Final Project

2025-05-14

1 Introduction

In this analysis, we examine the **burn** dataset from the `KMsurv` package, which contains clinical records of 154 burn patients including time to staphylococcus aureus infection and censoring indicators.

We define the failure time as `T3` (days until Staphylococcus aureus infection or censoring) and the event indicator `D3` (1 = infection, 0 = censored). Covariates include:

- **Z1**: Treatment type (0 = routine bathing, 1 = body cleansing)
- **Z2**: Gender (0 = male, 1 = female)
- **Z3**: Race (0 = nonwhite, 1 = white)
- **Z4**: Percent total surface area burned
- **Z5-Z10**: Indicators for burn site in head, buttock, trunk, upper leg, lower leg, respiratory tract (0/1)
- **Z11**: Burn type (1 = chemical, 2 = scald, 3 = electric, 4 = flame)

The main scientific question motivating this study is: *How does the cleansing treatment affect the hazard of Staphylococcus aureus infection, accounting for patient and burn characteristics?*

2 Model Fitting

We start with univariate Kaplan-Meier estimation and then fit multivariable Cox proportional hazards models, using AIC for forward stepwise selection to identify the most influential covariates.

2.1 Kaplan-Meier Estimate

```
burn.surv <- Surv(time = burn$T3, event = burn$D3)
ggsurvplot(
  survfit(burn.surv ~ 1),
  surv.median.line = "hv",
  data = burn,
  xlab = "Time (Days)",
  ylab = "Survival Probability",
  title = "KM Estimate of Time to Staphylococcus Aureus Infection"
)
```
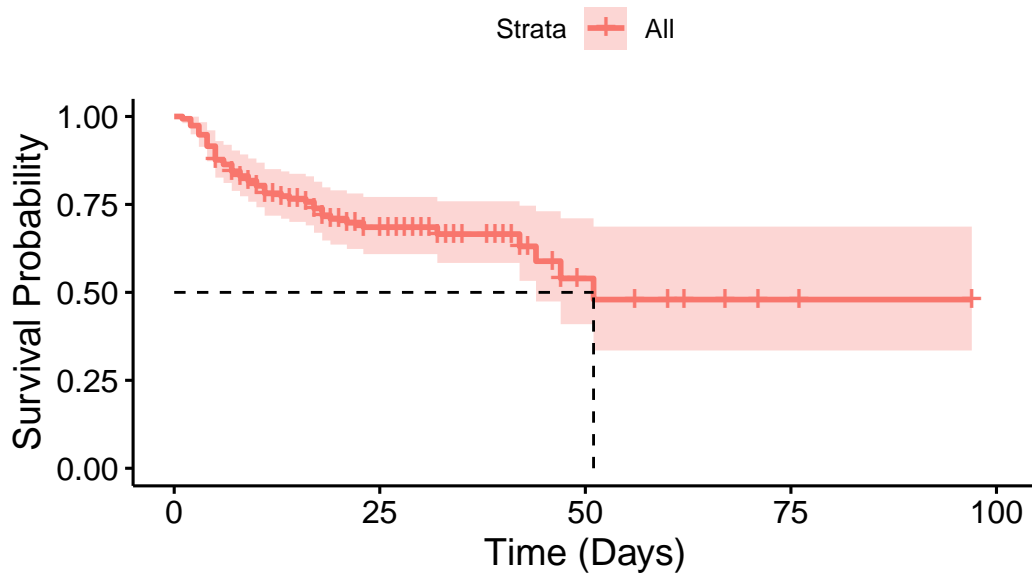

The KM curve estimates the survival probability for time to Staphylococcus aureus infection across all patients. The median survival time, where the probability drops to 50%, is approximately 51 days. This provides a baseline understanding of infetion risk before adjusting for covariates.

