**Project:** Project 1, BIOS 6623

**Report:** Descriptive Statistics & Bayesian Analysis

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**Introduction**

The goals of this project are to examine the difference in treatment responses of hard drug users and those who don’t report hard drug use in HIV-1 infected homosexual and bisexual men in the Multicenter AIDS cohort study. Outcomes of interest include two laboratory measures—viral load and CD4+ T cell count—and two quality of life scores—aggregate mental score and aggregate physical score from the SF-36.

These measures were taken on men at baseline and throughout the follow-up period of the study, but this analysis aims to examine how these treatment responses differ between users and non-users of hard drugs from baseline values to their responses at the 2 year follow-up time point in the study.

**Methods**

There were 715 men included in the study at baseline, but 209 of these men did not have data at the 2 year follow-up, so they were excluded. Of the remaining 506, 28 were excluded since they did not have data available for all 4 outcomes, which was acceptable since none of those excluded were hard drug users, so it didn’t exclude any data on our population of interest.

The following demographic variables and potential covariates were selected in addition to hard drug use on the basis of covariate adjustment in previous studies: baseline outcome values, age, BMI, race, baseline marijuana use, baseline alcohol use, baseline smoking status, income, education, and adherence to ART at 2 years.

Some of these variables’ categories were collapsed to match how they were categorized in previous studies. Race was categorized into non-Hispanic white vs. other (reference); alcohol use was categorized into > 13 drinks per week vs. 13 or fewer drinks per week (reference); smoking was categorized into current smokers vs. never/former smokers (reference); income was categorized into < $10,000 (reference), $10,000 - $40,000, and > $40,000; education was categorized into greater than a high school education vs. a high school education or less (reference); and ART adherence at the 2 year mark was categorized into > 95% vs. < 95% (reference).

Continuous variables all remained continuous for the purposes of the analysis and descriptive statistics. Impossible values for BMI (> 500) were removed, and viral load was transformed on the log10 scale.

The linear regression models for the differences of each outcome as functions of all previously listed demographics variables and hard drug use were fitted in a Bayesian framework. All coefficients had vague priors that were normally distributed with means of 0 and variances of 1000, except for the parameters in the CD4+ count model, which had variances of 10000 under the normal distribution with mean 0. The variance had an inverse gamma prior with a shape of 2.001 and a scale of 1.001.

PROC MCMC was utilized to simulate the posterior distribution for each outcome with random walk Metropolis-Hastings algorithm. All covariate parameters had starting values of 0, and the error had a starting value of 1.

All models were run with a single chain, but each outcome required different numbers of iterations to reach convergence with acceptable mixing. Both quality of life outcomes were run for 30000 iterations with 2500 iterations discarded for burn-in. The log10 viral load models were run for 50000 iterations with 2500 burn-in iterations. Finally, the models for CD4+ count were run with 7500 burn-in iterations and 250000 total iterations, with only every 10th iteration included in the posterior distribution.

The Geweke statistic was used to assess model convergence, and model mixing was assessed with trace plots and autocorrelation plots. The results of these models were summarized with the posterior mean and 95% HPD credible intervals.

A model was fitted for each of the four difference outcomes with only hard drug use and baseline values for each outcome as the predictors. Then, full models were fitted for each of the difference outcomes, which included hard drug use, baseline outcome value, and the other demographics previously listed.

To explore which variables contributed most to model fit, one covariate was removed at a time from the full model, and the DIC from the full and reduced model were compared to determine if the model was improved with this variable included. It was requested that hard drug use, baseline outcome value, age, BMI, drug adherence, race, and at least one measure of socioeconomic status (education or income) remain in the model throughout the process. Therefore, models were tested with the removal of baseline values of alcohol consumption, smoking status, marijuana use, and income or education. Once all DIC values were compared, all variables that improved DIC when removed were all removed in one step, and this DIC was compared to that of the full model to determine if they could all be removed at once. If so, the process of removing the removable variables one at a time and comparing DIC to the new full model was repeated.

None of the estimates of hard drug use changed between the crude models and full model, so no further exploration into confounding or correlation was required to select final models.

**Results**

Table 1 reports the mean and standard deviation for continuous demographic variables and count and percentage for categorical demographics variables, and it is stratified by hard drug use.

Table 2 contains the differences from baseline to the 2 year mark in the study for each outcome, also stratified by hard drug use.

Table 3 includes the posterior means and the 95% HPD intervals for the hard drug use variable for each outcome’s model, adjusted for baseline, age, BMI, ART adherence at the 2 year mark, race, and income.

Hard drug use was not a strong predictor of the difference in SF-36 MCS over the course of 2 years after adjusting for age, BMI, race, income, adherence, and baseline values; hard drug users had a mean difference in SF-36 aggregate mental score that was 0.2167 points lower than non-hard drug users (95% HPD interval: -3.4630, 3.33566). Hard drug use was a much stronger predictor of the difference in SF-36 aggregate physical score after the same covariate adjustments. Hard drug users had a mean difference in physical quality of life score that was 3.6128 points lower than the physical score of non-hard drug users (95% HPD interval: -5.9669, 3.33566).

