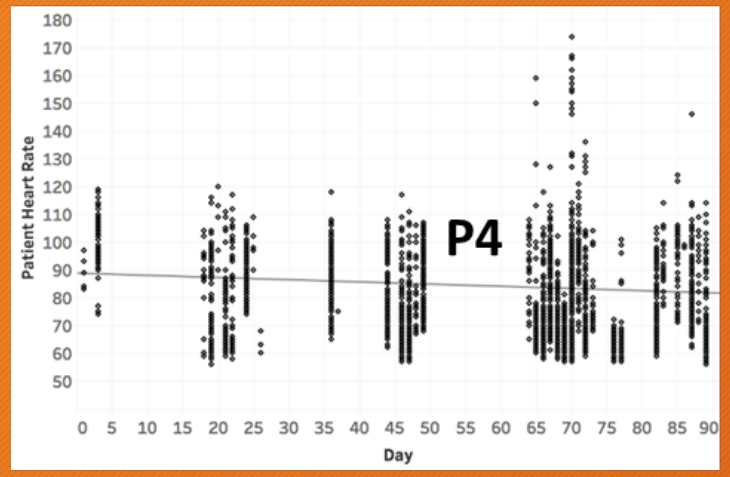
Daily Average Hear Rate for Patient1(P1), Patient3 (P3), Patient4 (P4), Patient 5 (P5) and Patient 6 (P6)



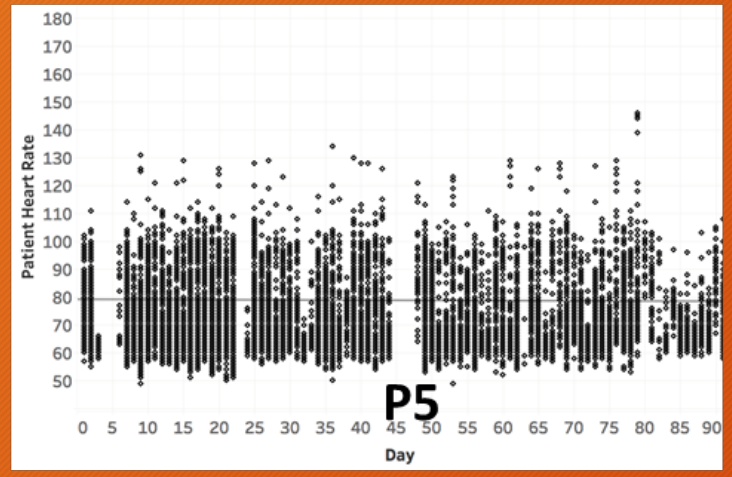
Patient1(P1)



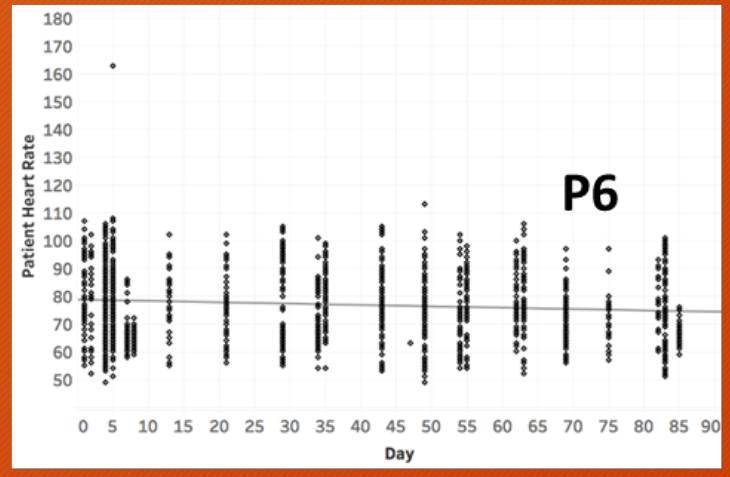
Patient3(P3)



Patient4(P4)

