BAYESIAN INFERENCE IN BIOENGINEERING

Course Project

Impact of VPC Suppression on Post-MI Survival

TEAM MEMBERS

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DATASET DESCRIPTION

- Subjects Enrolled: 809 total
- Main Subset with Paired Data: 734 subjects
- Each has two recordings
  - Baseline (a): Pre-treatment
  - On-therapy (b): During antiarrhythmic drug therapy
- This gives 734 × 2 = 1468 records
- Additional Subjects: 75 subjects
- Each has only one acceptable recording (either baseline or on-therapy, not both)
- Total Records: 1468 (paired) + 75 (single) = 1543 records
- Each record is named by drug, subject number, and phase.
  - Example: f004a = Flecainide, subject 004, baseline; f004b = same subject, on-therapy
- About 150 million RR intervals (beat-to-beat intervals)
- Annotations: Each QRS complex is labelled (normal, ventricular, etc.)

CONSTRAINTS

- The linkage between a subject and their mortality status is not directly encoded in the annotation or header files provided in the public database. The documentation notes the number of deaths but does not provide a subject-by-subject death indicator in the downloadable files.
- The documentation states, “Limited access to additional data from the original CAST and CAST II studies is available to qualified investigators on application to the NHLBI. This suggests that subject-level death data (such as exact time to death or censoring) is not included in the public release, but may be available by request to the NHLBI.
- If using only the public PhysioNet database we cannot directly perform subject-level survival analysis (e.g., Kaplan-Meier curves, Cox regression) because we do not have the death/censoring status or time for each subject.

PROBLEM STATEMENT

- Do drugs reduce ventricular premature complexes (VPCs)?
- Do these drugs affect heart rate?
- Can VPC suppression potentially improve survival in MI patients

