Data Processing Framework for Digital Health Monitoring using Roadmap 2.0

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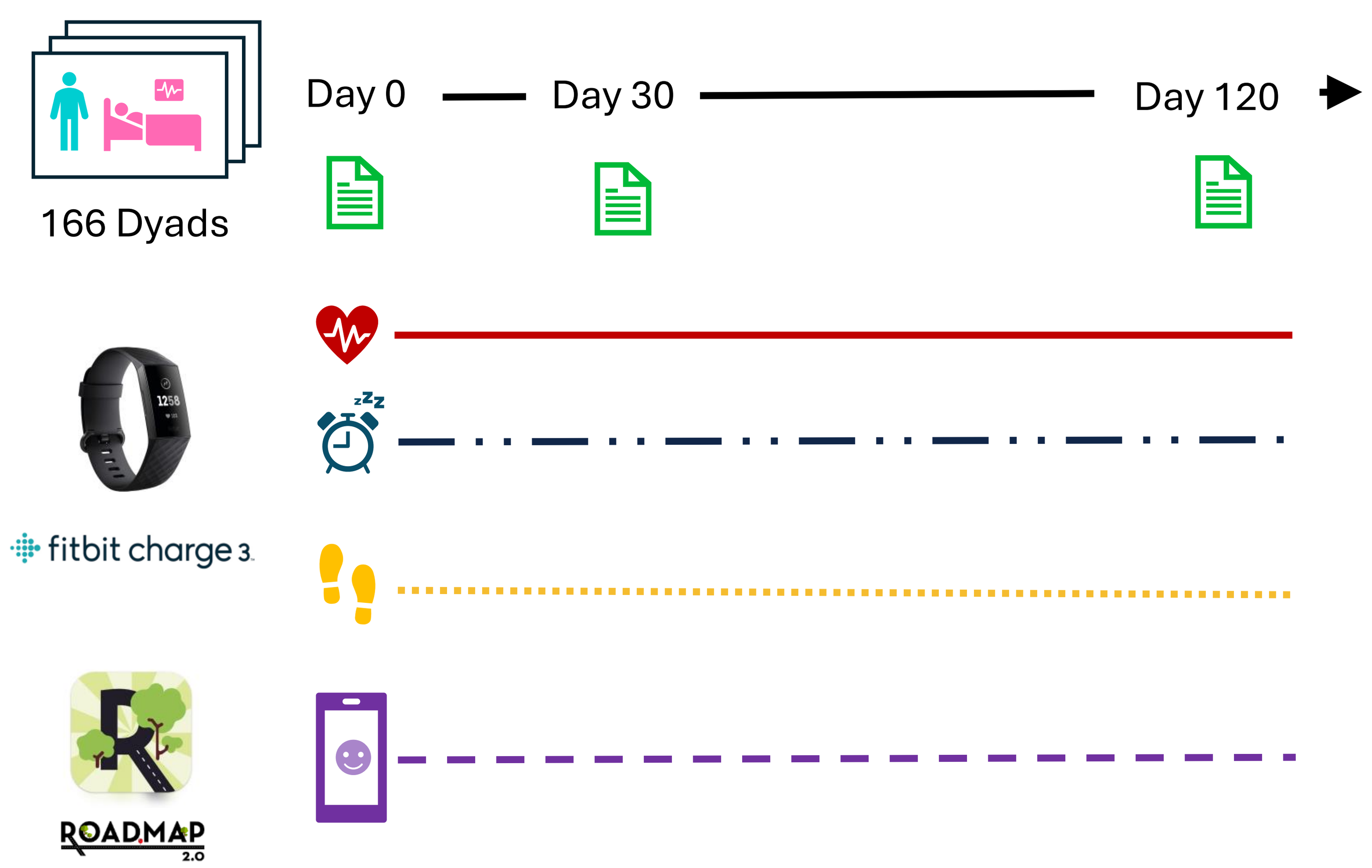
Background

Mobile health technologies offer unprecedented opportunities for longitudinal data collection in clinical research[1]. However, the vast amount and complexity of raw data generated pose significant challenges in data preprocessing, analysis, and reproducibility.