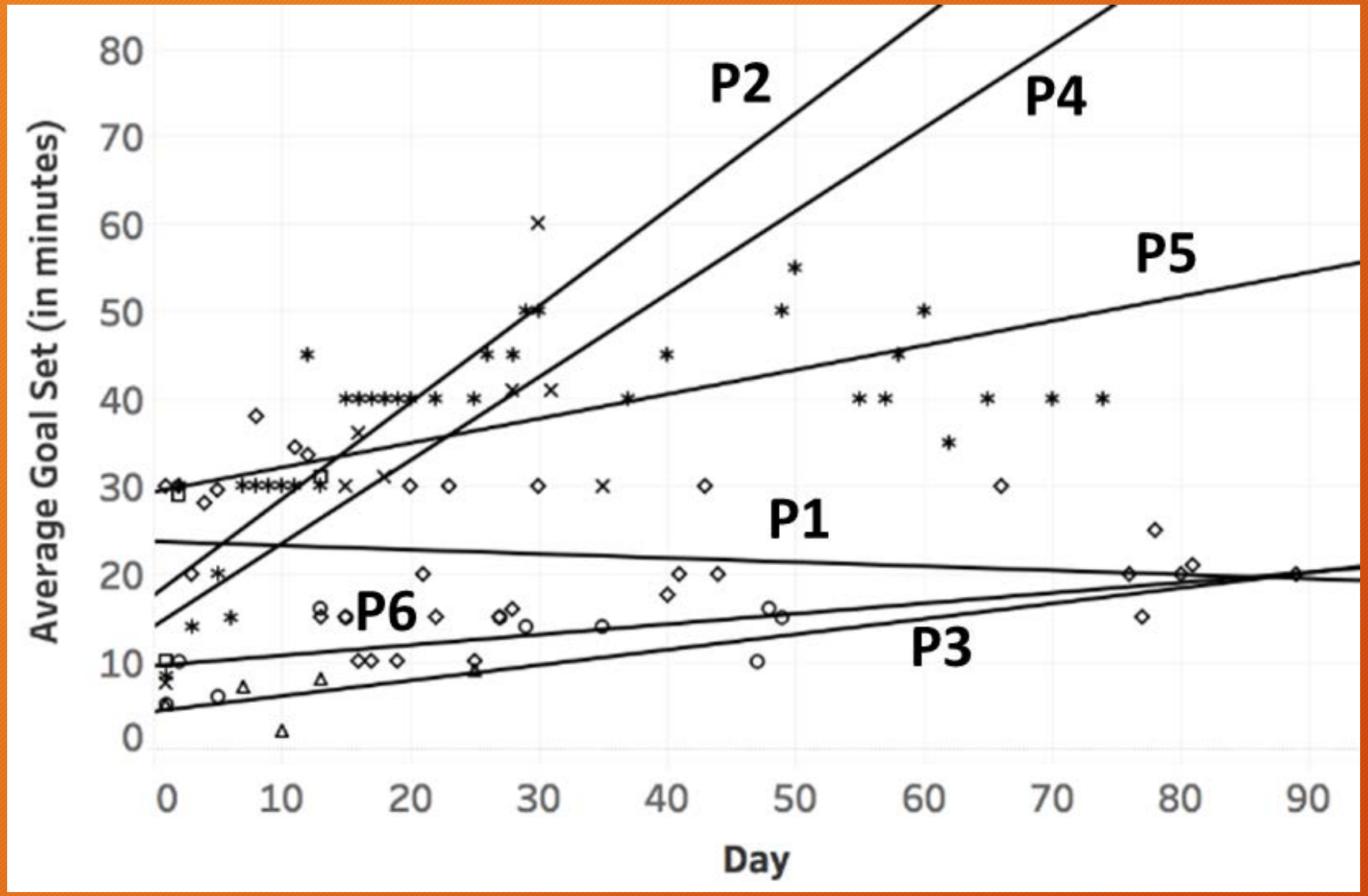


Patient5(P5)

