Assessing the Effects of Changes to the Nutritional Environment at Coffee Creek Correctional Facility-Minimum on Female Inmates with Diabetes

by

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CERTIFICATE OF APPROVAL

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Abstract

Background: Within the last five years, the prevalence of diabetes among inmates living in Oregon prisons has increased by 50%. The number of Oregon inmates living with diabetes is expected to increase with the aging inmate population and the obesity epidemic. To reduce risk for chronic disease, the Healthy Food Access Project (HFAP) was implemented in the minimum-security facility at Coffee Creek Correctional Facility (CCCF) to improve nutrition for female inmates and teach them food-related skills by: 1) expanding the prison garden, 2) education and skills training, and 3) reducing prison menu by 800 calories a day (3,000 to 2,200). The goal of the study was to evaluate the effectiveness of HFAP on diabetes management by: a) describing the changes in glycemic control and other biometric measures and b) measuring the impact HFAP had on canteen purchases.

Methods: A quasi-experimental study was conducted among female inmates with diabetes living at CCCF in order to assess the effects the HFAP had on female inmates with diabetes. Inmates exposed to the HFAP in the minimum facility for at least 90 days (exposed group) were compared to inmates who were not (control group). Medical chart abstractions were conducted for a two-year period to describe changes in glycemic control and other biometric measures, and canteen receipts were collected for a month before and a month after the intervention was implemented to evaluate the impact on canteen purchases. Linear mixed effects models were built to assess the difference in biometric trends between exposed and unexposed female inmates with diabetes.

Results: Sixty-three female inmates with diabetes resided at CCCF; 24 were exposed to the intervention and 39 were unexposed. Female inmates with diabetes exposed to the intervention reduced their Hba1c by 0.03 units per month compared to changes in Hba1c among unexposed participants (b 0.03 p 0.04). Changes in BMI were dependent upon the amount of time a participant had served at the prison (p 0.03). Exposed participants within their first year at the prison gained an average of 0.23 BMI units each month or 17 pounds a year for a 5’5” 150 pound woman. Participants purchased an average of 1,094 calories from canteen each day. Participants exposed to the intervention did not purchase more calories from canteen after their menu had been reduced by 800 calories a day, nor did they purchase more unhealthy food items from canteen after the intervention was implemented.

Conclusion: Exposure to the HFAP supported modest improvement in glycemic control among female inmate with diabetes. Female inmates with diabetes exposed to the reduced calorie menu did not supplement calories from canteen.

DEFINITIONS

CCCF. Coffee Creek Correctional Facility refers to all female inmates residing in the correctional facility.

Medium facility. All female inmates admitted into the correctional facility and residing in the Medium security Coffee Creek Correctional Facility (used as the control group, see below).

Minimum facility. All female inmates admitted into the correctional facility and residing in the Minimum security Coffee Creek Correctional Facility (exposed to the intervention, see below).

Case definition. All female inmates at CCCF with a diagnosis of diabetes by a CCCF medical provider prior to August 28th 2013 (n=63). Progress of diabetes management was recorded on a chronic disease visit report during face-to-face medical visits. A diabetes diagnosis was indicated on the face sheet of each medical chart. Because not all inmates with diabetes were diagnosed with diabetes upon admission to the facility or during incarceration, the timing of the diabetes diagnosis was determined for each participant.

Presumed diabetes. A diabetes diagnosis was obtained at the intake physical either from inmate medical history and/or diabetes-related medication and documentation transported with the inmate. A diabetes diagnosis was then confirmed by laboratory testing.

Confirmed diabetes. A diabetes diagnosis made from a Hba1c test of ≥6.5% or fasting plasma glucose ≥126mg/dl after admittance into CCCF.

Suspect. A prediabetes diagnosis was determined from a Hba1c test of 5.7-6.4% or fasting plasma glucose 100-125 mg/dl after admittance into CCCF.

Exposure to Health Food Access Project (HFAP). All inmates residing in the minimum facility were exposed to the reduced calorie menu and changes to the food environment. Exposure to HFAP consisted of 1) expansion of the prison garden 2) education and training classes on food preparation and harvesting and 3) reduced calorie menu and menu labeling. This analysis was focused on changes in biometric measures and canteen purchases before and after implementation of the reduced calorie menu. The reduced calorie menu was implemented on August 1st 2012.

Exposed female inmates with diabetes. Exposure status was determined from inmate housing assignment during August 1st 2012-August 28th 2013. A Department of Corrections database that records inmate housing movement was reviewed for each enrolled inmate. Inmates frequently transfer back and forth from the minimum to the medium facility for disciplinary actions and alterations in their sentence. As a precaution, changes in facility will be considered, and each inmate that was enrolled will be assigned to either the minimum or medium facility based on where they resided from August 1st 2012-August 28th 2013. A female inmate with diabetes was exposed to HFAP if she had resided in the minimum facility for a cumulative of 90 days during August 1st 2012-August 28th 2013.

Length of sentence. The length of sentence was determined from the date a woman was admitted to CCCF and her earliest release date. Earliest release dates are often recalculated during an inmate's sentence because they are dependent on additional charges added to an inmate's sentence and an inmate's behavior while incarcerated. Length of sentence for each participant was determined from the earliest release date that was calculated in September 2013.

Time served. The amount of time an inmate has served at CCCF for a current sentence in months at the time the sample was pulled (August 28th 2013).

Data sources. Two data sources were used to address biometric changes and canteen data. Medical chart abstraction (abstraction form Appendix A) and canteen receipts for June 2012 and June 2013 were collected for each participant. Individual participants identified in each data source were coded with a unique study ID and linked to one another in a study database.

Medical chart abstraction. Paper medical record abstractions allowed for biometric measures to be compared before and after exposure to the reduced calorie menu in the minimum facility and between female inmates with diabetes residing in the minimum (exposed) and medium (unexposed) facility. Female inmates with diabetes frequent the medical facility for diabetes management. It is common for inmates with diabetes to be seen every few months or up to a year between visits if diabetes is well managed. At most, eight medical visits are anticipated per female inmate with diabetes during the 24-month collection period.

Medical visit. Any contact with CCCF health services in relation to diabetes management, including a face-to-face chronic disease visit or a blood draw for the purpose of measuring Hba1c or lipids.

Data collection window for medical abstraction: All medical visits within the 24-month collection period (August 28th 2011-August 28th 2013).

Baseline measurement. All enrolled female inmates with diabetes had a baseline glycated hemoglobin (Hba1c), total cholesterol, low-density lipoprotein (LDL), high-density lipoprotein (HDL), and blood pressure measurements from a blood draw that was ordered at the intake physical or from the oldest lab result provided in their medical chart.

Oral diabetes medication. A participant was determined to be on diabetes medication if diabetes-related oral medication was prescribed during a chronic disease visit with a health care provider. Most common drugs included Metformin and Glipizide. Dose of medication at the time of special needs visit was abstracted as well. Adjustments to medication between visits and medication compliance were not considered. Each participant with at least one chronic disease visit was determined to be medicated, non-medicated, or transitioned off medication. Insulin use was noted, but the dose could not be quantified, as it was dependent on blood sugar reading.

Canteen receipts. Receipts were collected for all participants during the months of June 2012 and June 2013. Inmates purchased canteen on a weekly basis.

Smart Snack standards. The Institute of Medicine put forth nutrition standards for competitive foods sold in schools that were adapted by USDA Smart Snacks in Schools.[1] The Smart Snack standards were applied to foods purchased from canteen. The Smart Snack standards required a snack food to have ≤200 calories and entrée items ≤350 calories, ≤35% of total calories from fat, <10% of total calories from saturated fat, zero trans fat, ≤35% of total calories from sugar, ≤200 mg of sodium for a snack food and ≤480 mg of sodium for an entrée food.

Healthier options. Healthier canteen food items are food items that meet at least five of the six Smart Snack standards.

Less healthy options. Less healthy canteen food items meet four or less of the Smart Snack standards.