Drugs Used

- Flecainide
- Encainide
- Moricizine

DATA VISUALIZATION

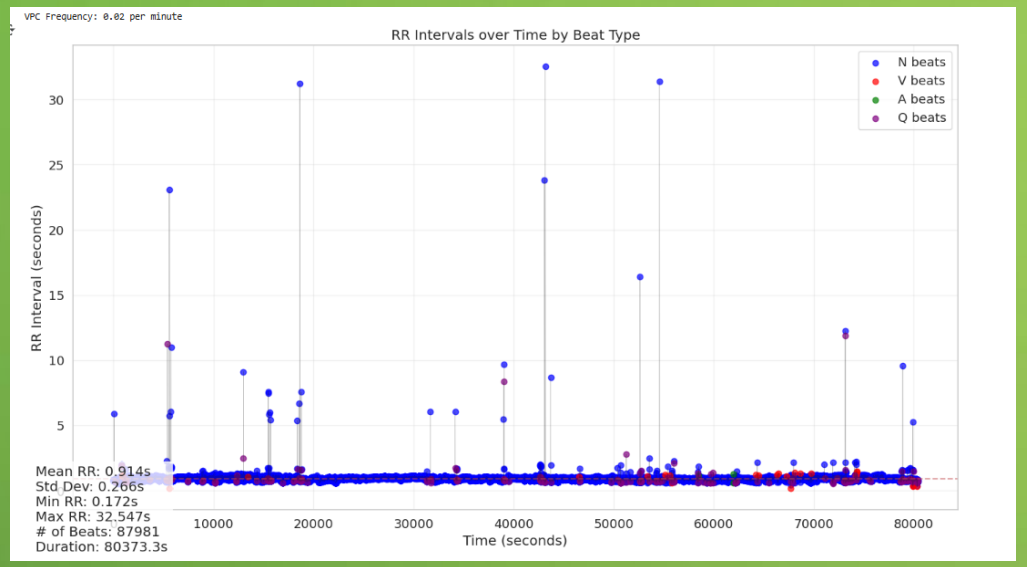


Fig: RR interval time-series with drug

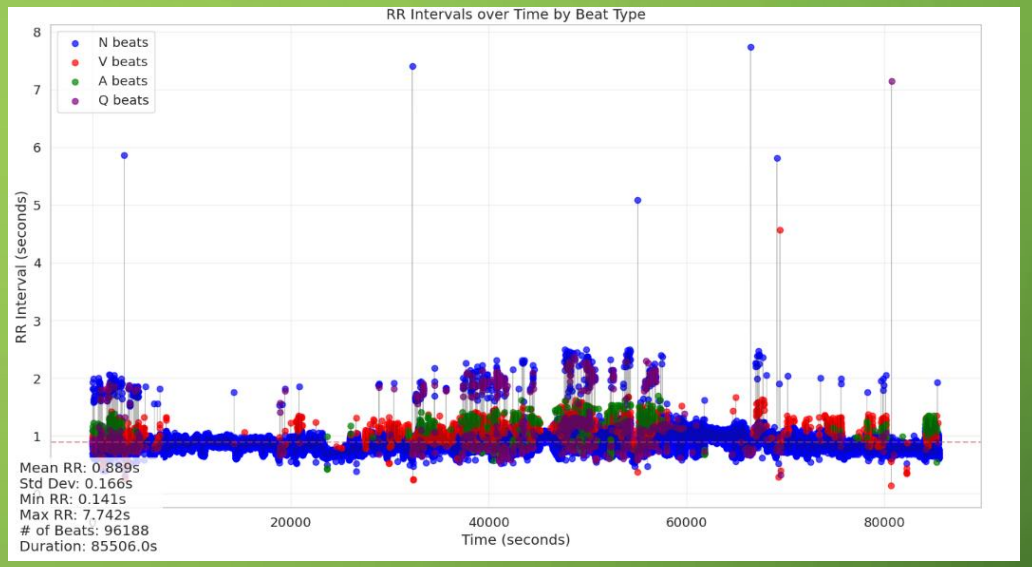


Fig: RR interval time-series without drug

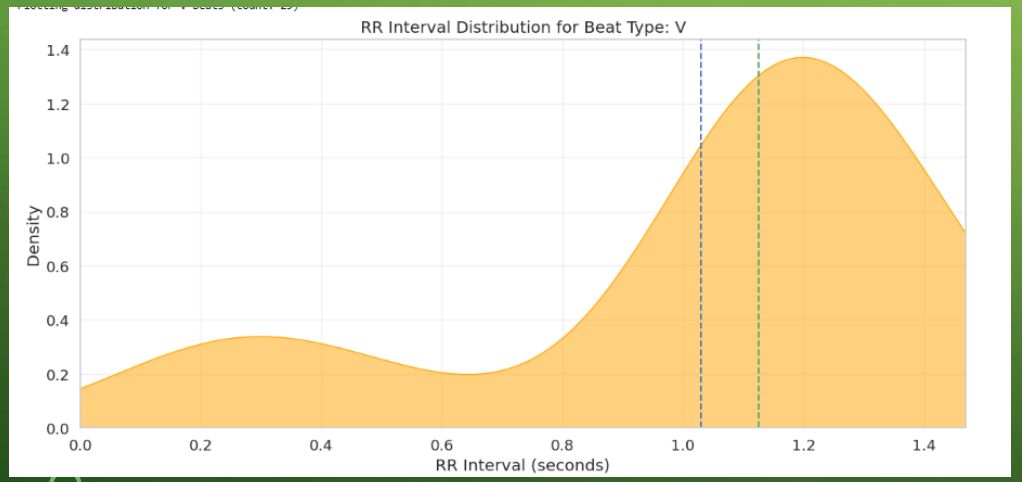


Fig: V beat interval distribution

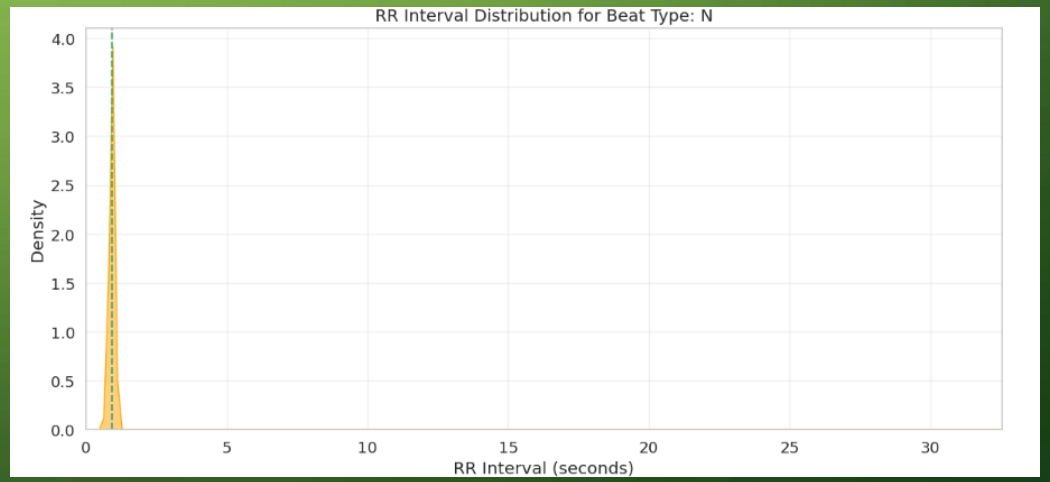


Fig: N beat interval distribution

BAYESIAN INFERENCE MODEL

Bayesian Model for Heart Rate Equation

$$\Delta_{\text{hr}} \sim \text{Normal}(\mu_{\text{hr}}, \sigma_{\text{hr}})$$

$$\mu_{\text{hr}} \sim \text{Normal}(0, 10)$$

$$\sigma_{\text{hr}} \sim \text{HalfNormal}(10)$$

Bayesian Model for VPC Frequency:

$$\Delta_{\text{vpc}} \sim \text{Normal}(\mu_{\text{vpc}}, \sigma_{\text{vpc}})$$

$$\mu_{\text{vpc}} \sim \text{Normal}(0, 5)$$

$$\sigma_{\text{vpc}} \sim \text{HalfNormal}(5)$$

HYPOTHESIS TESTING

Null Hypothesis (H_0):

$$\mu_{\text{VPC}} = 0 \quad \text{and} \quad \mu_{\text{HR}} = 0$$

Alternative Hypothesis (H_1)