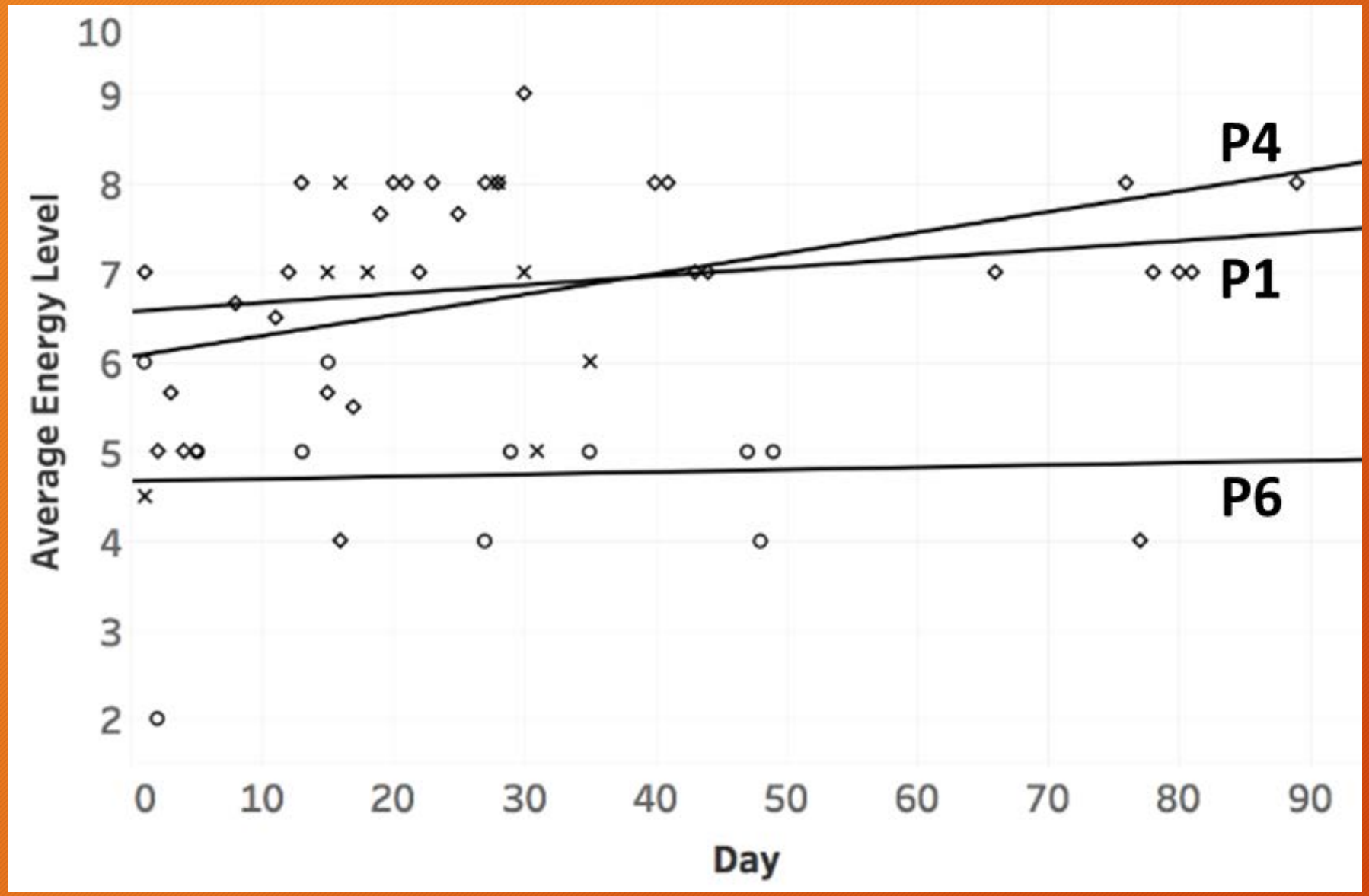


Patient6(P6)