Calorie content of canteen purchases. The calorie content for each food item purchased by participants in June 2012 and June 2013 was determined using calorie counters and calculators recommended on the USDA National Agricultural

Library website and visiting the Oregon Department of Corrections canteen distribution center in Salem, Oregon

Introduction

More people in the United States die of diabetes each year than of breast cancer and HIV combined.[2] Currently, diabetes affects 8.3% of the US population.[3] The prevalence of diabetes in the US has increased by 176% over the past 30 years (1981-2010).[4] Diabetes is a substantial economic burden in the US. The estimated cost of diabetes was $245 billion during 2012.[5] An individual diagnosed with diabetes is estimated to spend $7,900 on diabetes-related medical care each year.[5]

The immense economic burden of diabetes can be ameliorated. The majority of type II diabetes diagnoses are preventable. Obesity is the strongest risk factor of type II diabetes, and the proportion of overweight and obese Americans continues to rise.[6] The rate of severe obesity (BMI ≥ $40 kg/m^2$) has increased by 52% in a span of five years.[7] Because of the increasing prevalence of obesity, population-level lifestyle interventions can be an effective method in reducing the increase of obesity-related conditions like diabetes.

The risk of diabetes is not evenly distributed among Americans. The incarcerated population in the US is at particular risk for diabetes. The rate of obesity among inmates mirrors that of the non-institutionalized population, and the increase in obese inmates will likely raise the prevalence of obesity-related diseases.[8] The age-adjusted prevalence of diabetes among prison inmates is significantly higher than that of the non-institutionalized adult US population (10.1% vs. 6.5%) in 2002.[9] The odds of diabetes among prison inmates is 47% higher than the odds of diabetes among non-institutionalized adults.[10] Furthermore, the odds of diabetes among female inmates is 2.14 times the odds of diabetes among male inmates.[11]

The increased risk of diabetes among inmates can partially be attributed to the difficulty in adhering to treatment and accessing medical services prior to incarceration. In the 12 months preceding incarceration, one third of prison inmates reported not seeing a medical provider because of cost, and two-thirds of female inmates reported obtaining health care at an emergency room.[12]

Correctional facilities provide a unique opportunity to intervene and improve diabetes management among a high-risk population.[13] For inmates in state correctional facilities, health care is entirely financed by the state government. Effectively managing diabetes and obesity-related conditions among female inmates can reduce medical costs to the state. An appropriate intervention to reduce diabetes-related morbidity, healthcare costs, and improve quality of life is through modifying the inmate food environment. Since food choice is limited in correctional facilities, introducing healthy foods could impact diet and lead to improved diabetes management.

Background

Diabetes management

Current strategies to manage diabetes require a combination of: monitoring glycemic control and implementing behavioral interventions. Glycemic control is measured by the amount of glycated hemoglobin (Hba1c), which reflects the average blood sugar level in the past two to three months.[14] The American Diabetes Association (ADA) set a target for Hba1c <7% among diabetics to reduce the risk of microvascular complications.[15] Glycemic control is often achieved through a combination of individual behavior change, nutrition therapy, and pharmacological therapy.[15] If diabetes is poorly managed, and blood sugar levels are consistency elevated, the individual is put at a heightened risk for cardiovascular events, loss of vision, renal failure, and amputation.[15]

Crucial to controlling diabetes is self-management and diet. Behavioral interventions focus on patient self-management. Diabetes self-management education (DSME) provides the individual with the skill set necessary to make healthy behavior changes to manage his or her diabetes and avoid or delay the onset of complications associated with diabetes.[15] Fundamental components of DSME interventions include self-monitoring blood glucose, recommended diet, and exercise changes to reduce the risk of complications associated with diabetes.[16]

Diabetes self-management education provides the necessary knowledge to implement a healthy diet. A diet that promotes healthy food choices, weight management, and glycemic control is the cornerstone for effective type II diabetes management.[17] Weight loss is a primary determinant of reducing the risk of diabetes. For every kilogram of weight loss, the risk of developing diabetes was reduced by 16 percent among a high-risk cohort.[18] The primary method of weight loss for diabetics is reducing daily caloric intake. Caloric restriction and consuming low glycemic foods are an effective method of controlling blood sugar. The ADA further recommends that diabetics monitor their carbohydrate intake. Saturated fat intake should remain below 7% of daily caloric intake, and the intake of trans fat should be minimized. If a low glycemic diet is followed, at least six servings of food with a glycemic index <56 should be consumed daily.[17] Despite food restrictions, meals should contain a variety of foods in order to meet recommended dietary allowance of micronutrients.[15] A multitude of healthy lifestyle interventions have achieved significant weight loss among diabetics through a healthy calorie-restricted diet. Weight loss among diabetics ultimately improves glycemic control and lowers dependence on glucose lowering medication.[19] A healthy diet is the foundation of diabetes management and reducing the risk of diabetes-related morbidities.

Diabetes management in correctional facilitates

People living with diabetes in the criminal justice system are at higher risk for poor glycemic control. Inmates are more likely to have faced barriers to healthcare prior to incarceration.[13] Potential barriers include: lack of health insurance,[20] poverty,[21] race,[22] transportation need,[21] disability,[23] substance abuse,[24] or mental disorders.[25] Risk factors for diabetes and other chronic conditions that are more prevalent in the incarcerated population include poverty, low levels of education, smoking, substance abuse, poor diet, and being of a minority race.[10,26] Taken together, individual risk factors and barriers to healthcare contribute to an increase in the prevalence of inmates with diabetes and poorly-managed diabetes upon admission into correctional facilities.

Diabetes management in correctional facilities has gained public interest as the rate of obesity and incarceration continue to rise in the United States.[8] Diabetes is a growing concern for stakeholders because current sentencing guidelines increase the number of aging prisoners, and the incidence of diabetes among younger people continues to rise.[26,27] Furthermore, the cost of diabetes management in correctional facilities is entirely financed by the state government. In Oregon, the average custody is 39 months and costs $100,500 per inmate, and an additional $25,675 can be spent on diabetes-related health care during the span of a 39-month sentence.[5] Controlling diabetes and obesity-related conditions can reduce this financial burden. Diabetes management in a correctional facility provides a unique opportunity to improve diabetes control and prevent diabetes-related morbidities among a high-risk population.

Controlling diabetes inside correctional facilities poses inherent challenges. The recommendations provided in the ADA position statement on Diabetes Management in Correctional Facilities addresses the complexities of diabetes management while maintaining security and order.[27] A diabetes management team should include health care providers, dieticians, and mental health specialists that collaborate to establish individual management plans.[27] Self-management education and nutrition therapy remain integral components of a successful management plan. The ADA recommends group nutrition education to cover menu planning and monitoring food intake as basic skills to promote glycemic control during and after incarceration.[27] Nutrition education is crucial in correctional facilities because inmates have limited choices in what they can eat.[28]

Barriers to nutrition therapy in correctional facilities

Obstacles to implementing a successful nutrition plan for inmates with diabetes include standardized meals, budget constraints, and the availability of unhealthy foods from canteen purchases. A master menu for each institution is established in order to provide ample calories and meet the recommended dietary allowance of micronutrients.[28] In many cases, the amount of calories offered far exceeds what is needed to maintain a healthy weight. Poor diet and rapid weight gain among inmates with diabetes can increase the risk of diabetes-related comorbidities. Inmates do have the option to be placed on a calorie-restricted diet, but a calorie-restricted diet may not promote low glycemic indexed (GI) foods that are recommended for people with diabetes.[26]

A barrier to offering heart healthy or low GI foods is cost. The average daily expenditure on food per inmate a day in the US was $3.32 in 2004.[28] Ultimately, a driving force in meal planning is dependent on food availability at the right price. Prison meals supplied by the department of corrections does not consider the proportion of food consumed each day that is purchased by the inmate.

Food that can be purchased from canteen is viewed as a major problem in achieving glycemic control among inmates with diabetes.[27] Canteen services offer purchasable goods to inmates. Available foods are consistent with what is sold at a convenience store, and snacks are likely to have high sugar and fat content.[27] Monitoring canteen purchases is difficult as food choices are based on availability and demand. The ADA recommends promoting healthy canteen items and listing the nutrient content of each item.[27]

With a little creativity, nutrition therapy can be effective for managing diabetes in correctional facilities. The amount of daily calories served can be reduced to a gender-appropriate amount that will support weight maintenance and decrease the amount of weight gain experienced by inmates while incarcerated.[29] By reducing the number of calories offered, the food budget can afford to add healthier items to the master menu. Labeling canteen items could also promote healthy food choices. A prison diet with sufficient fruits, vegetables, and whole grains may improve health, decrease diabetes and diabetes-related morbidities, and reduce medical costs.