2.2 Cox Proportional Hazards Model

2.2.1 Full Model

```
cox_full <- coxph(burn.surv ~ Z1 + Z2 + Z3 + Z4 + Z5 + Z6 + Z7 + Z8 + Z9 + Z10 + as.factor(Z
summary(cox_full)
```

```
Call:
coxph(formula = burn.surv ~ Z1 + Z2 + Z3 + Z4 + Z5 + Z6 + Z7 +
    Z8 + Z9 + Z10 + as.factor(Z11), data = burn)

  n= 154, number of events= 48

                       coef exp(coef)  se(coef)      z Pr(>|z|)
Z1               -0.651754  0.521131  0.323330 -2.016   0.0438 *
Z2               -0.556911  0.572976  0.405182 -1.374   0.1693
Z3                2.149127  8.577367  1.040139  2.066   0.0388 *
Z4                0.002041  1.002043  0.009843  0.207   0.8357
Z5               -0.014035  0.986063  0.370920 -0.038   0.9698
Z6                0.541461  1.718516  0.430265  1.258   0.2082
Z7               -0.055650  0.945870  0.507956 -0.110   0.9128
Z8               -0.171817  0.842133  0.393707 -0.436   0.6625
Z9               -0.324566  0.722841  0.373905 -0.868   0.3854
Z10               0.228682  1.256943  0.372930  0.613   0.5397
as.factor(Z11)2   1.527828  4.608156  1.128623  1.354   0.1758
as.factor(Z11)3   2.192439  8.957029  1.130097  1.940   0.0524 .
as.factor(Z11)4   0.949734  2.585021  1.036308  0.916   0.3594
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

                exp(coef) exp(-coef) lower .95 upper .95
Z1                 0.5211     1.9189    0.2765    0.9821
Z2                 0.5730     1.7453    0.2590    1.2677
Z3                 8.5774     0.1166    1.1168   65.8752
Z4                 1.0020     0.9980    0.9829    1.0216
Z5                 0.9861     1.0141    0.4766    2.0400
Z6                 1.7185     0.5819    0.7395    3.9939
Z7                 0.9459     1.0572    0.3495    2.5598
Z8                 0.8421     1.1875    0.3893    1.8218
Z9                 0.7228     1.3834    0.3474    1.5042
Z10                1.2569     0.7956    0.6052    2.6107
```

```
as.factor(Z11)2      4.6082      0.2170      0.5045      42.0933
as.factor(Z11)3      8.9570      0.1116      0.9777      82.0549
as.factor(Z11)4      2.5850      0.3868      0.3391      19.7048


Concordance= 0.739  (se = 0.036 )
Likelihood ratio test= 27.29  on 13 df,   p=0.01
Wald test            = 22.39  on 13 df,   p=0.05
Score (logrank) test = 26.23  on 13 df,   p=0.02
```

The full Cox model assessed factors influencing time to Staphylococcus aureus infection in burn patients. Key results include:

Treatment (Z1): Hazard ratio (HR) = 0.521 (95% CI: 0.276–0.982, p = 0.044). Body cleansing reduces infection risk by 47.9% compared to routine bathing, a significant finding.

Race (Z3): HR = 8.577 (95% CI: 1.117–65.875, p = 0.039). White patients have a higher infection risk than nonwhite patients, warranting further study.

Burn Type (Z11): Electric burns (Z11=3) show a marginally significant higher risk (HR = 8.957, p = 0.052) vs chemical burns.

Other factors (e.g., gender, burn extent, burn sites) were not significant. Model fit is good (concordance = 0.739), with significant overall tests (p 0.05). Body cleansing appears protective, while race differences need exploration.