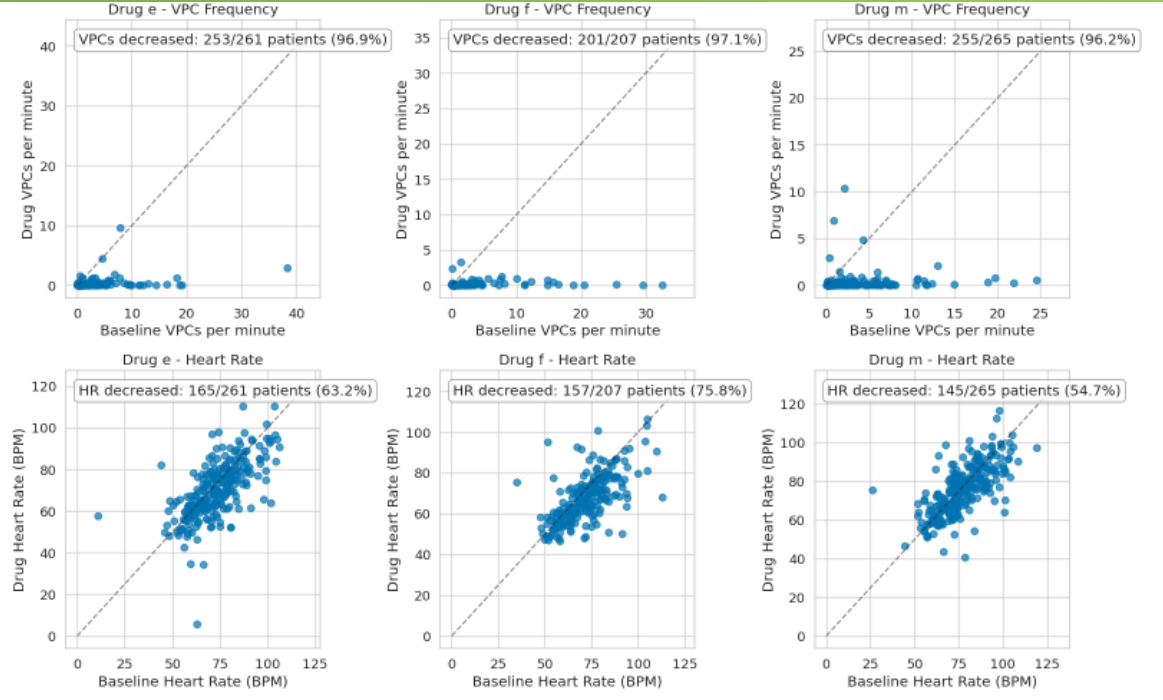
$$\mu_{\text{VPC}} < 0 \quad \text{and} \quad \mu_{\text{HR}} \neq 0$$

Posterior Distribution Plots

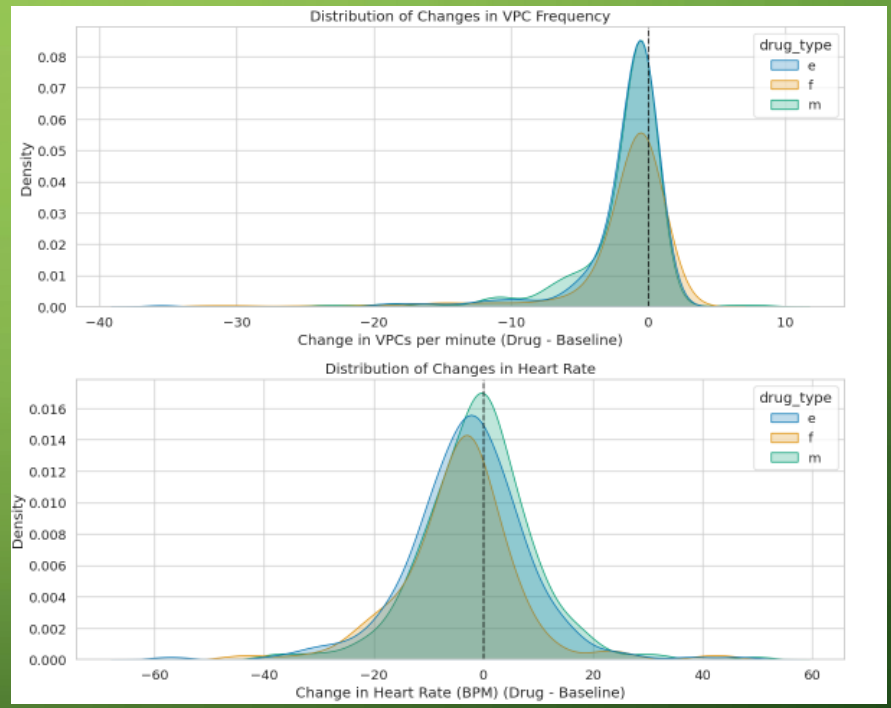
Bayesian posterior distributions for each drug parameter is computed using MCMV

- Posterior for μ_vpc (VPC frequency change)
- Posterior for μ_hr (heart rate change)
- With 95% HDI (Highest Density Interval)
- Reference line at zero