Hard drug use was also not a strong predictor of difference in log10 viral load after adjustment for age, BMI, race, income, adherence, and baseline values. **NEED TO SAY STUFF HERE.** However, hard drug use was a much stronger predictor of CD4+ count after these covariate adjustments. Hard drug users had a difference in CD4+ count that was 157.4 less than non-hard drug users (95% HPD interval: -216.4, -100.0).

|  |  |  |
| --- | --- | --- |
| **Outcome** | **Hard drug posterior mean** | **Hard drug 95% HPD interval** |
| SF-36 MCS (Mental)\* | -0.2167 | -3.4630, 3.33566 |
| SF-36 PCS (Physical)\* | -3.6128 | -5.9669, -0.8246 |
| Log10 Viral Load\* | -0.0363 | -0.1595, 0.1015 |
| CD4+ Count\* | -157.4 | -216.4, -100.0 |

* received from the investigator) and the scientific hypothesis of interest. Rephrase the scientific hypothesis of interest into testable statistical hypotheses (~.5 page).  Note this is NOT a scientific introduction to a paper and should give information pertinent to the data analysis, not more general biology background.
* Methods: Describe the methods used to clean and analyze the data. Justify and explain your data analysis approach (~ 2 pages).  Should be written in past tense and should not include results.  Do NOT include equations.
* Results: Present results for analyses described in the methods (~1-1.5 pages). Use Tables and Figures as appropriate, including in the text the full interpretation of statistical results for the main findings (i.e. point estimates, confidence bounds, p-values, interpretation of results of test).
* Conclusions: Interpret your results (~.5 to 1 page) in context of scientific question(s). Also discuss any limitations to your analysis that may affect interpretation or that require additional consideration by the investigator.

**Table 1.**

|  |  |  |  |
| --- | --- | --- | --- |
|  | **Total** | **Hard drugs = Yes** | **Hard drugs = No** |
| **Age at baseline** | 43.26 ± 8.72 | 44.62 ± 9.49 | 43.14 ± 8.65 |
| **BMI at baseline** | 25.21 ± 4.34 | 23.62 ± 3.45 | 25.34 ± 4.39 |
| **Alcohol use at baseline** |  |  |  |
| 13 or fewer drinks per week | 443 (93.07) | 37 (94.87) | 406 (92.91) |
| > 13 drinks per week | 33 (6.93) | 2 (5.13) | 31 (7.09) |
| **Smoking status at baseline** |  |  |  |
| Never/former | 291 (61.13) | 9 (23.08) | 282 (64.53) |
| Current | 185 (38.87) | 30 (76.92) | 155 (35.47) |
| **Marijuana use at baseline** |  |  |  |
| Yes | 194 (40.76) | 12 (30.77) | 182 (41.65) |
| No | 282 (59.24) | 27 (69.23) | 255 (58.35) |
| **Income level at baseline** |  |  |  |
| < $10,000 | 99 (20.8) | 14 (35.9) | 85 (20.24) |
| $10,000 - $40,000 | 196 (41.18) | 16 (41.03) | 180 (42.86) |
| > $40,000 | 164 (34.45) | 9 (23.08) | 155 (36.9) |
| **Education at baseline** |  |  |  |
| HS or less | 101 (21.22) | 16 (41.03) | 85 (19.45) |
| >HS | 375 (78.78) | 23 (58.97) | 352 (80.55) |
| **Adherence at 2 years** |  |  |  |
| <95% | 50 (10.5) | 1 (2.56) | 49 (11.21) |
| >95% | 426 (89.5) | 38 (97.44) | 388 (88.79) |
| **Baseline log10 viral load** | 4.52 ± 0.92 | 4.52 ± 0.86 | 4.52 ± 0.93 |
| **Baseline CD4+ count** | 373.53 ± 200.46 | 352.18 ± 194.67 | 375.44 ± 201.07 |
| **Baseline SF36 MCS score** | 44.89 ± 13.5 | 42.31 ± 11.22 | 45.12 ± 13.68 |
| **Baseline SF36 PCS score** | 51.04 ± 9.05 | 47.7 ± 8.5 | 51.34 ± 9.05 |

**Table 2.**  This table displays the difference in the four outcomes from baseline to the 2 year mark in the study.

|  |  |  |  |
| --- | --- | --- | --- |
|  | **Total** | **Hard drugs = Yes** | **Hard drugs = No** |
| **Difference in log10 viral load** | 0.41 ± 0.37 | 0.39 ± 0.25 | 0.41 ± 0.38 |
| **Difference in CD4+ count** | 169.21 ± 183.2 | 13.43 ± 195.73 | 183.11 ± 175.67 |
| **Difference in SF36 MCS score** | 2.34 ± 12.1 | 3.58 ± 15.07 | 2.23 ± 11.82 |
| **Difference in SF36 PCS score** | -1.55 ± 8.37 | -3.85 ± 8.71 | -1.34 ± 8.32 |