Coffee Creek Correctional Facility

The state of Oregon is not exempt from the rise in obesity and incarceration. Nearly 6 percent of Oregon residents were involved in the criminal justice system during 2013.* All adult inmates sentenced to serve time with Oregon Department of Corrections undergo intake and assessment at Coffee Creek Intake Center located within Coffee Creek Correctional Facility (CCCF). The intake and assessment process takes an average of three to four weeks, and during this time inmates undergo assessments to determine medical, mental health, substance abuse, security, education, and cognitive needs of the inmate.[30] A case plan is structured for each inmate and includes individual custody and classification assignment. Male inmates are then transferred to a long-term facility and female inmates remain at CCCF. A woman is either assigned to a medium or minimum facility based on health needs, sentencing guidelines, and security level. The severity of the crime and length of sentence impact the initial security level of an inmate. Some inmates have the opportunity to reduce their security level through good behavior and completion of select courses in order to be eligible to transition to the minimum facility. Higher security and longer sentences tend to require inmates to reside in medium facility longer than inmates with shorter sentences. However, facility assignment is not static and movement between facilities is relatively common for disciplinary action or court hearings.

*The proportion reported is a 2013 estimate of the number of people booked in county jail in Oregon (181,333)[59] and involved in Oregon Department of Corrections (46,267)[60] out of 3,919,020 Oregon

Female inmates at Coffee Creek Correctional Facility in Oregon

Female inmates are the fastest growing segment of the incarcerated population, and obesity is more prevalent among female inmates.[11,31] To address this increase, an intervention aimed at altering the nutrition environment at CCCF minimum facility was implemented. CCCF is the only female prison in the state of Oregon. During the Summer of 2013, an average of 3,000 calories were served each day at the medium facility.[32] Analysis of adherence to dietary reference intake recommendations revealed an excess of cholesterol, sugar, and sodium (163%, 346%,[†] and 343%, respectively).[32] The amount of magnesium, potassium, vitamin D, and Vitamin E were lower than recommended (62%, 76%, 4%, and 22%, respectively).[32] Furthermore, a sedentary female inmate who eats roughly 75% of the food offered each day will gain 1 pound every 8 days, equating to 47 pounds a year.[‡] The Oregon Department of Corrections food budget was $2.40 per inmate per day during 2012.[33] Creative solutions to improve the food environment at CCCF within tight budgetary constraints were goals of the Healthy Food Access Project.

Healthy Food Access Project

The Health Food Access Project (HFAP) was established in 2011 at the Coffee Creek Correctional Minimum Facility in Wilsonville, Oregon and supported by a three-year Kaiser Permanente Community Benefit grant. Female inmates had identified weight gain and unhealthy eating as priority health concerns. Through collaboration with the

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[†] Added sugar is determined from the USDA recommendation for a 2,000 calorie daily diet of 32 grams.

[‡] Weight gain is calculated from the USDA estimated calorie need of 1,800 calories a day for a sedentary female 31-50 years old.[61] Weight gain= (3,000x0.75) – 1,800= 450 extra calories a day (3,500/450)= 7.78 days to gain 1 pound or (365.25/7.78)= 46.95 pounds a year

Oregon Public Health Division, Oregon Department of Corrections, Mercy Corps Northwest, and Coffee Creek Gardens, the HFAP aimed to improve nutrition for female inmates and teach them food-related skills that they can share with their families when they return home. In the past three years, the food environment in the minimum facility has been improved by: 1) expansion of the prison garden, 2) improved diet, 3) education through menu labeling, classes and training opportunities. The goal of these efforts was to improve women's health and success while in prison and when they return home.

During the past three years, much progress has been made on the first three objectives of the project. First, the prison garden was expanded by 13,000 square feet and produced 5,000 pounds of produce each year. A gender-appropriate menu was implemented in the minimum facility cafeteria on August 1st 2012. On average, the daily menu was reduced by 800 calories (3,000 to 2,200) and fresh produce from the Coffee Creek Garden was added to the menu. Menu boards labeled the nutritional content of food served in the cafeteria, and nutrition and gardening classes were offered to support women in making healthy food choices. Learning to make healthy food choices would potentially reduce the amount of unhealthy food purchased by inmates from canteen each week.

Evaluation of the HFAP was the final objective of the project. Timely evaluation was crucial because HFAP served as a pilot for altering the food environment in other Oregon prisons. Evaluation methods focused on survey results and inmate feedback groups. A quasi-experimental study with a historic control group was conducted that included collecting surveys and recording waist and weight measurements among female inmates living in the minimum facility. The baseline survey was conducted in June 2012 and found 89% of female inmates in the minimum facility were overweight or obese and had gained an average of 17 pounds within their first two years at CCCF. Female inmates in the minimum facility were at a high risk for developing chronic disease. The results of the baseline study spurred interest in assessing the effects changes in the nutrition environment had on a subset of female inmates living with a chronic disease at CCCF. Improving chronic disease management could greatly impact quality of life and dependency on costly pharmaceuticals while incarcerated and once they return home.

Purpose of the study

This study aims to assess the effects changes in the food environment have had on female inmates living with diabetes. To address the question, does a healthier menu improve diet and diabetes management? A quasi-experimental study was conducted. To evaluate the impact of the HFAP, medical record abstractions were conducted and canteen receipts were collected for all female inmates with diabetes at CCCF.

The goal of the study was to evaluate the effectiveness of HFAP on diabetes management by:

a) Describing the changes in glycemic control and other biometric measures.

b) Measuring the impact HFAP had on canteen purchases.

We hypothesized that a significant reduction in the slope of Hba1c will be detected among female inmates with diabetes exposed to HFAP compared to unexposed female inmates with diabetes. Female inmates with diabetes that are exposed to HFAP will purchase less calories and unhealthy food items from canteen after implementation of the reduced calorie menu.

METHODS

Study population

The study includes all female inmates residing in CCCF with a diagnosis of diabetes by a CCCF medical provider prior to August 28th 2013 (n=63). A diabetes diagnosis was indicated on the face sheet of each medical chart. The date of diabetes diagnosis for female inmates diagnosed prior to incarceration was recorded in her medical history, and the date of diabetes diagnosis for female inmates diagnosed during incarceration was recorded on her face sheet.

Exposure to the Healthy Food Access Project

Exposure to the intervention in the minimum facility was determined by the cumulative amount of time a female inmate with diabetes had been exposed to the reduced calorie menu. Housing assignment for each participant was considered, and the number of days each participant had resided in the minimum facility after August 1st 2012 (the reduced calorie menu was implemented) was determined. The cutoff for exposure to the intervention was set at 90 cumulative days of exposure. The 90-day cutoff was used because 90-days is a common metric to measure sustained dietary behavior change.[34] Emphasis was placed on the amount of cumulative exposure since movement between facilities is relatively common.

Medical chart data

Medical chart abstractions were conducted during August-October 2013 for each of the inmates enrolled in the study. Abstractions were conducted by hand from paper medical records inside CCCF medical facility. Protected health information was obtained from face sheets, chronic disease visits, and laboratory results in each medical record. From the face sheet and intake physical we obtained: date of birth, age, intake date at CCCF, race, length of sentence (months), height, weight, systolic BP, diastolic BP, Hba1c, total cholesterol, HDL cholesterol, LDL cholesterol, and if diet restrictions were ordered. At subsequent medical appointments we recorded: date of medical visit, weight, height, diabetes medication (oral/injection), assessment/plan (e.g. exercise, weight loss, lower daily caloric or carbohydrate intake), systolic BP, diastolic BP, Hba1c, total cholesterol, HDL cholesterol, and LDL cholesterol. Which facility the inmate resided in at each medical visit and blood draw was recorded (Appendix A).

The number of measures collected for each inmate was dependent on the frequency of medical visits. Ideally, at least one medical visit with lab measurements prior to August 1st 2012 (before reduced calorie menu was implemented in minimum) and one medical visit during exposure to the reduced calorie menu would be recorded. All medical visits (i.e. chronic disease visits and blood collection/lab measurements) were recorded for the 24-month collection period beginning 12 months prior to the reduced calorie menu through at least 12 months of exposure to the reduced calorie menu in the minimum facility (August 28th 2011-August 28th 2013). Conceivably, women with diabetes could attend diabetes-related medical visits quarterly, and eight series of measurements could be collected.

Canteen receipts

Canteen receipts were obtained from CCCF medical staff. Receipts were printed for inmate purchases during the months of June 2012 and June 2013. Canteen receipts were de-identified.