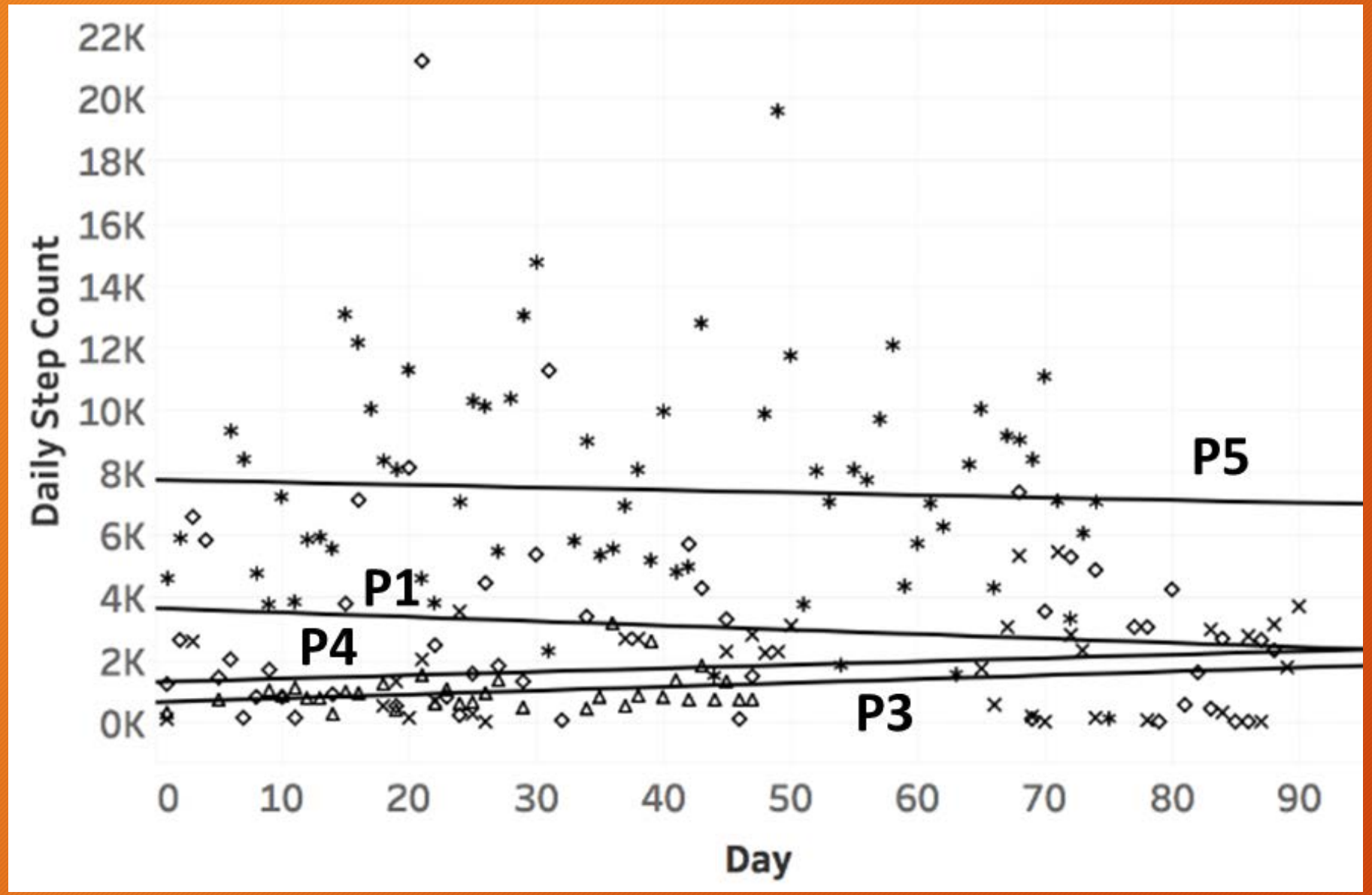
Results : Average Goal Set



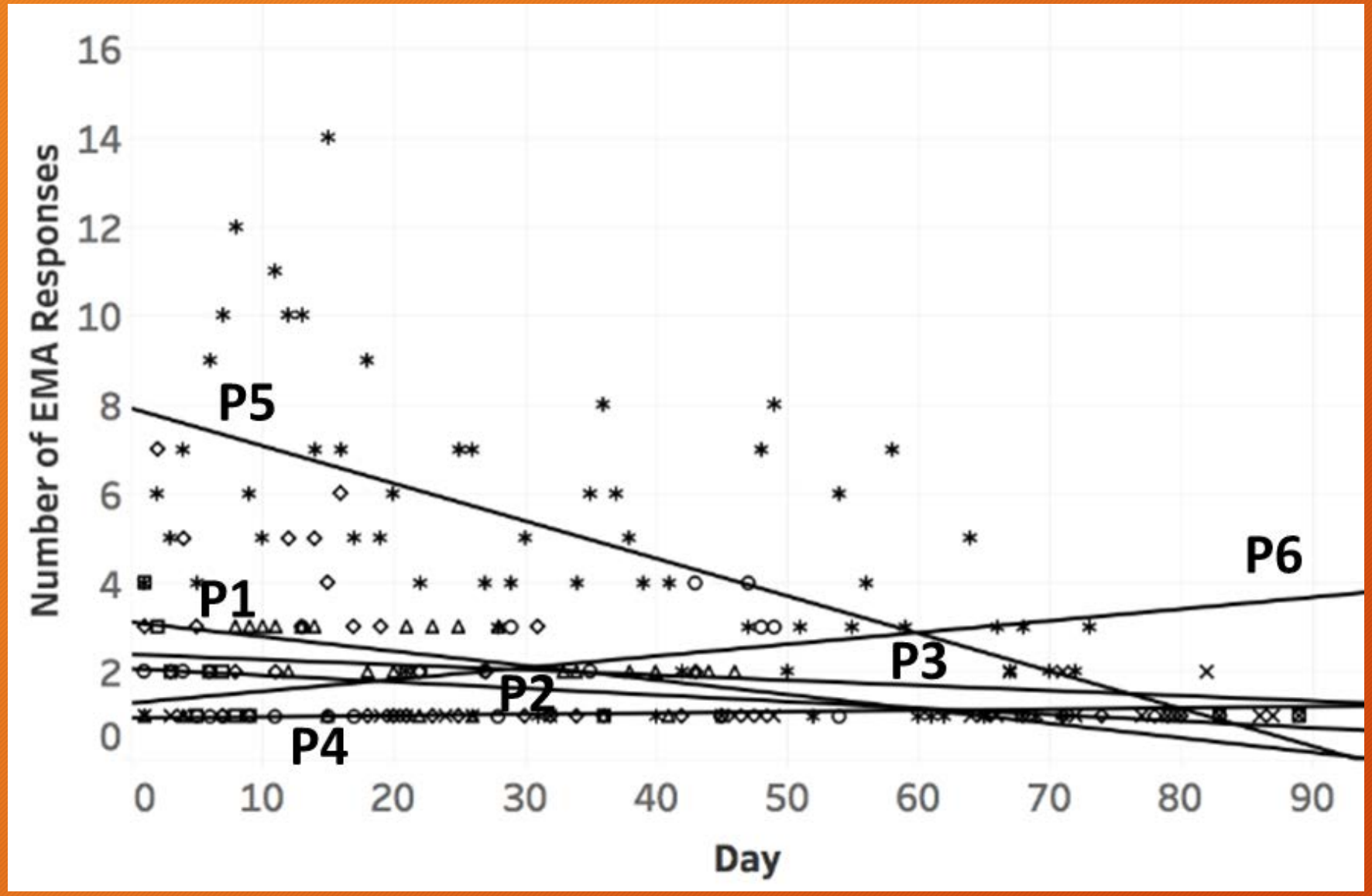
Results : Average Energy Level



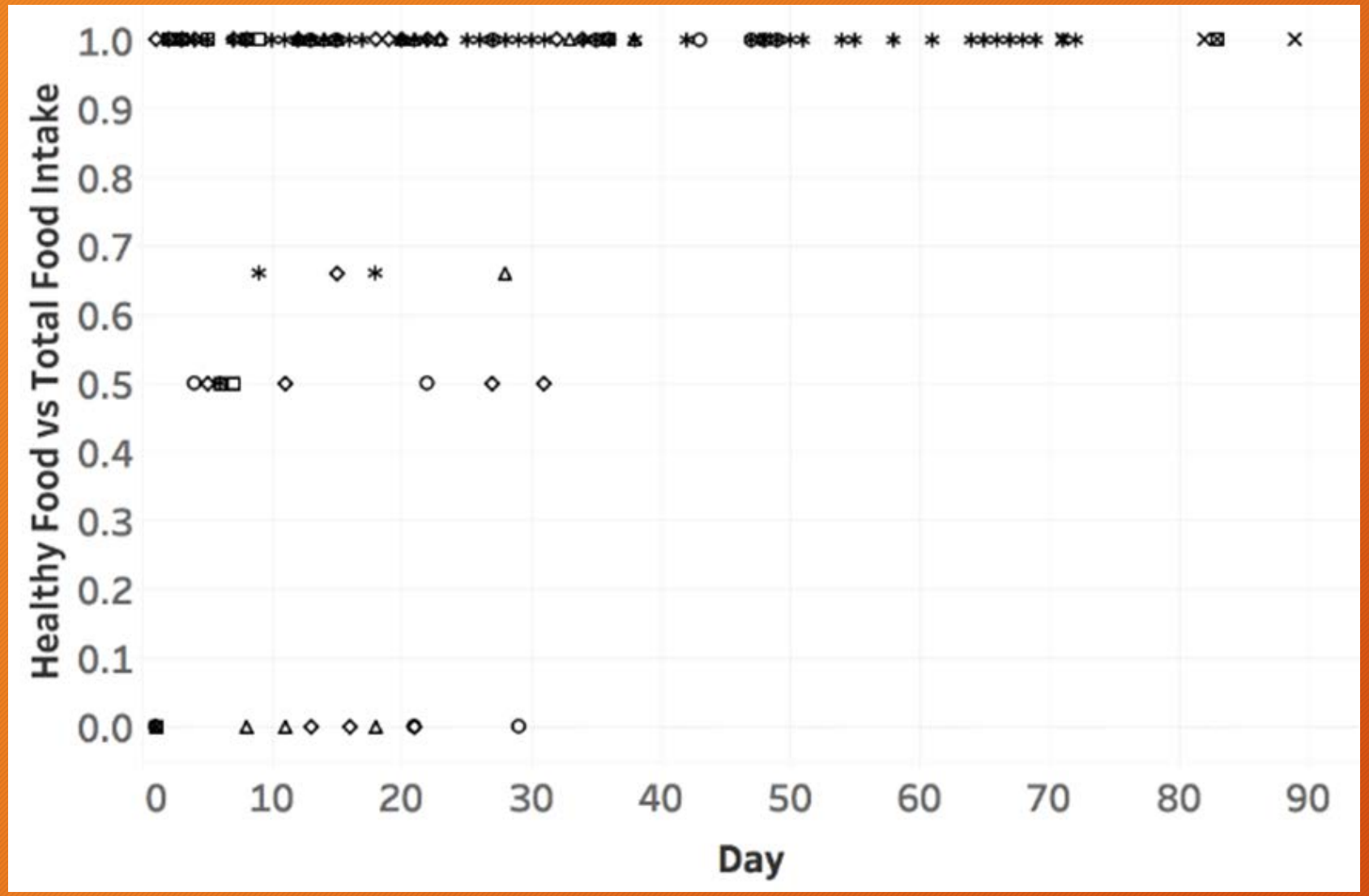
Results : Daily Step Count



Results: Number of EMA Responses

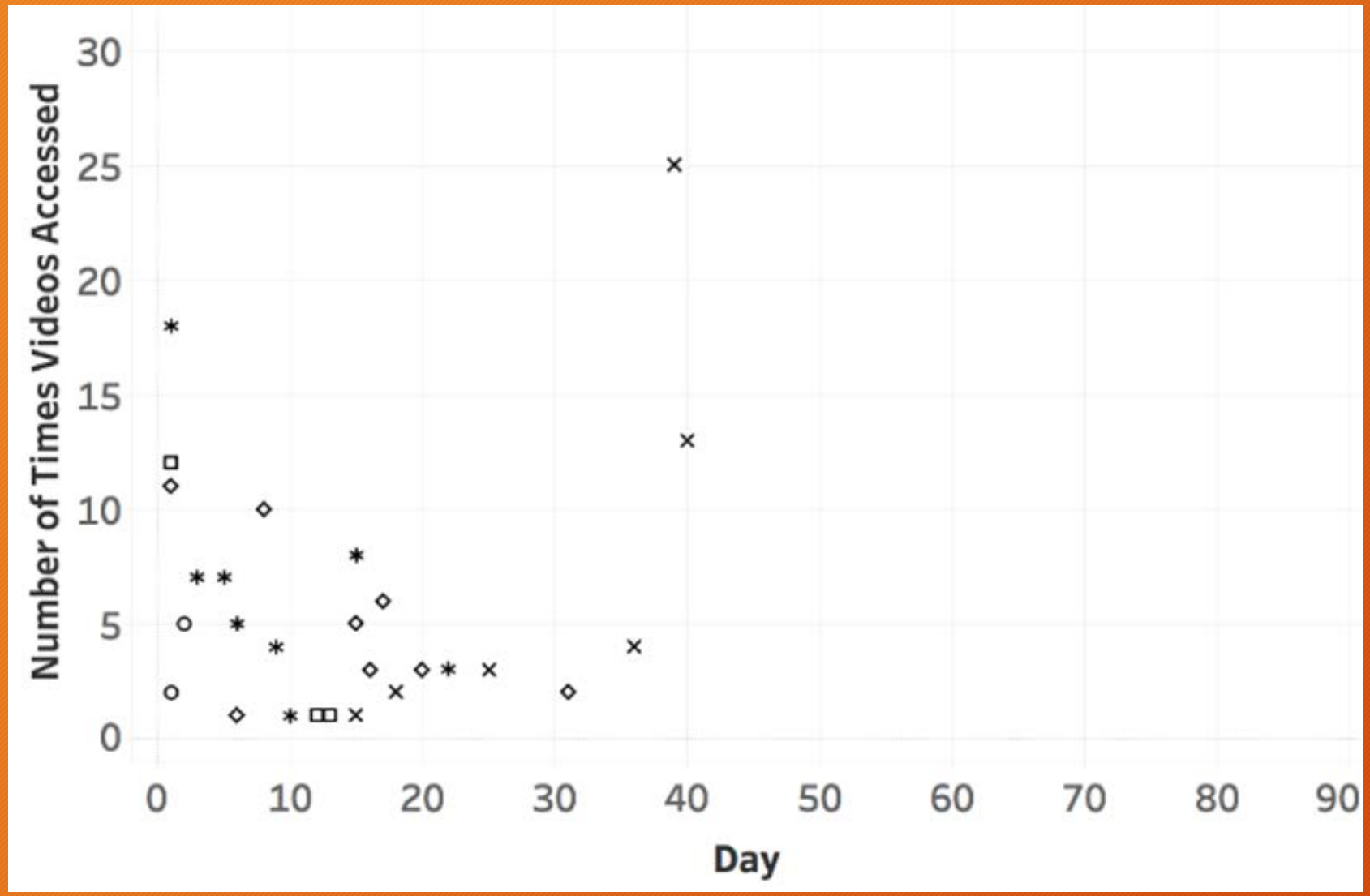


Results: Healthy Food Intake Ratio



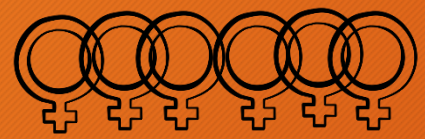
◇ =Patient1
□ =Patient2
△ =Patient3
✖ =Patient4
✱ =Patient5
● =Patient6

Results: Number of Times Educational Video Accessed Per Day



◇ =Patient1
□ =Patient2
△ =Patient3
✖ =Patient4
✱ =Patient5
● =Patient6

Results



Patient ID	Average Goal Set (in minutes) (Standard Dev)	Physical Activity			EMA Survey Response											