Roadmap, a mobile app for positive wellness-based psychology interventions[2], was used to collect physiological and psychological data from bone marrow transplant (BMT) patient-caregiver dyads for up to 120 days post-transplant using **Fitbit® Charge 3** devices

Study Design



Data Modality	Sampling Rate	# Records
Surveys	3 timepoints	526
Heart rate	Every few seconds	5M+
Sleep Patterns	Every few hours	45K+
Physical Activity	Every minute	450M+
Self reported mood	Daily	20K+

Fig 1: Data Collection timeline. BMT transplant performed on Day 0,. Baseline PROMIS survey was performed the day after transplant, followed by additional surveys after 30 and 120 days. Fitbit® Charge 3 was used to collected heartrate, physical activity and sleep data of both patients and caregivers.

Objectives

To develop a flexible, efficient, and standardized data processing pipeline for **Roadmap** that can :-

- Process multi-source digital health data
- Ensure data quality and reliability
- Maintain privacy and security
- Enable scalable analysis

Key Features

1) Modular pipeline architecture
2) Automated validation checks
3) Flexible integration capabilities

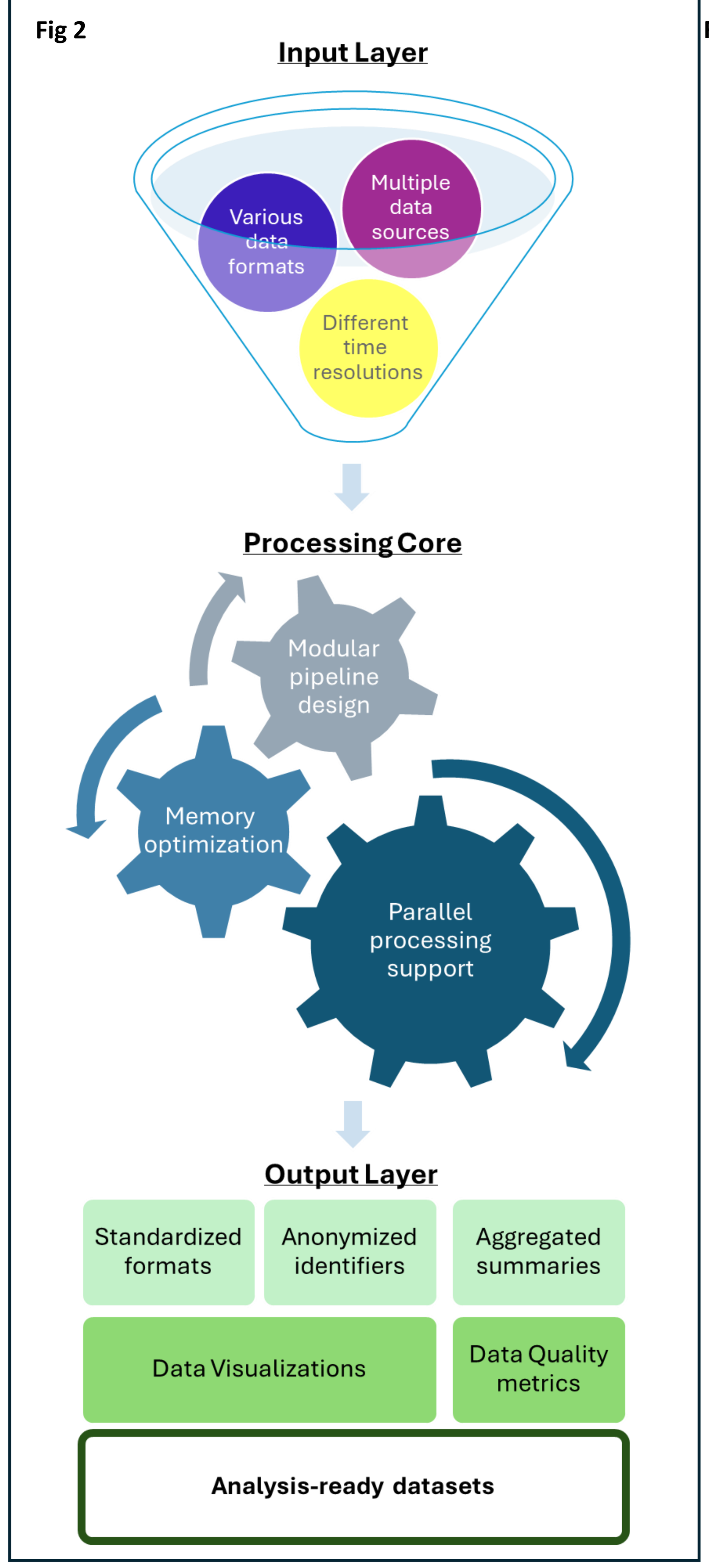
Conclusions

The developed modular data processing pipeline significantly enhances the efficiency and reproducibility of mobile health research using Roadmap 2.0 data. The pipeline addresses critical challenges in handling complex, multi-source mobile health data. This approach not only streamlines data management throughout the research lifecycle but also sets a foundation for more advanced analytics, including the potential integration of machine learning techniques[3].