Weekly canteen receipts recorded the name, size, price, and quantity purchased of each item. Canteen receipts were entered by the quantity of each item an inmate purchased during the months of June 2012 and June 2013. This information was used to determine the caloric and nutritional content of each item purchased. The caloric value of each purchased item was used to calculate the average amount of calories purchased each day from canteen.

Several assumptions were made about the ingredients and serving size of canteen foods in order to assess the nutritional quality of the food. Nutrition information for non-perishable foods was recorded for a serving size as designated on the food item packaging. For perishable items, the serving size was determined to be the whole food item since such foods must be consumed in one sitting (e.g. a pint of ice cream). The caloric and nutrition information was determined from online nutrition resources and visiting Oregon Department of Corrections canteen distribution center in Salem, Oregon. Assumptions on serving sizes were made for unlabeled multi-serving packages. A serving of nuts or seeds from a multi-serving package was 1 ounce. A "CCCF bakery item" included all baked goods made at the facility and sold on canteen. For the purpose of this analysis, the nutritional content of a hoagie roll was used as a proxy for a CCCF bakery item. A "soda coupon" assumed inmates consumed regular sugar soda. These assumptions provided reasonable estimates in order to describe the quality of canteen food purchased by female inmates with diabetes.

The nutrient information was assessed using the Smart Snacks in Schools rubric. These standards were adapted from the nutrition recommendations put forth by the Institute of Medicine for competitive foods sold in schools.[1] Smart Snack standards require each item to meet the following standards:

-The package sold is 1 snack serving with ≤200 calories or 1 entrée serving with ≤350 calories

-≤35% of total calories from fat

- <10% of total calories from saturated fat

-Zero trans fat

-≤35% of total calories from sugar

-≤200 mg of sodium for snack items and ≤ 480 mg for entrée items

Foods that are exempt from the total fat and saturated fat standards are reduced fat cheese, nuts and seeds, products consisting of only dried fruit with nuts or seeds and no additive sweeteners or fats, and seafood with no added fat. Sugar exemptions include dried fruits and vegetables with no or minimal added sweeteners that are required for processing or palatability (e.g. cranberries or tart cherries), and products consisting of only dried fruit and nuts/seeds with no added sweetener.

Canteen foods were scored as having met each of the six Smart Snack standards. Less healthy food options were canteen foods that met no more than four of the six Smart Snack standards. Healthier food items met at least five of the six Smart Snack standards.

The Smart Snack standards were intended for items sold in single-serving packages, though most canteen food items were sold in multi-serving packages. The nutrition standards were adapted and applied to a serving size of food as designated on the package. In the instance when a food item must be consumed during one sitting (e.g. a pint of ice cream) then the nutritional content was applied to the whole item.

Data management

A list of study participants was generated by CCCF Chief Medical Officer, Dr. Elizabeth Sazie. The list contained the name and SID number of each inmate. A study ID linkage key was created on-site at CCCF and was held in locked storage at CCCF medical. Each inmate enrolled in the study was issued a unique study ID and all abstracted data was coded with her study ID.

Paper copies of abstracted data and canteen receipts were recorded by participant study ID and transported from CCCF to Oregon Public Health Division (OPHD) in a locked bag that was carried by the abstractor. Only de-identified data left CCCF. At OPHD the paper copies were filed in a locked file drawer within a locked, limited-access office at Program Design & Evaluation Services.

Data was entered into Access by participant study ID. Data quality was assessed prior to exporting data into SAS for analysis. For each participant, measurements were recorded by date and facility residence at the time of medical visit or blood draw. The quantity and calorie content of each item purchased from canteen was reported for June 2012 and June 2013.

Approval to conduct medical chart abstractions and collect canteen receipts for female inmates with diabetes was obtained from the Oregon Department of Corrections Research Committee, Oregon Public Health Division IRB, and Oregon Health & Science University IRB.

Power analysis

An a priori time-averaged difference power analysis was conducted.[35] To achieve 80% power at the 0.10 level of significance among an average of 30 participants in each group, a average difference of 1.15 Hba1c units between groups would need to be detected. This calculation assumed the standard deviation of Hba1c does not exceed 2.0

at each measure and each participant had an average of 3 repeated measures and a strong within-subject correlation (0.70).

Variable dictionary

See Appendix A

Statistical Analysis

Missing data

Participants without a Hba1c or lipid measure at intake or during the medical record abstraction period (8/28/11–8/28/13) were excluded from Hba1c or lipid analysis.

Invalid LDL measures

LDL-cholesterol values were indirectly estimated using the Friedewald formula (FF). Limitations of the FF include underestimating LDL cholesterol when triglycerides become too high.[36,37] To estimate LDL for the invalid measures, the modified Friedewald Formula indirectly estimated LDL cholesterol by adjusting the correlated parameters of non-HDL cholesterol and triglycerides.[36] To compute an LDL-estimate, total-cholesterol and HDL-cholesterol values from the blood draw were used and triglycerides were assumed to be 400 mg/dL. This provided a conservative estimate of LDL compared to LDL measured directly with the N-geneous assay.

Descriptive statistics

Socio-demographic characteristics and biometric measures were compared between female inmates with diabetes exposed and unexposed to the Healthy Food Access Project with Fisher's exact test and T-tests. Canteen receipts were described by the amount of calories purchased for all participants that purchased food from canteen during the months of June 2012 and June 2013. The nutrient content of canteen food was described by Smart Snack standards.

Plots

To highlight change in biometric measures over time, measures from intake are justified to the beginning of the medical abstraction period, August 28th 2011. The majority of intake measures was collected prior to the medical abstraction period and was reflective of the inmate at a time near admission into the institution. We plotted biometric data in spaghetti plots to visualize the change in biometric measures over time for each women and stratified graphs by exposure status. Non-parametric curves were fit to assess the nature of the trends in biometric data.

Canteen items were plotted by frequency of the item purchased during each year by exposure group. The distribution of canteen purchases by the number of Smart Snack Standards met was plotted by year and exposure status.

Models

Linear mixed effect models were fit to the data to describe changes in Hba1c, BMI, and lipids over time by exposure group.[38] Time was centered on August 1st 2012 (the day the reduced calorie menu was implemented in the minimum facility). The primary hypothesis was to determine if biometric trends are different between exposure groups. Baseline differences between female inmates with diabetes exposed and unexposed to HFAP were considered as potential confounding factors when modeling biometric changes. All statistical analyses were conducted using SAS version 9.3.

Results

Exposure

Sixty-three female inmates with diabetes resided at CCCF on August 28th 2013. When the sample was pulled, 27 participants resided in the minimum facility and 36 in the medium facility. Twenty-four participants were sufficiently exposed to HFAP as determined by residing in the minimum facility for at least 90 days after the new menu was implemented. Among the 24 exposed participants, the average length of exposure was 257±95 days. The amount of exposure ranged from 104 days to 392. Six participants were exposed to HFAP for the entirety of the monitoring period (392 days of exposure). The remaining 39 participants were determined to be unexposed. Seven of the unexposed participants had resided in the minimum facility during the preceding 12 months but had fallen short of the 90-day cutoff (mean: 53.6±21.16 days).

Participant characteristics

Among the 63 female inmates with diabetes residing at CCCF, two exposed and seven unexposed women did not meet with a health care provider for a diabetes chronic disease visit during the medical abstraction period. Their biometric data was obtained from lab results and other visits during the abstraction period.

The average female inmate with diabetes was 46 years old, non-Hispanic white, and diagnosed with diabetes prior to admittance into CCCF. The female inmates with diabetes exposed to HFAP were more likely than those unexposed to have: a lower BMI

(31 vs. 35; p-value: 0.04), a shorter prison sentence (30 months vs. 124 months; p-value: <0.01), and served less time at CCCF (12 months vs. 46 months; p-value: 0.03) (Table 1).

Female inmates with diabetes exposed to HFAP had resided in prison for less time and were serving shorter sentences when compared to unexposed women. The median sentence was drastically shorter for exposed women compared to unexposed women. Half of the exposed women were serving sentences between 16 and 48 months compared to half of the unexposed women were serving sentences between 28 and 261 months. The median amount of time an exposed women with diabetes had resided in CCCF was nearly ¼ of the median amount of time an unexposed women with diabetes had spent in CCCF (Table 1). For six unexposed female inmates serving life sentences, the length of sentence was calculated as the difference between the average lifespan for a woman in Oregon (82 years) and their age at intake into CCCF.