		Average Brisk walk (in minutes)	Average Step Count	Average Distance Travelled (in miles)	Activity Status (Count)		Companion Status (Count)		Recent Eating Episode (Count)		Location (Count)		Average Mood Score (Scale: 1 to 5)	Average Energy level (Scale: 1 to 10) (Standard Dev)	Total Number of Times Educational Video Accessed	Average Daily Heart Beat (Standard Dev)
					Inactive	Active	Without Companion	With Companion	Healthy	Unhealthy	Private location	Public Location				
Patient1	22 (9.9) ↓	17 → (21.94)	2751 → (3524.2)	1.37 → (1.76)	33	46	35	51	27 ↓	12 ↑	65	21	3.77 ↓	6.73 (1.58) ↑	41 ↓	72.5 (9.2) ↓
Patient2	23.33 (9.46) ↑	9 (15.5) ↓	1449 ↓ (2464.5)	0.72 ↓ (1.2)	4	11	9	10	12 ↑	2 ↓	12	7	4.57 →	6 (0.81) ↓	14 ↓	80.8 (12.8) ↑
Patient3	6.2 (2.48) ↑	6 ↑ (3.81)	911 ↑ (612.5)	0.45 ↑ (0.3)	29	26	17	40	17 ↑	5 ↓	48	9	3.82 ↓	2.6 (1.85) ↓	0	76.3 (6.0) ↓
Patient4	33.55 (15.5) ↑	11 ↑ (9.34)	1815 ↑ (1499.5)	0.90 ↑ (0.74)	2	22	14	18	5 ↑	1 ↓	12	20	4.5 ↑	6.33 (1.33) ↑	48 ↑	80.44 (11.7) ↓
Patient5	35.6 ↑ (11.93)	45 → (22.68)	7226 → (3628.3)	3.61 → (1.81)	71	228	56	246	109 ↑	9 ↓	164	138	4.05 →	2.48 (0.98) ↓	53 ↓	72.14 (4.5) ↓
Patient6	12.36 ↑ (3.79)	8 ↓ (6.12)	1293 ↓ (994)	0.65 ↓ (0.49)	21	20	21	20	13 ↑	5 ↓	10	31	3.73 ↓	4.72 (1.05) ↑	7 ↑	74.33 (6.0) ↓