Methods

Framework Architecture

Fig 2



Processing Pipeline

Fig 3

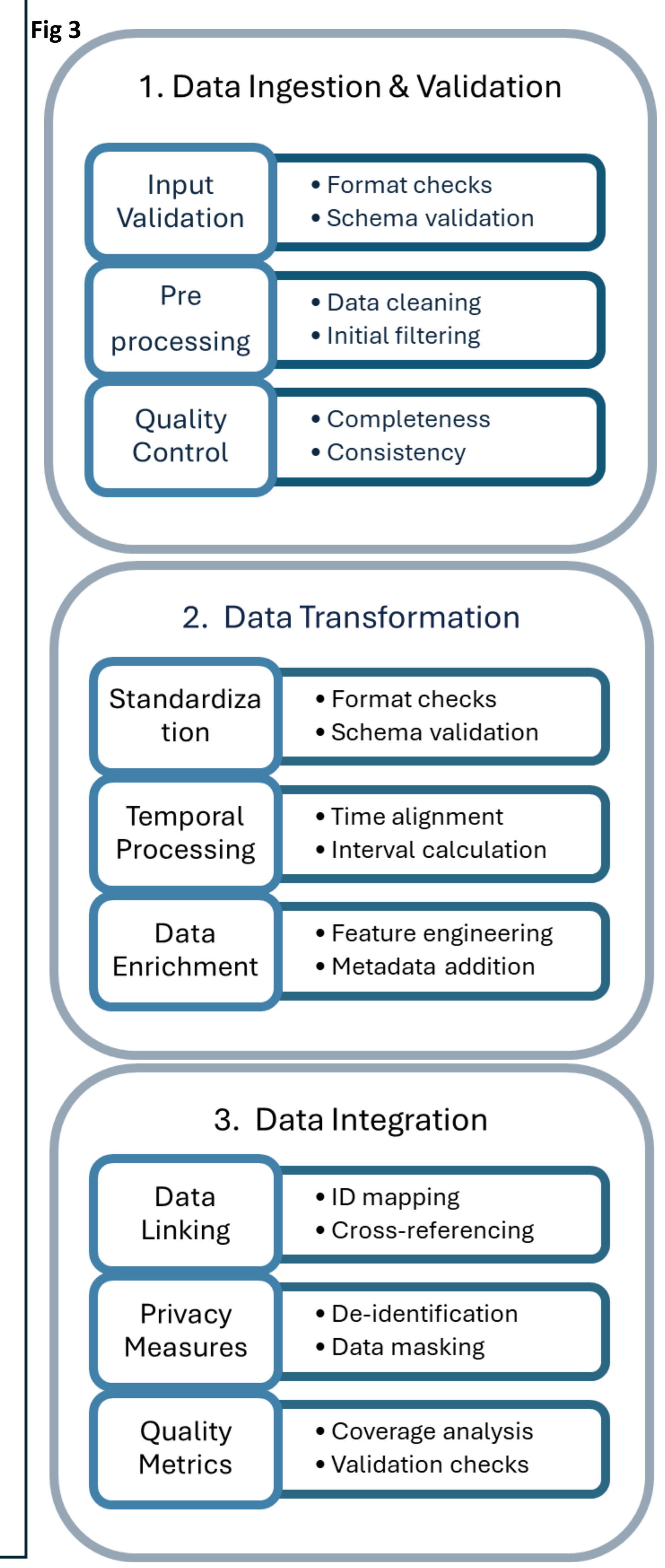
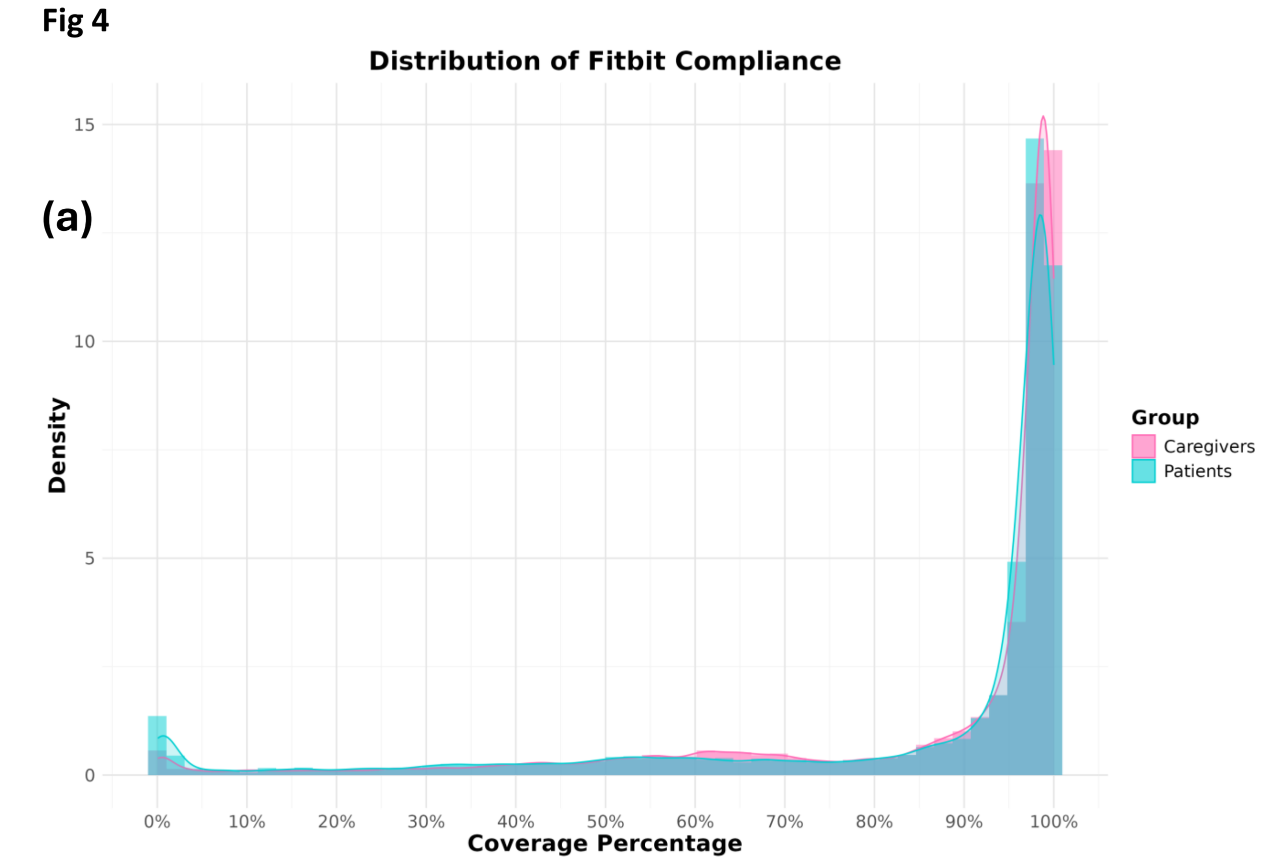