2.2.2 Stepwise Selection by AIC

```
cox_step <- step(cox_full, direction = "forward", k = 2)
```

```
Start:  AIC=437.29
burn.surv ~ Z1 + Z2 + Z3 + Z4 + Z5 + Z6 + Z7 + Z8 + Z9 + Z10 +
    as.factor(Z11)
```

```
summary(cox_step)
```

```
Call:
coxph(formula = burn.surv ~ Z1 + Z2 + Z3 + Z4 + Z5 + Z6 + Z7 +
    Z8 + Z9 + Z10 + as.factor(Z11), data = burn)

  n= 154, number of events= 48
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```
                   coef exp(coef)  se(coef)       z Pr(>|z|)
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```

The retention of all covariates in the stepwise selection process highlights their combined importance in predicting infection risk, even if only Z1 and Z3 are individually significant. The consistent significance of body cleansing (Z1) reinforces its protective effect, while race (Z3) emerges as a key risk factor. The marginal significance of electric burns (Z11=3) and the potential violations of the proportional hazards assumption for Z9 and Z10 suggest areas for

further investigation, possibly through stratified models or time-varying effects. Overall, the model provides a robust framework for understanding infection risk in burn patients, with a good fit and reliable predictors.

3 Checking Proportional Hazards Assumptions

We use Schoenfeld residuals and the global test to assess the PH assumption:

```
zph_test <- cox.zph(cox_step)
print(zph_test)
```
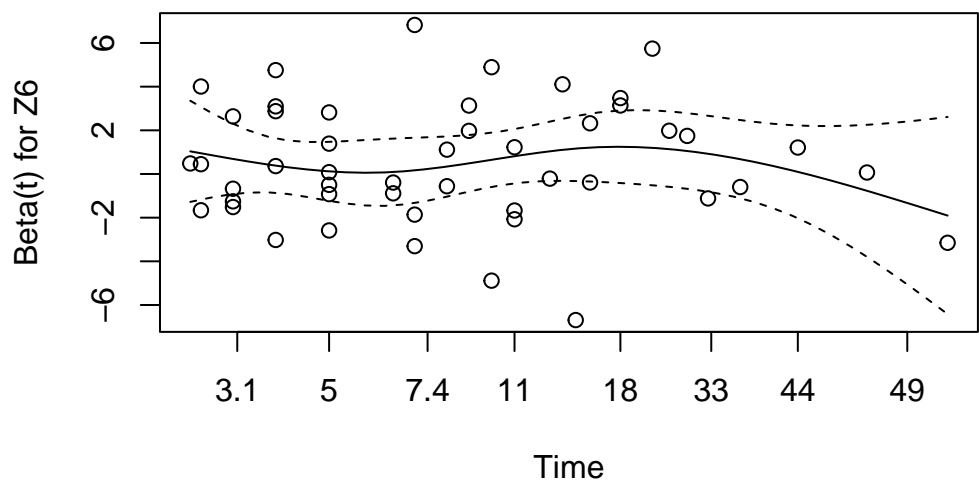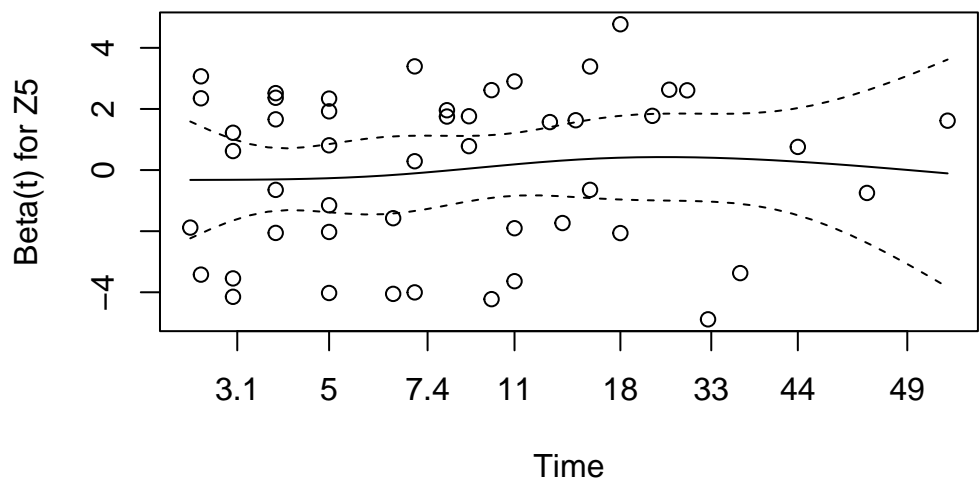
```
                chisq df       p
Z1             0.4991  1 0.480
Z2             1.6728  1 0.196
Z3             2.4235  1 0.120
Z4             0.0335  1 0.855
Z5             2.1733  1 0.140