Baseline biometric measures varied little between exposure groups. The average Hba1c at intake was similar between exposed and unexposed women (7.32 vs. 7.08). Baseline lipids were similar between groups, and the average total cholesterol for both groups was within the desirable range (≤200 mg/dL). LDL cholesterol was near ideal with an average of 110.2±46.36 mg/dL among exposed women and 113.3±33.54 mg/dL among unexposed women. The average HDL measures were poor, 43.55±9.59 mg/dL among exposed and 40.6±8.76 mg/dL among unexposed women.

Table 1: Baseline characteristics among female inmates with diabetes at Coffee Creek Correctional Facility by exposure status

	Total (n=63)	Exposed (n=24)	Unexposed (n=39)	
		Mean±STD or n(%)		p-value
Age (yrs)	45.87±11.63	46.29±10.72	45.62±12.29	0.73
Race:				
White, non-Hispanic	47(75)	19(79)	28(72)	0.57
Black, non-Hispanic	5(8)	1(4)	4(10)	0.64
Hispanic	6(10)	3(13)	3(8)	0.67
American Indian/Native Alaskan	3(5)	0	3(8)	0.28
Asian	2(3)	1(4)	1(3)	1.00
		Median(25%–75%)		
Length of sentence (months)	49.10(23.70–180.53)	29.58(16.33–47.70)	124.23(28.10–260.80)[1]	<0.01
Time served (months)	23.10(9.60–71.40)	12.15(9.34–33.59)	45.93(10.3–107.13)	0.03
		Mean±STD or n(%)		
Diabetes diagnosis after intake[2]	17(35)	2(15)	15(42)	0.11
Obese	42(67)	15(63)	27(69)	0.30
Body Mass Index	33.3±6.75	31.33±4.26	34.51±7.71	0.04
Hba1c (%)[3]	7.16±1.69	7.32±1.77	7.08±1.67	0.52
Total cholesterol (mg/dL)[4]	186.27±54.58	181.1±51.73	195.6±45.87	0.12
LDL (mg/dL)[5]	103.32±42.00	110.2±46.36	113.3±33.54	0.39
HDL (mg/dL)[6]	41.65±9.09	43.55±9.59	40.6±8.76	0.20
Systolic blood pressure (mmHg)	126.41±18.87	129.2±25.66	124.7±13.22	0.48
Diastolic blood pressure (mmHg)	80.60±10.52	81.67±11.52	79.95±9.95	0.68

[1]For 6 unexposed women serving life sentences, their sentence was calculated as the difference between the average life expectancy for a women in Oregon (82 years) and their age at intake into Coffee Creek Correctional Facility
[2]Missing diabetes diagnosis determination for 14 participants
[3]Missing baseline Hba1c for 4 exposed women (n=20)
[4]Missing baseline total cholesterol for 4 exposed and 8 unexposed women (n=20 & n=31, respectively)
[5]Missing baseline LDL for 3 exposed and 1 unexposed women (n=21 & n=38, respectively)
[6]Missing baseline HDL for 3 exposed women and 1 unexposed women (n=21 & n=38, respectively)
*Wilcoxon Rank Sum or Fisher's exact test

Hba1c

Among 63 female inmates with diabetes, two exposed women did not have a Hba1c measure recorded at intake or during the medical record abstraction period. The mean number of Hba1c measures among 61 participants was 3.67±2.01 with a minimum of one and a maximum of nine measures. Measures include Hba1c blood draws at intake and during the 24-month abstraction period.

Among the 22 exposed women with at least one Hba1c measure: 18 had at least one Hba1c measure prior to implementing the reduced calorie menu and one after, three women only had measures prior to the reduced calorie menu, and one woman only had measures after the reduced calorie menu was implemented. For the 18 exposed women with a Hba1c both before and after the implementation of the reduced calorie menu, the median Hba1c reduced slightly after the reduced calorie menu was implemented (6.60 vs. 6.65) (Figure 1). The amount of change varied from a 2.85 point reduction to a 1.4 point increase in Hba1c. Plotting individual Hba1c trends supported an average decrease in Hba1c over time (Figure 2).

For unexposed women, 33 had at least one Hba1c reported prior to and after August 1st 2012. The six women without at least one measurement during both time frames had either been admitted to the prison during 2013 (n=4) or did not have a Hba1c test reported after August 1st 2012 (n=2). The median Hba1c after August 1st 2012 was an insignificant 0.05 points higher than Hba1c before August 1st 2012 (Figure 1). When individual Hba1c trends were plotted, a linear trend suggested a slight increase in Hba1c over time (Figure 2).

Figure 1: Distribution of Hba1c before and after implementation of the reduced calorie menu by exposure group

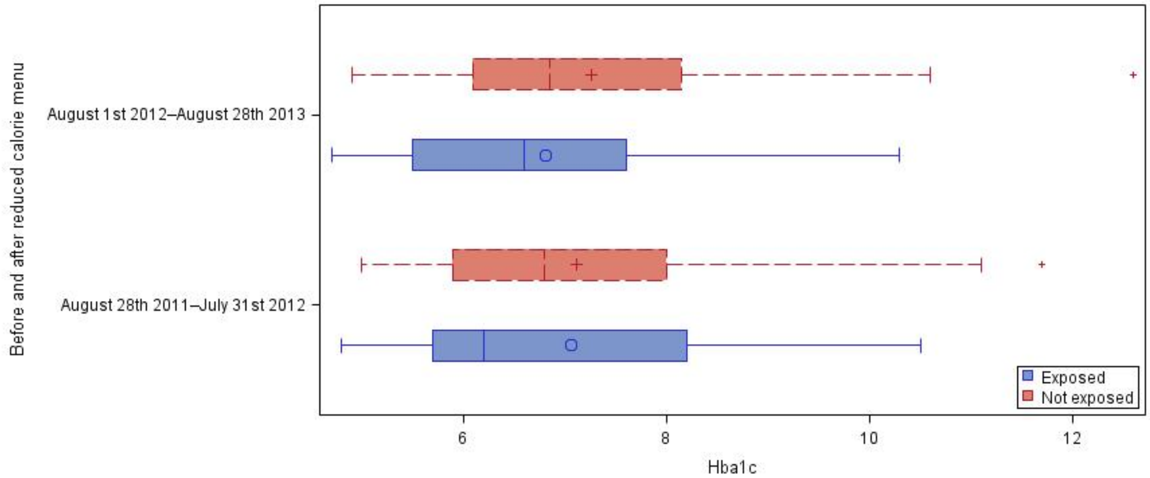
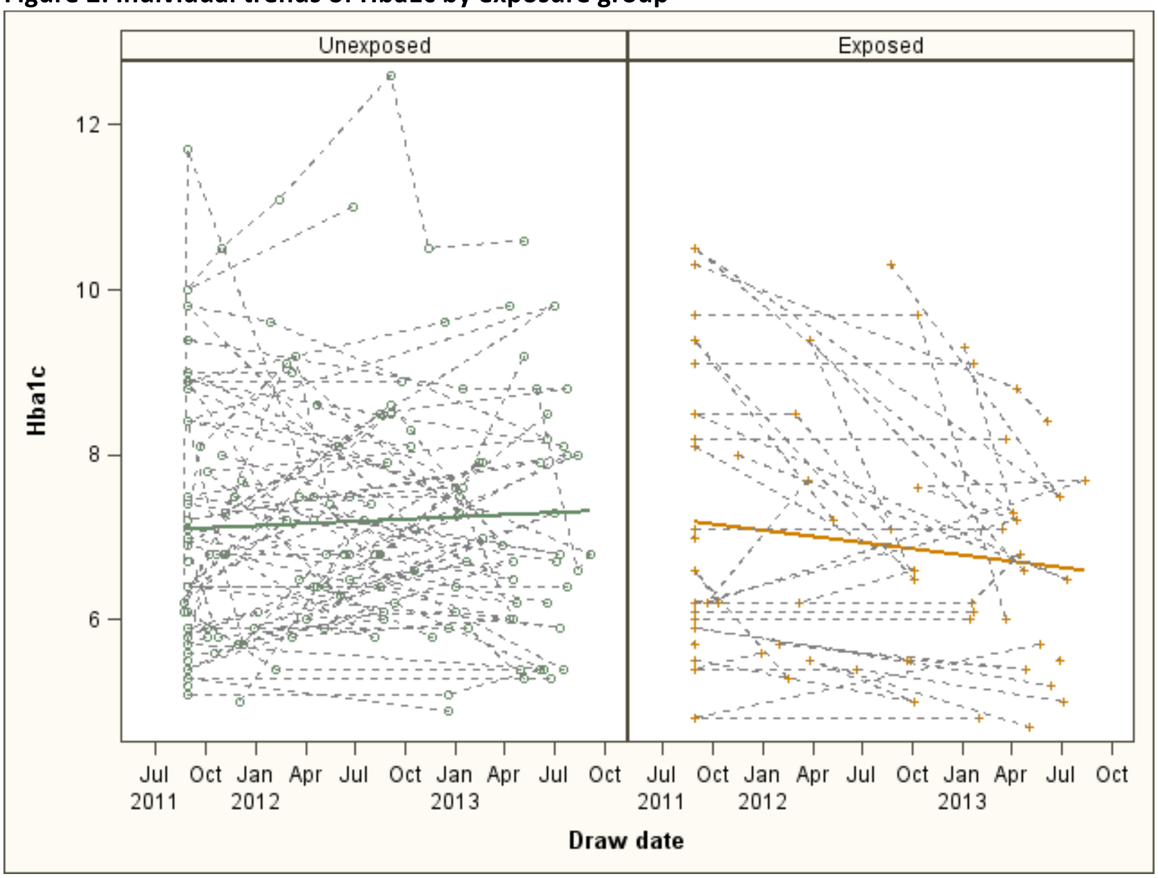