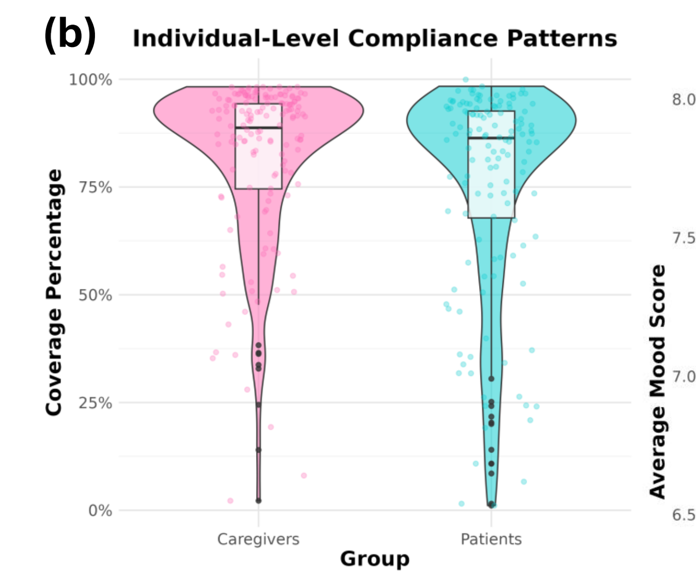
Fig 2: Multi-layer digital health data processing framework designed for scalable patient monitoring data. The input layer handles diverse data streams from wearable devices (Fitbit heart rate, sleep, activity), mobile applications (mood scores), and clinical records (EHR data). The processing core implements modular components for data validation, transformation, and integration with parallel processing capability for high-throughput analysis. The output layer produces standardized, analysis-ready datasets with comprehensive quality metrics and validation reports. Each layer maintains strict privacy controls and data integrity checks.

Fig 3: Three-stage data processing pipeline optimized for heterogeneous health monitoring data

Results

Fig 4





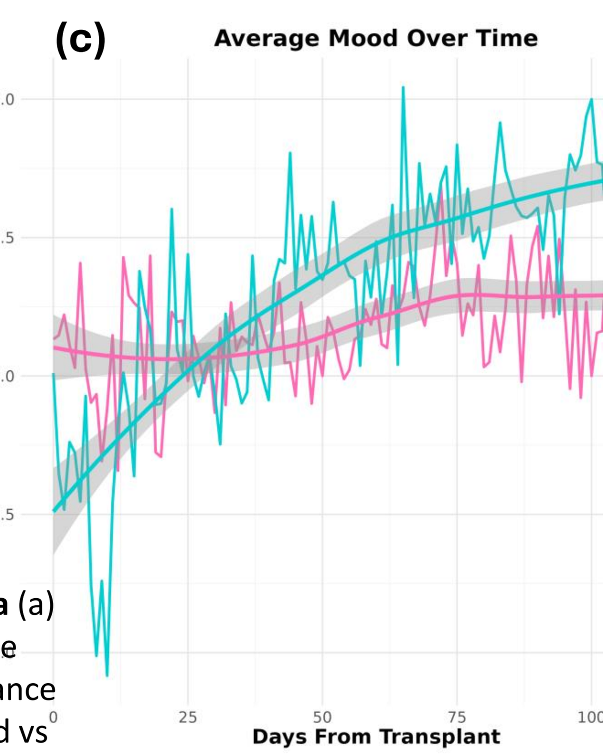


Fig 4 : Visualizations of Fitbit® and app data (a) Distribution of daily heart rate data coverage showing median (b) Individual-level compliance patterns (c) Plot of average self report mood vs days from transplant

Table 1: Missing data patterns of self reported mood.

Group	Early CV	Early Mean	Early SD
Patients	36.9	80.6	29.8
Caregivers	15.7	86.5	22.2

Table 2: Early post-transplant heart rate variability.

Group	Mean total gaps	Max gap length	Mean gap length	Median gap length	Mean days missed
Patients	12.5	83	5.83	1	36.9
Caregivers	15.7	89	4.31	1	39.9

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