Z6             0.7846  1 0.376
Z7             0.0287  1 0.866
Z8             0.2612  1 0.609
Z9             4.4130  1 0.036
Z10            3.8397  1 0.050
as.factor(Z11) 9.0926  3 0.028
GLOBAL        18.3219 13 0.146
```
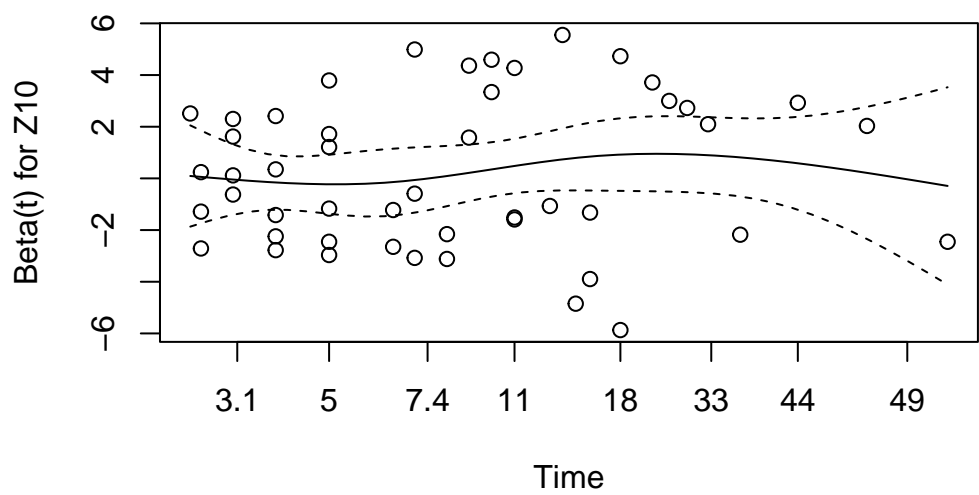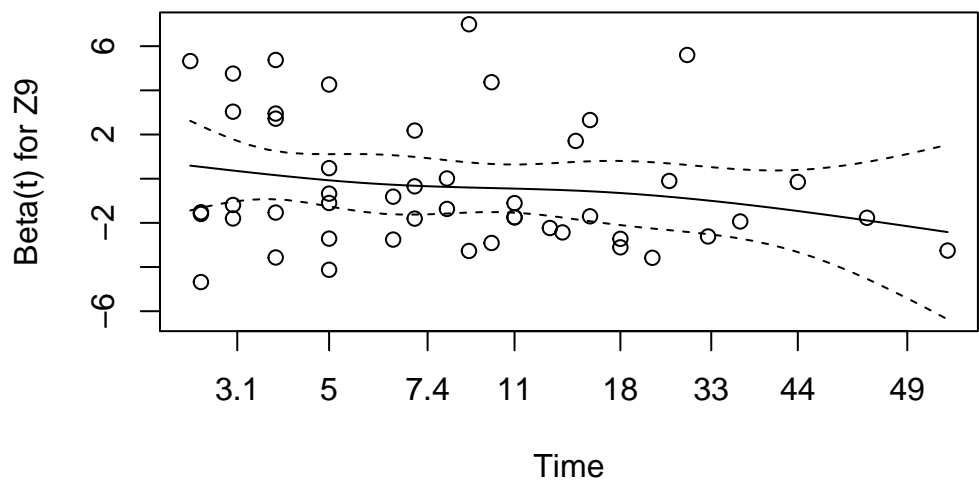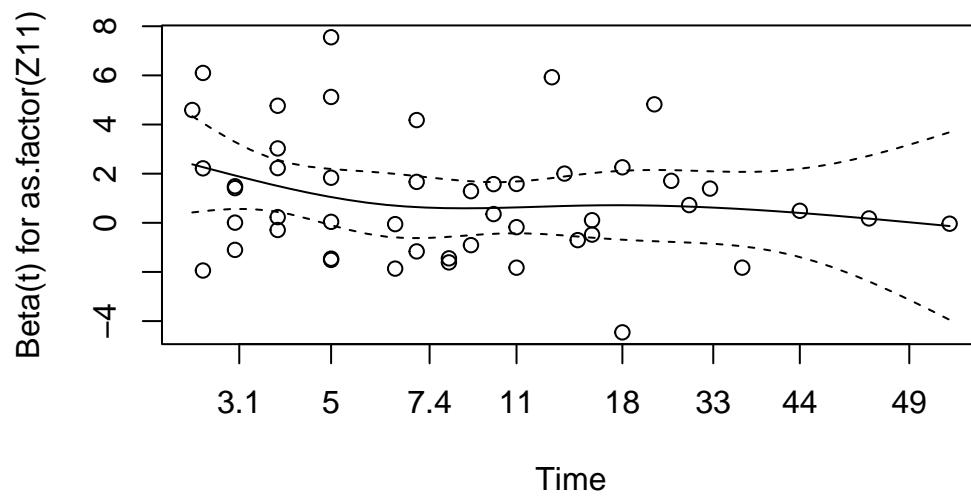