**Table 3.** This table shows the posterior means and 95% HPD intervals for the hard drug use variable in each of the 4 covariate-adjusted models.

|  |  |  |
| --- | --- | --- |
| **Outcome** | **Hard drug posterior mean** | **Hard drug 95% HPD interval** |
| SF-36 MCS (Mental)\* | -0.2167 | -3.4630, 3.33566 |
| SF-36 PCS (Physical)\* | -3.6128 | -5.9669, -0.8246 |
| Log10 Viral Load\* | -0.0363 | -0.1595, 0.1015 |
| CD4+ Count\* | -157.4 | -216.4, -100.0 |

*\*Adjusted for baseline, age, BMI, ART adherence at 2 year mark, race, income*

**Table 4.** This table displays the results of the final model for the difference in SF-36 MCS score from baseline to the 2 year mark.

|  |  |  |  |
| --- | --- | --- | --- |
| **Parameter** | **Mean** | **95% HPD Interval** | |
| **Intercept** | 19.4077 | 11.5768 | 26.6034 |
| **Baseline SF-36 MCS** | -0.5363 | -0.6096 | -0.4696 |
| **Hard drug use** | -0.2167 | -3.463 | 3.3566 |
| **Age** | 0.091 | -0.0254 | 0.1973 |
| **BMI** | 0.00921 | -0.1952 | 0.2233 |
| **Adherence** | 2.5114 | -0.6865 | 5.4813 |
| **Race** | -0.2294 | -2.331 | 2.0777 |
| **Income (Medium)** | 0.6213 | -1.8418 | 3.1895 |
| **Income (High)** | 2.0207 | -0.7472 | 4.8331 |
| **Variance** | 98.797 | 86.01 | 111.9 |

**Table 5.** This table displays the results of the final model for the difference in SF-36 PCS score from baseline to the 2 year mark.

|  |  |  |  |
| --- | --- | --- | --- |
| **Parameter** | **Mean** | **95% HPD Interval** | |
| **Intercept** | 14.7989 | 7.59 | 22.1062 |
| **Baseline SF-36 PCS** | -0.3152 | -0.4026 | -0.2303 |
| **Hard drug use** | -3.6128 | -5.9669 | -0.8246 |
| **Age** | -0.1158 | -0.198 | -0.0262 |
| **BMI** | 0.0746 | -0.1001 | 0.2433 |
| **Adherence** | 1.5434 | -0.9391 | 3.9661 |
| **Race** | -1.0081 | -2.6029 | 0.6921 |
| **Income (Medium)** | 2.58 | 0.7087 | 4.4375 |
| **Income (High)** | 3.5038 | 1.3955 | 5.7371 |
| **Variance** | 58.0263 | 50.3957 | 65.7037 |

**Table 6.** This table displays the results of the final model for the difference in log10 viral load score from baseline to the 2 year mark.

|  |  |  |  |
| --- | --- | --- | --- |
| **Parameter** | **Mean** | **95% HPD Interval** | |
| **Intercept** | 1.2247 | 0.8845 | 1.5665 |
| **Baseline log10 viral load** | -0.0854 | -0.1242 | -0.0475 |
| **Hard drug use** | -0.0363 | -0.1595 | 0.1015 |
| **Age** | -0.0005 | -0.0045 | 0.00326 |
| **BMI** | -0.0074 | -0.0154 | 0.00066 |
| **Adherence** | -0.1442 | -0.261 | -0.0283 |
| **Race** | -0.0036 | -0.085 | 0.0775 |
| **Income (Medium)** | -0.0682 | -0.1621 | 0.0263 |
| **Income (High)** | -0.1508 | -0.2528 | -0.0433 |
| **Variance** | 0.1344 | 0.1172 | 0.1526 |

**Table 7.**

|  |  |  |  |
| --- | --- | --- | --- |
| **Parameter** | **Mean** | **95% HPD Interval** | |
| **Intercept** | 43.1248 | -64.414 | 143.9 |
| **Baseline CD4+ count** | -0.0463 | -0.1241 | 0.0332 |
| **Hard drug use** | -157.4 | -216.4 | -100 |
| **Age** | -0.3321 | -2.0326 | 1.383 |
| **BMI** | 4.5319 | 0.9319 | 8.5578 |
| **Adherence** | 57.8586 | 7.7837 | 107.9 |
| **Race** | 28.5692 | -9.7254 | 63.5578 |
| **Income (medium)** | 5.3645 | -37.778 | 47.1722 |
| **Income (high)** | -48.476 | -94.295 | -2.9473 |
| **Variance** | 29902.9 | 26062 | 34039.9 |

**Conclusion**

https://github.com/BIOS6623-UCD/bios6623-johnsra3/tree/master/Project1

**Code**