EFFECT OF DRUG

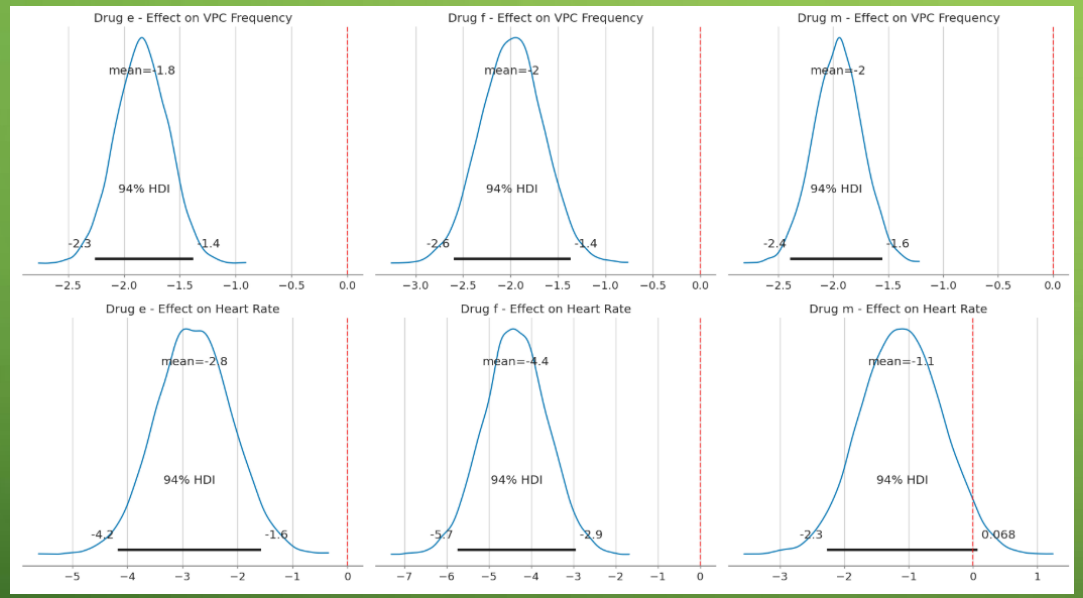


Visual description of Effect of Drug

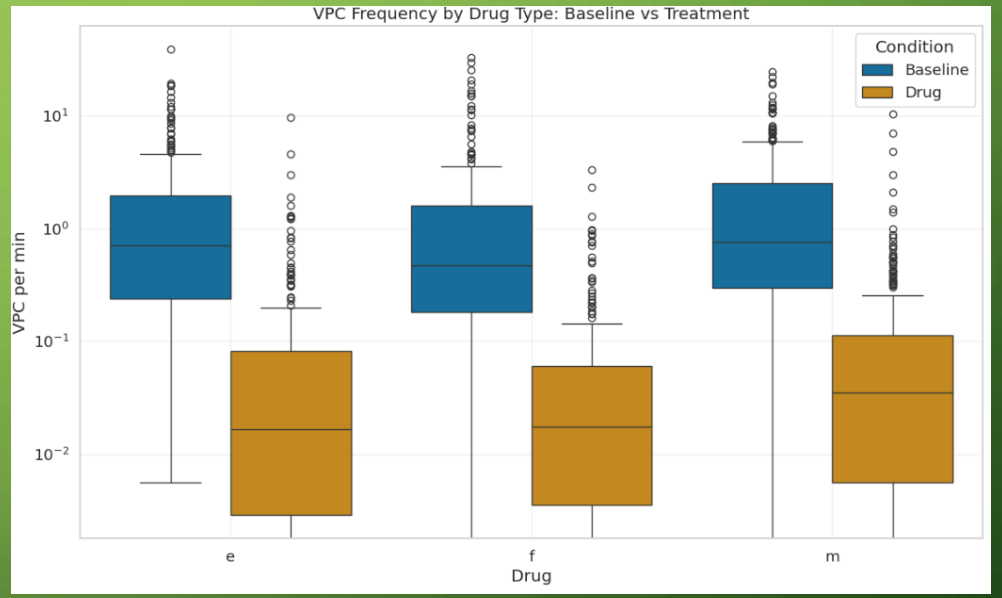


Computed Posterior Distributions

EFFECT OF DRUG



HPDI Intervals for Posterior Distribution



Box Plot Representation of Posterior Distributions