Figure 2: Individual trends of Hba1c by exposure group



Mixed effects model

In order to assess changes in Hba1c trends between exposure groups as a linear function of time, the data was fit with a linear mixed effects model. The heterogeneity between individual Hba1c trends supported using a mixed effects model. Random effect parameters were added to the model and nested models were compared using log likelihood and the X^2 distribution at the 0.10 level of significance. The inclusion of a random linear slope in the model did not improve the fit of the data when compared to the random intercept model (deviance 2.0 < X^2_{1df} 2.71).

A random intercept model was fit to assess the difference in Hba1c trends between female inmates with diabetes by exposure to HFAP (Table 2). The results of the model indicate that there was a significant difference in Hba1c trends between exposed and unexposed groups at the 0.05 level of significance (X^2:4.22 p-value: 0.04). For every month a female inmate with diabetes was exposed to the reduced calorie menu, Hba1c decreased by 0.03 units compared to changes in Hba1c among unexposed female inmates with diabetes.

Table 2. Mixed effect model of changes in Hba1c by exposure to Healthy Food Access Project among female inmates with diabetes

Predictor	**Coef. β**	**SE(β)**	**T***	**p**	**Coef. β**	**SE(β)**	**T***	**p**
Intercept	6.91	0.22	31.77	<0.01	7.62	0.31	24.50	<0.01
Exposed	-0.13	0.36	-0.34	0.73	-0.18	0.34	-0.52	0.60
Time (months)	-0.01	0.01	-0.59	0.56	-0.01	0.01	-0.59	0.55
Time(months)*Exposed	-0.03	0.02	-2.05	0.04	-0.04	0.02	-2.15	0.03
Obese at baseline					-1.04	0.35	-3.00	<0.01
≤ 12 months time served								

Predictor	**Coef. β**	**SE(β)**	**T***	**p**
Intercept	7.50	0.38	22.92	<0.01
Exposed	-0.28	0.35	-0.81	0.42
Time (months)	-0.01	0.01	-0.59	0.56
Time(months)*Exposed	-0.04	0.02	-2.18	0.03
Obese at baseline	-1.12	0.35	-3.19	<0.01
≤ 12 months time served	0.39	0.34	1.15	0.25

*T-value computed

Potential confounding factors were added to the model. Both the amount of time served and BMI at intake were significantly different between exposure groups and warranted consideration in the model (Table 1). BMI at intake was assessed as a dichotomous variable (obese vs. non-obese). When obese at intake was added to the model, the fit of the data significantly improved (deviance 8.1). Though, the estimate for the difference in Hba1c trends was only altered by 6% (-0.033 vs. -0.035), which suggested that obese at intake did not confound the relationship between exposure and changes in Hba1c. When time served was included in the model as a dichotomous variable (≤ 12 months in the prison vs. > 12 months in the prison), the estimate for the difference in Hba1c trends did not change (Table 2).

Neither potential confounding factor appeared to significantly influence the relationship between exposure to the reduced calorie menu and changes in Hba1c. Thus, Hba1c was modeled with exposure to the reduced calorie menu, time centered at implementation of the reduced calorie menu, and the interaction between the two measures. The fit of the preliminary model was assessed from residual plots and influential statistics. Residuals appeared normally distributed. Two participants had outlying observations with a Mahalanobis distance p-value <0.025 (Appendix C). The potential outliers were excluded from the model, and the fit of the data drastically improved (AIC 652.7 vs. 715.1). The estimate for exposure decreased by 31% (-0.13 vs. -0.16) and difference in trends of Hba1c between exposed and unexposed women increased by 10% (-0.033 vs. -0.030). The difference in trends remained marginally significant at the 0.05 level of significance when outliers were excluded (X^2 3.90 p-value 0.05).

Post hoc analysis

With a modest difference in the trends of Hba1c between exposure groups, there was concern that the observed difference was due to chance or bias from an unmeasured confounding factor. Differential diabetes medication use between exposed and unexposed participants was considered.[39] Most participants were prescribed oral diabetes medication (68% among exposed and 75% among unexposed). Individual trends of Hba1c were plotted by oral diabetes medication use and exposure to HFAP.

The effect of oral medication use on Hba1c trends was minimal (Appendix F, Figure 1). Among women who were seen for a chronic disease visit, 15 exposed women (15/22; 68%) were prescribed oral diabetes medication compared to 24 unexposed women (24/32; 75%). A third of exposed women (5/22; 32%) were not prescribed oral medication for diabetes compared to a quarter of unexposed women (8/32; 25%). Little difference in Hba1c trends was detected between medicated and non-medicated female inmates (Appendix F, Figure 1). Oral medication use was not considered in the model because medical chart abstractions were not able to record the duration a female inmate had been medicated, medication compliance, or insulin use.

Body Mass Index

The mean number of BMI measures among 63 participants was 3.62±1.62 with a minimum of two and a maximum of seven measures. For exposed female inmates with diabetes, the median BMI insignificantly increased after the reduced calorie menu was implemented (33.10 after August 1st 2012 vs. 31.80 before August 1st 2012; p-value: 0.40) (Figure 3 & 4). Female inmates with diabetes not exposed to the reduced calorie menu saw little change in their median BMI (32.0 after August 1st 2012 vs. 32.90 before August 1st 2012; p-value: 0.64) (Figure 3 & 4).