```
plot(zph_test)
```

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11
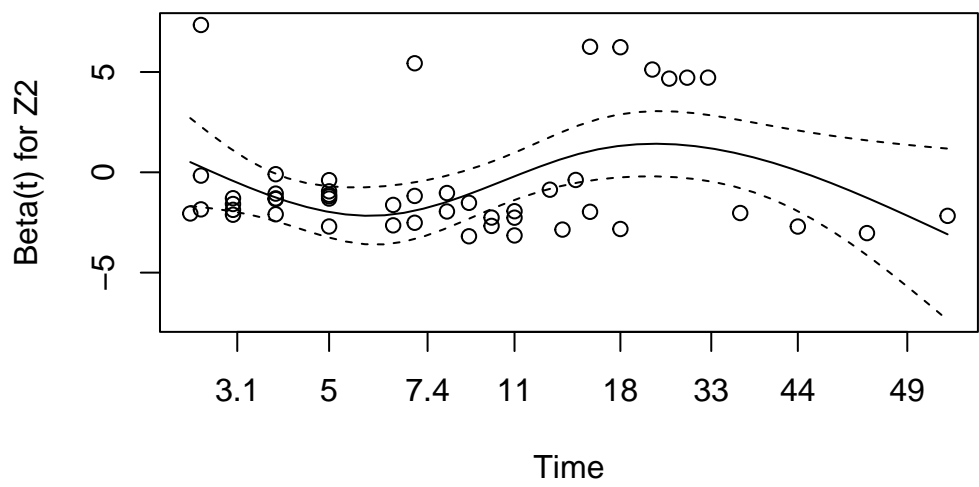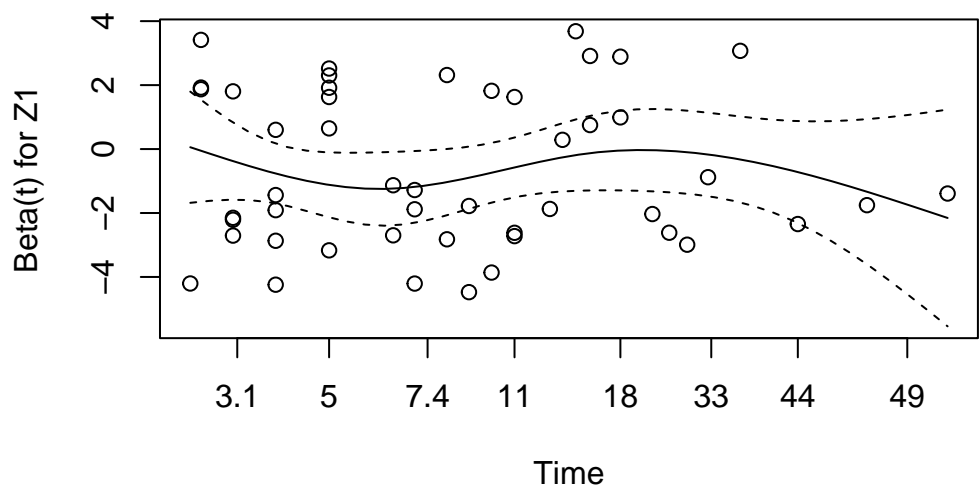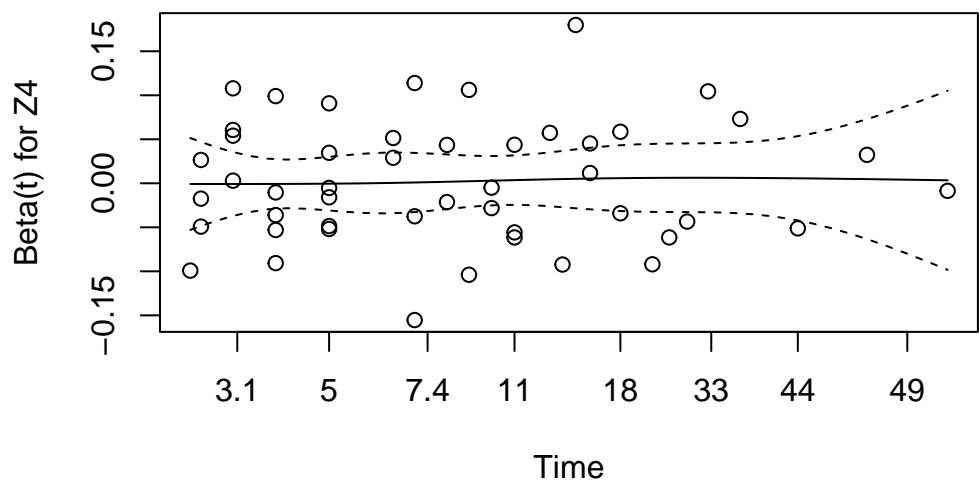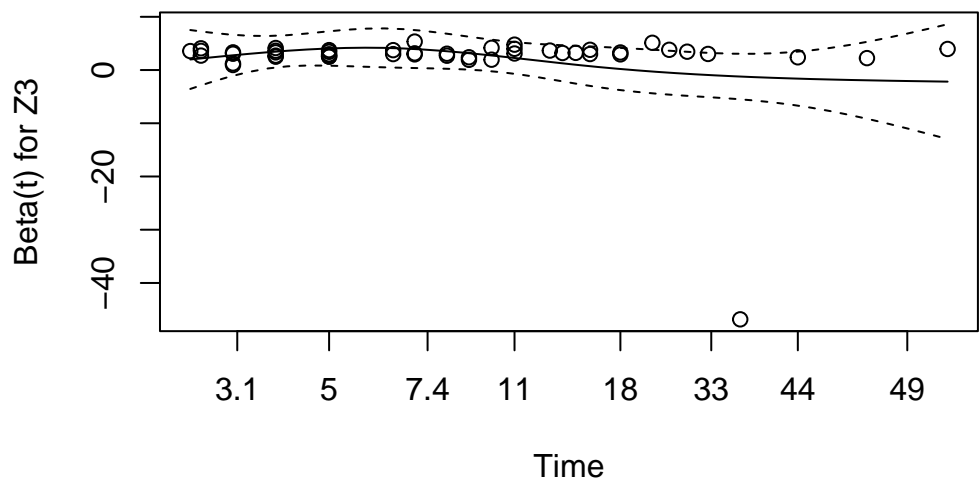
add analysis here

4 Time-Varying Treatment Effect

```
#continue here
```

5 Conclusions