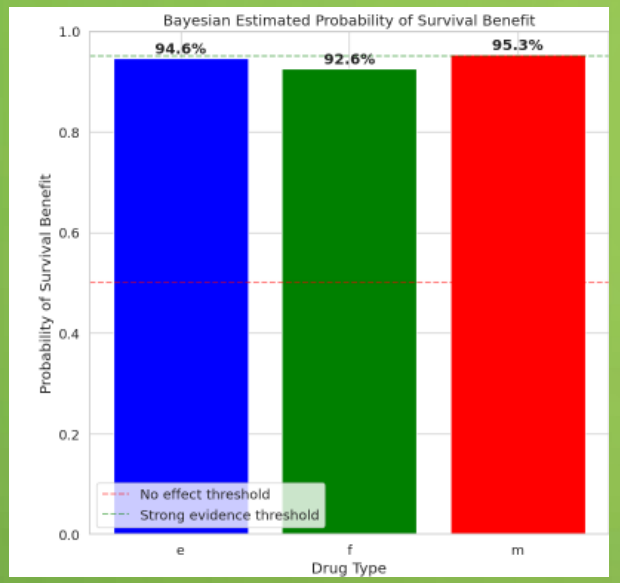
SURVIVAL MODEL

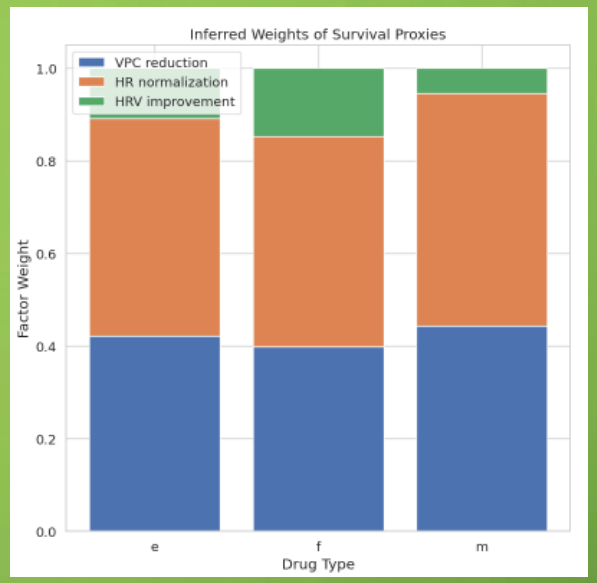
$$\text{Survival Benefit} = w_{\text{vpc}} \cdot \text{VPC}_{\text{benefit}} + w_{\text{hr}} \cdot \text{HR}_{\text{benefit}} + w_{\text{hrv}} \cdot \text{HRV}_{\text{benefit}}$$