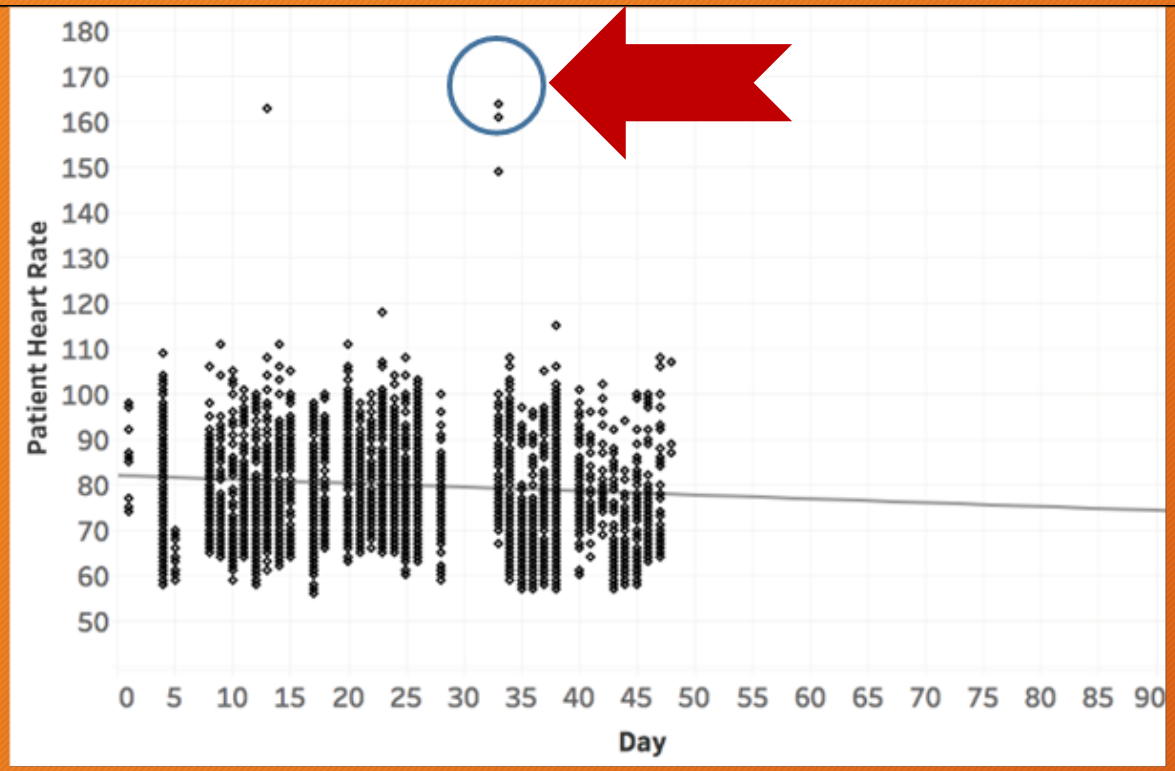
Note: Black arrows represent the trend that is observed for each individual patients for different measures. We consider a trend as increasing or decreasing over the time only if the amount of increase or decrease is more than 10% of the average value of the measure for that individual patient.

Results : Design Lessons Learned

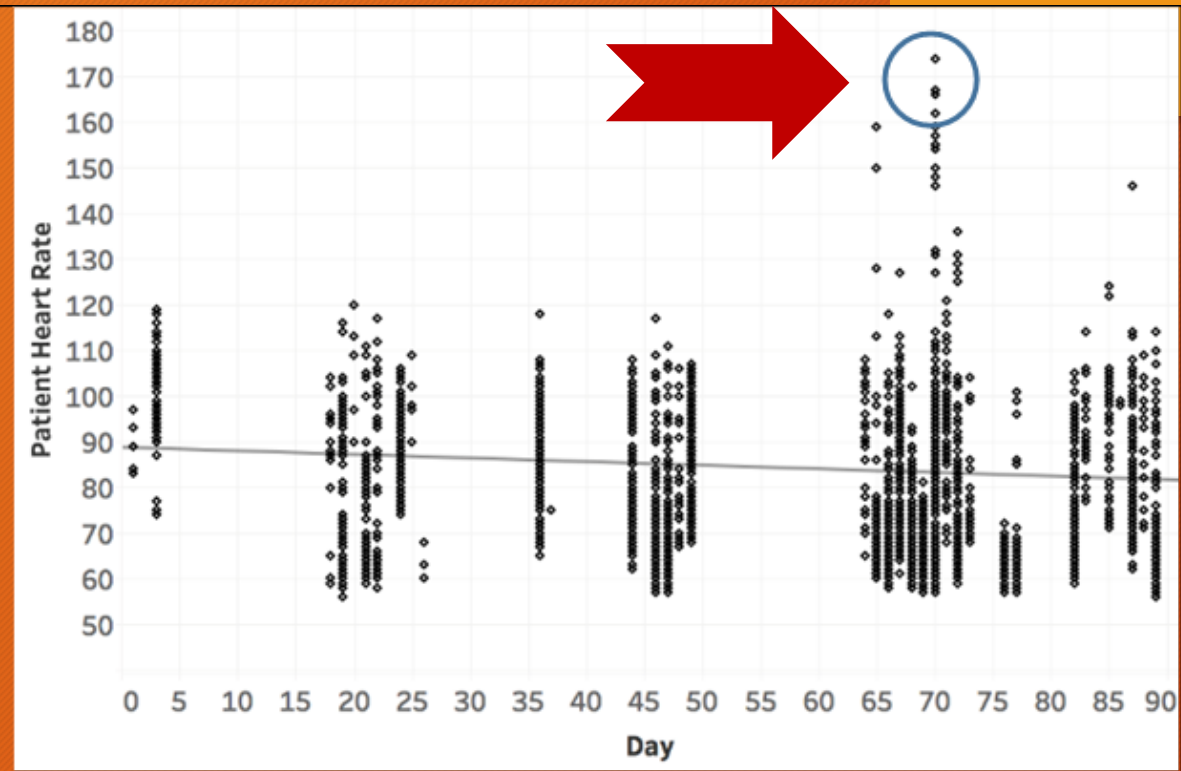
Patient Motivation	Patient Memory	System Usage
Random Motivational Messages after EMA responses help in adherence	Need daily reminder for setting up physical activity goal	Health related incidence, poor battery life of the smart watch, travelling can reduce the usage of HBCR system