Figure 3: Individual trends of BMI by exposure group

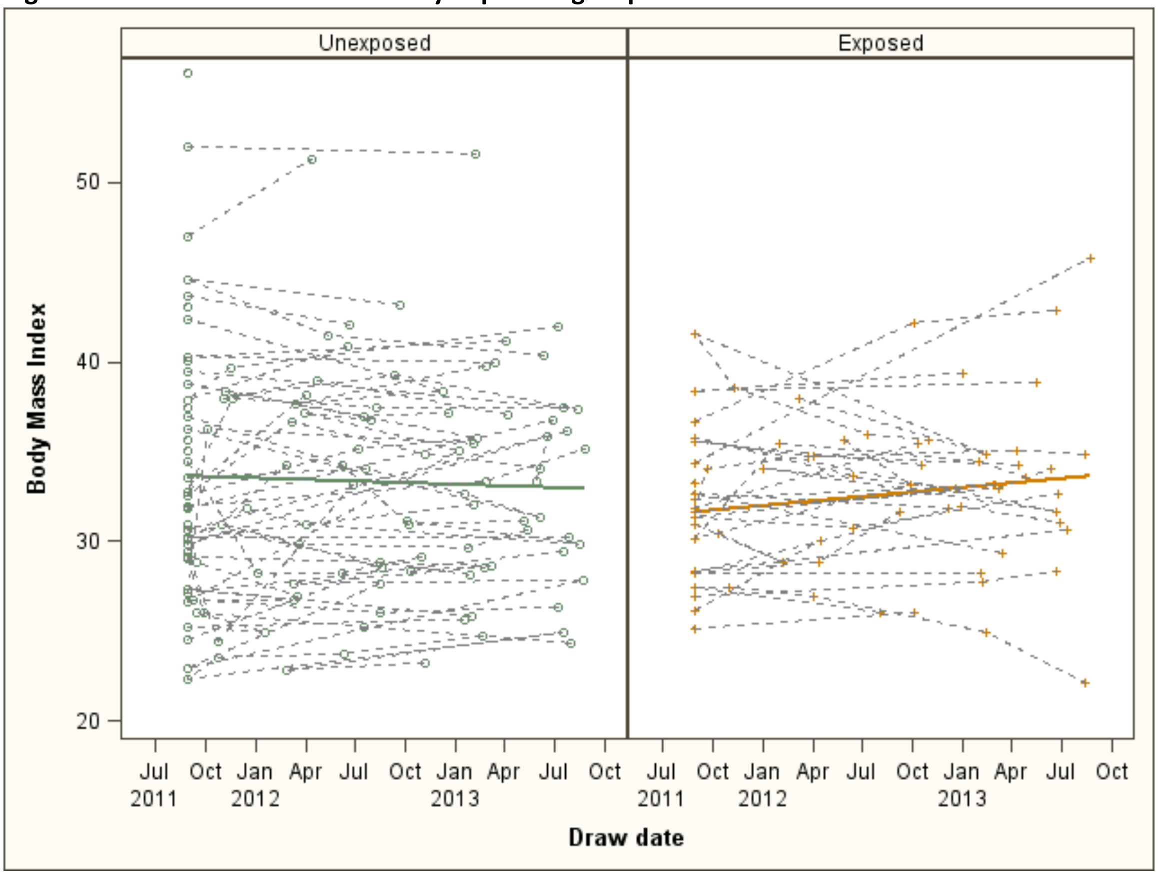
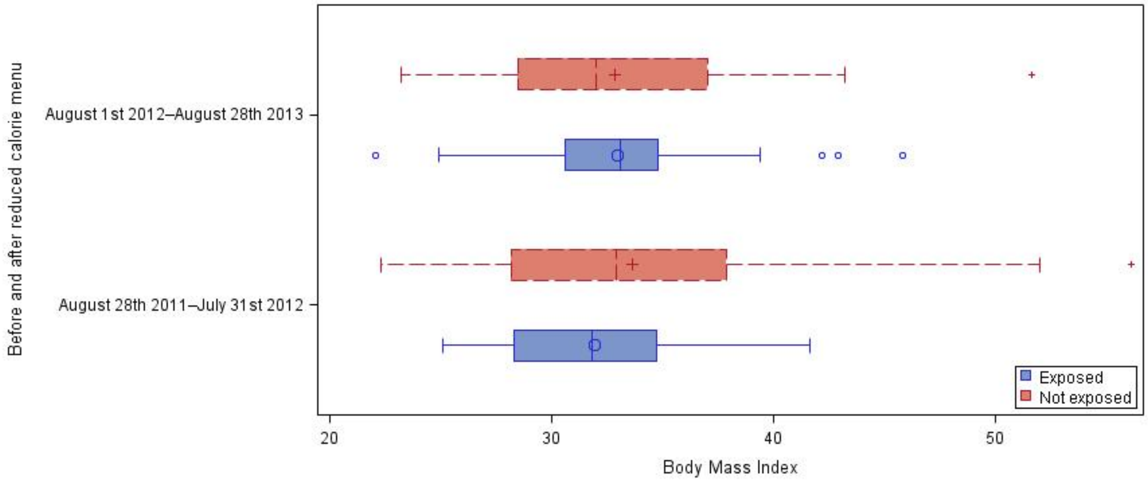


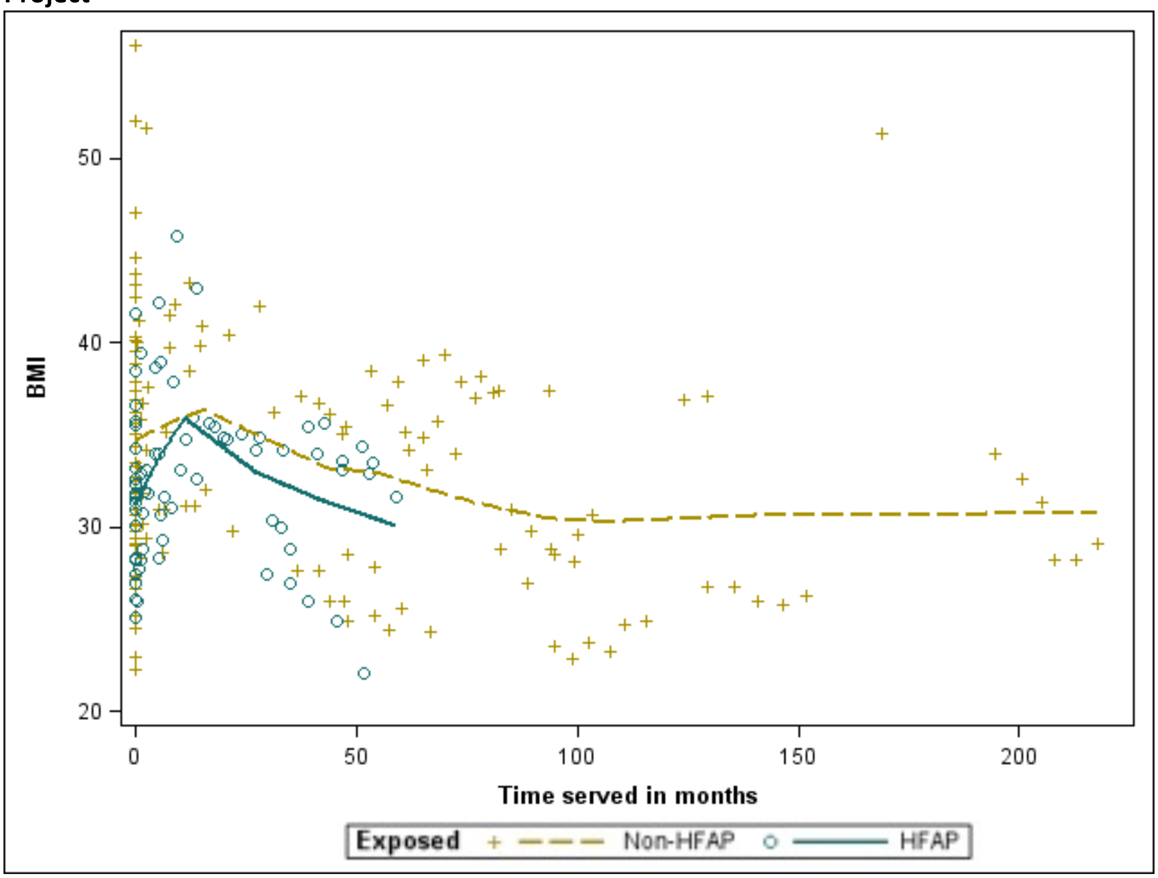
Figure 4: Distribution of BMI before and after implementation of the reduced calorie menu by exposure group



Potential confounding factors may explain why BMI increased among female inmates with diabetes exposed to the reduced calorie menu. The difference between exposure groups in the amount of time served and length of sentence were considered. On average, unexposed women had considerably longer sentences (117 months vs. 35 months) and had served more time at the prison than exposed women (63 months vs. 23 months). Furthermore, only 33% (8/24) of exposed women compared to 54%(21/39) of unexposed women were admitted to CCCF prior to the start of the medical abstraction period (August 28th 2011). This suggests that unexposed women had acclimated to the prison environment far before exposed women were even admitted.

From plotting BMI by the amount of time served, it appeared that during the first year or so, female inmates with diabetes gained the most weight (Figure 5). A linear spline random intercept model was fit to the data to describe the changes in BMI by the amount of time served. The trends in BMI were significantly different between exposure groups (F: 4.85 p-value: <0.01) (Appendix D). Furthermore, the slope of BMI when a woman had served more than a year was significantly different than the slope of BMI when a woman was within her first year at the prison (X^2: 16.02 p-value: <0.01). Thus, the results of the spline model supported adjusting for the amount of time served when modeling the changes in BMI by exposure group.

Figure 5: Loess plot of BMI by time served at the prison and exposure to Healthy Food Access Project



Mixed effects model

The difference in BMI trends between exposure groups was assessed with a linear mixed effects model. Adjusting for the amount of time served improved the fit of the model (AIC: 1099.6 vs. 1106.8) (Table 3), but the trends in BMI are not significantly different between exposure groups (X^2: 0.29 p-value:0.59). That is to say, over time, the changes in BMI are similar between exposed and unexposed women when the effects of the amount of time served have been adjusted for.