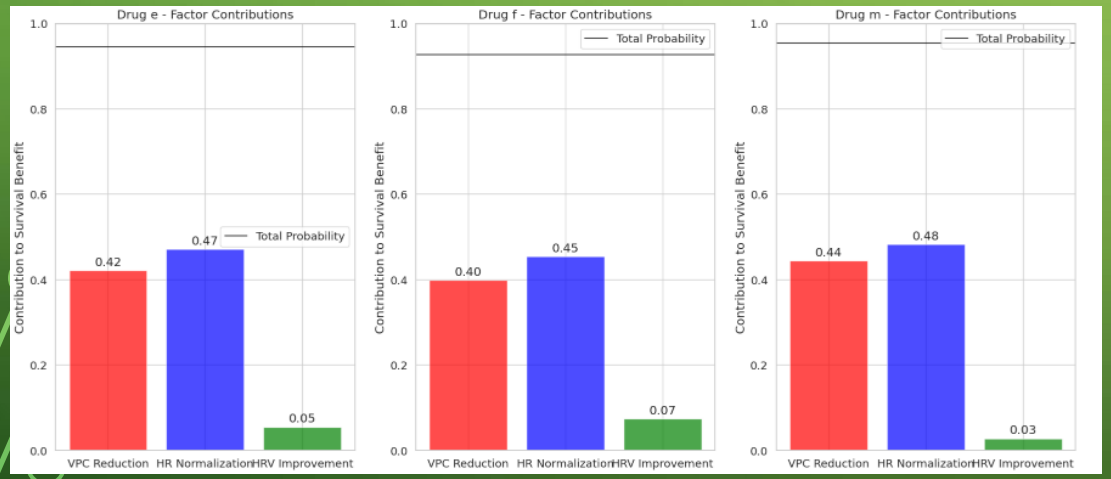
- w_{vpc}: Weight for VPC reduction benefit
- $\text{VPC}_{\text{benefit}}$: Standardized decrease in abnormal heartbeats
- w_{hr}: Weight for heart rate improvement
- $\text{HR}_{\text{benefit}}$: Standardized normalization of heart rate
- w_{hrv}: Weight for HRV improvement
- $\text{HRV}_{\text{benefit}}$: Standardized increase in heart rate variability
- **Weights sum to 1**: $w_{\text{vpc}} + w_{\text{hr}} + w_{\text{hrv}} = 1$

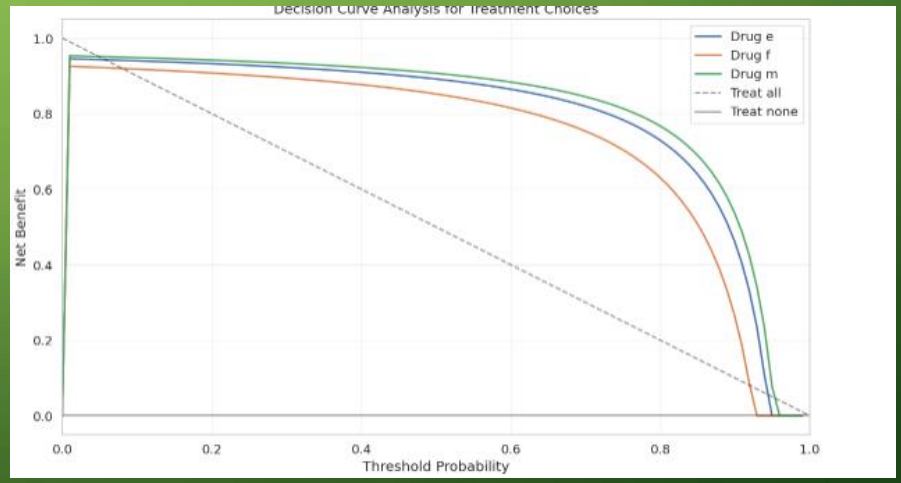
$$P(\text{Survival Benefit}) = w'_{\text{pc}} \cdot P(\mu_{\text{vpc}} < 0) + w'_{\text{hr}} \cdot \max\left(P(\mu_{\text{hr}} < 0), P(\mu_{\text{hr}} > 0)\right) + w'_{\text{hrv}} \cdot 0.5$$

SURVIVAL ANALYSIS









CONCLUSION

- We concluded that all the three drugs Flecainide , Encainide and Moricizine decrease the frequency of ventricular premature complexes using the HDI Interval of the posterior distribution
- Moreover the survival model predicits that all the three drugs lead to an increment in the survival of the patient by using a proxy measure for survival