Results : Design Lessons Learned

Personal Care	Safety	False Alarm
Remote ‘activity monitoring’ by a health coach is rather a positive thing	Unique intervention opportunities to the health coach	Intervention messages received by patients from health-coach were particularly well taken



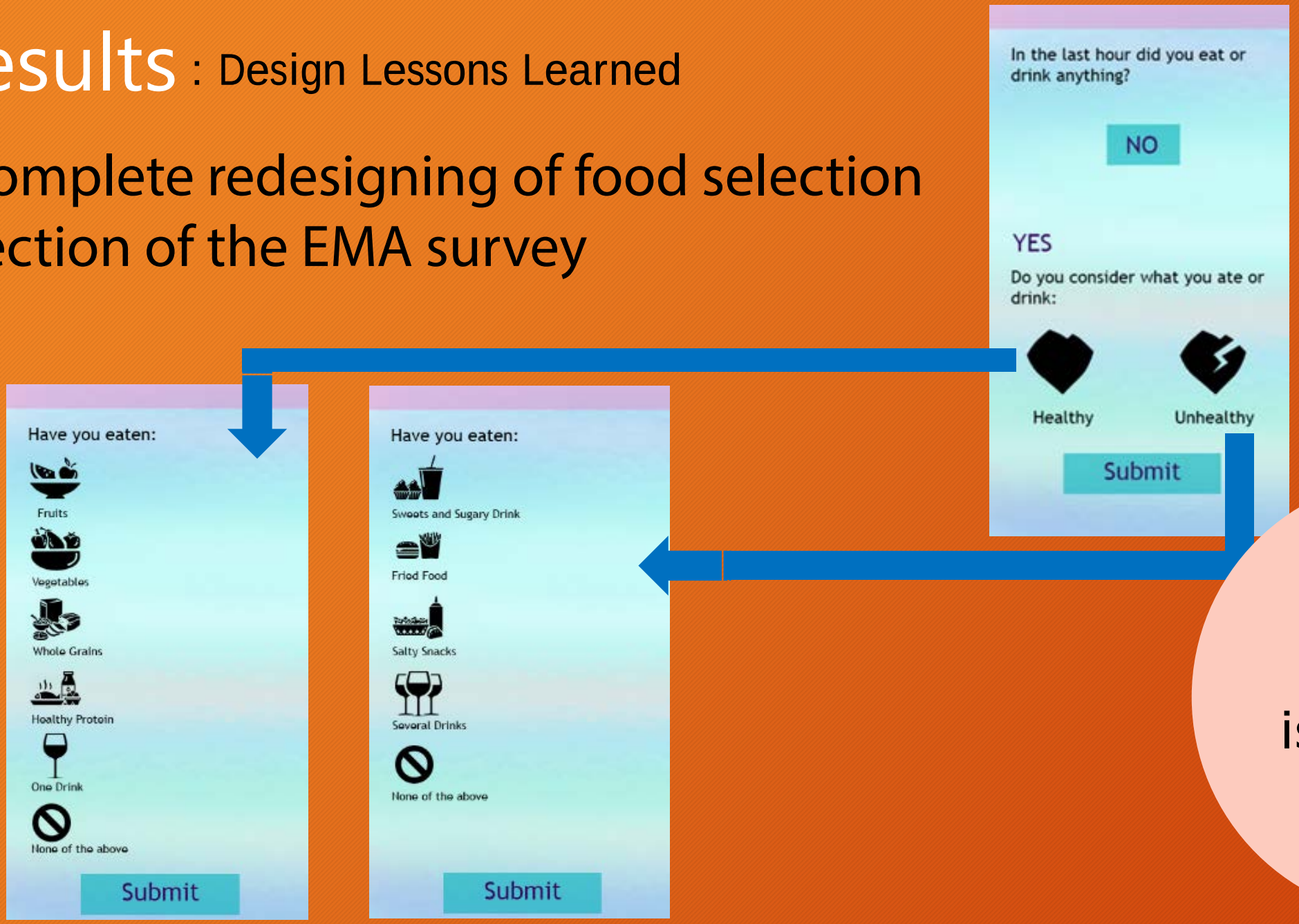
Patient3: Daily Heart Beat Rate



Patient4: Daily Heart Beat Rate

Results : Design Lessons Learned

Complete redesigning of food selection section of the EMA survey



Food selection is not that explicit

Contribution

Contributions

- describes the process for developing instantiations of sex-specific theory-guided behavior change interventions
- provides insights regarding the design of an HBCR program augmented with a health coach’s involvement
- demonstrated the effectiveness of the HBCR system using a case study methodology
- generated insights, based on which designed guidelines are prepared for designing future versions of HBCR system

Contributions

While 80% of health-related apps are abandoned after only two weeks of usage (Baldwin, 2017)

Our HBCR system performed fairly well during the field trial (usage of the system was completely voluntary)

Transformational Impacts: Agarwal and Lucas (2005)

- provides new levels of customer service and convenience and enriches people's lives
- alters cost structures and provides new opportunities for revenue
- offers the opportunity to create new industries and innovative forms of business

What Next?

A
Micro-
Randomized
Trial

A
Large Scale
Clinical trial
with
Version 2.0

Thank You