Table 3. Mixed effect model of changes in BMI by exposure to Healthy Food Access Project among female inmates with diabetes

Predictor	Coef. β	SE(β)	T*	p	Coef. β	SE(β)	T	p
Intercept	34.95	1.00	34.93	<0.01	34.98	1.00	34.94	<0.01
Exposed	-2.85	1.62	-1.76	0.08	-2.91	1.62	-1.80	0.07
Time (months)	0.03	0.03	1.06	0.29	0.03	0.02	1.76	0.08
Time(months)*Exposed	0.02	0.04	0.53	0.60				
≤ 12 months time served								
Predictor	**Coef. β**	**SE(β)**	**T**	**p**				
Intercept	33.33	1.24	26.82	<0.01				
Exposed	-3.80	1.63	-2.34	0.02				
Time (months)	0.03	0.02	1.73	0.09				
Time(months)*Exposed								
≤ 12 months time served	3.41	1.60	2.13	0.03				

*T value

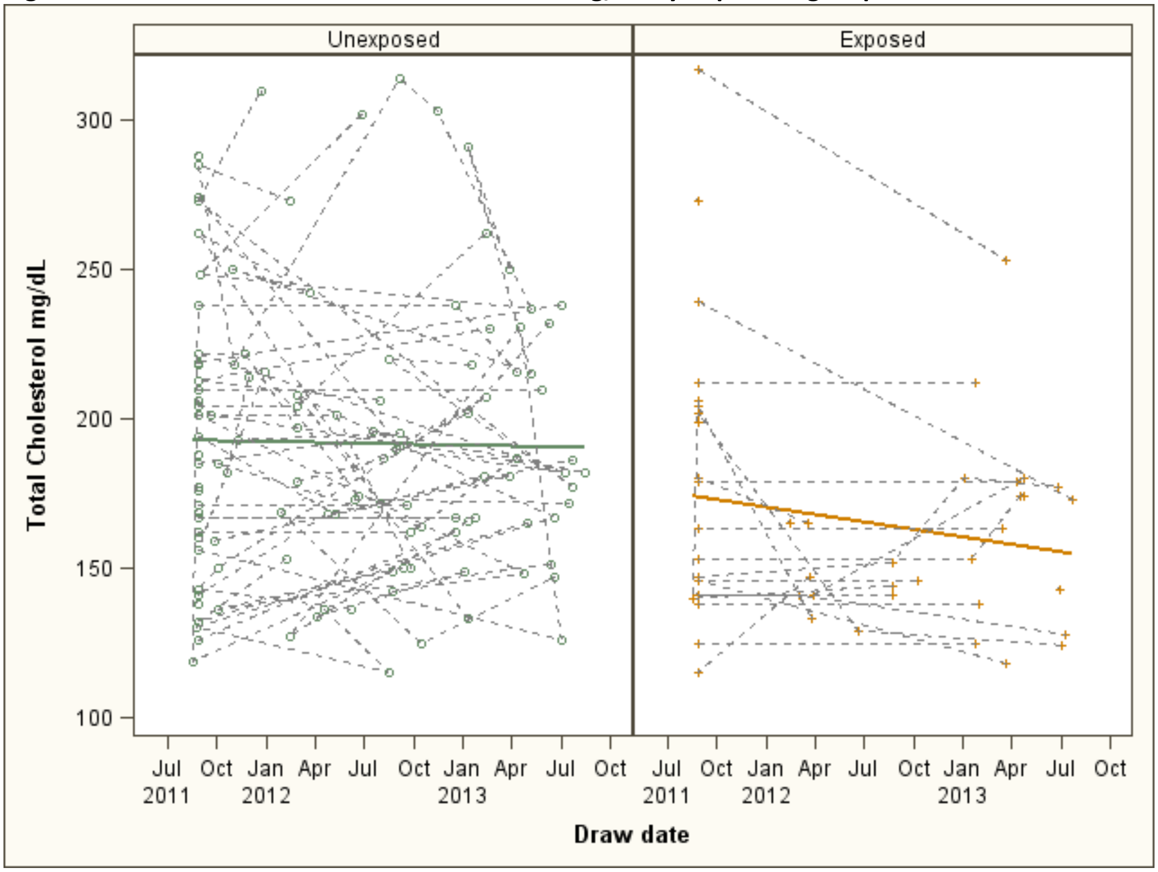
Despite similar BMI trends between groups, significant differences in baseline BMI and the amount of time served were observed between exposure groups. Women within their first year at the prison and exposed to the reduced calorie menu had an average BMI at intake of 33 compared to 37 among unexposed women within their first year. For women that had lived in the prison at least a year, exposed women had an average BMI of 30 compared to 33 among unexposed women that had resided in the prison at least a year. Overall, BMI was not static over time but marginally increased by 0.03 units each month when the amount of time served and exposure status were adjusted for (X^2: 2.99 p-value: 0.08).

The final model included the independent effects of exposure status, time, and time served. The fit of the model was assessed from residual plots and influential statistics. A discernable pattern was not detected in the residual plots. Outlier participants were detected if their predicted BMI value exceed 50 and their Mahalanobis distance had a p-value <0.025. When the five outlying participants were excluded from the model the exposure estimate decreased by 18% (-3.1 vs. -3.8)(Appendix D). Excluding the outliers from the final model improved the precision of the estimates but would diminish the sample size by 8%. The loss of information from excluding the participants may outweigh improving the precision of the estimates since the goal of the model was to describe the relationship between exposure to the reduced calorie menu and changes in BMI, not to necessarily build a parsimonious model. Thus, the final model included all 63 participants.

Total cholesterol

On average, female inmates with diabetes had 2.75±1.73 total cholesterol measures collected. The median total cholesterol was 176.5 mg/dL with an interquartile range of 148.5mg/dL to 210mg/dL. Exposed women had a median total cholesterol lower than unexposed women (153 mg/dL vs. 185 mg/dL, respectively). From plotting total cholesterol, the average total cholesterol appeared to decline over time for exposed women and time had no effect on the average total cholesterol among unexposed women (Figure 6). This may be due to the large variance in total cholesterol measures across time among unexposed women that may influence the population mean. The heterogeneity in measures over time suggested using a mixed effects model to describe differences in total cholesterol trends between exposure groups.

Figure 6: Individual trends of total cholesterol mg/dL by exposure group



Mixed effects model

A random intercept model was used to describe the difference in total cholesterol trends between exposure groups. Log total cholesterol was modeled because total cholesterol measures were not normally distributed (Appendix E). The trends of log total cholesterol were not significantly different between exposure groups (β 0.00 p-value: 0.20), and time appeared to have no effect on log total cholesterol (β 0.00 p-value:0.32). Though, the differences in log total cholesterol between exposure groups at baseline persisted over time (p-value:0.03) (Table 4). On average, exposed women had a baseline total cholesterol of 18.24 mg/dL less than unexposed women.

Table 4. Mixed effect model of changes in log(total cholesterol) over time by exposure to Healthy Food Access Project among female inmates with diabetes

Predictor	Coef. β	SE(β)	T*	p	Coef. β	SE(β)	T	p
Intercept	5.22	0.03	167.48	<0.01	5.23	0.05	114.54	<0.01
Exposed	-0.12	0.05	-2.34	0.02	-0.11	0.05	-2.14	0.03
Time (months)	0	0	0.26	0.79	0	0	-0.60	0.55
Time(months)*Exposed	0	0	-1.3	0.20				
Obese at baseline					-0.03	0.05	-0.60	0.55
≤ 12 months time served								

Predictor	Coef. β	SE(β)	T*	p
Intercept	5.20	0.04	137.02	<0.01
Exposed	-0.12	0.05	-2.21	0.03
Time (months)	0	0	-0.51	0.61
Time(months)*Exposed				
Obese at baseline				
≤ 12 months time served	0.03	0.05	0.61	0.54

*T value

To determine if the lack of association between change in total cholesterol and exposure were due to a confounding factor, obesity at intake and the amount of time served were considered in the model. When both covariates were added to the model, multicollinearity was detected between obesity and time served (Appendix E). The amount of time served remained in the model, and the exposure estimate changed by 9%. The difference in log total cholesterol between exposure groups at baseline still persisted over time when the amount of time served had been adjusted for (X^2 4.87 p-value: 0.03).

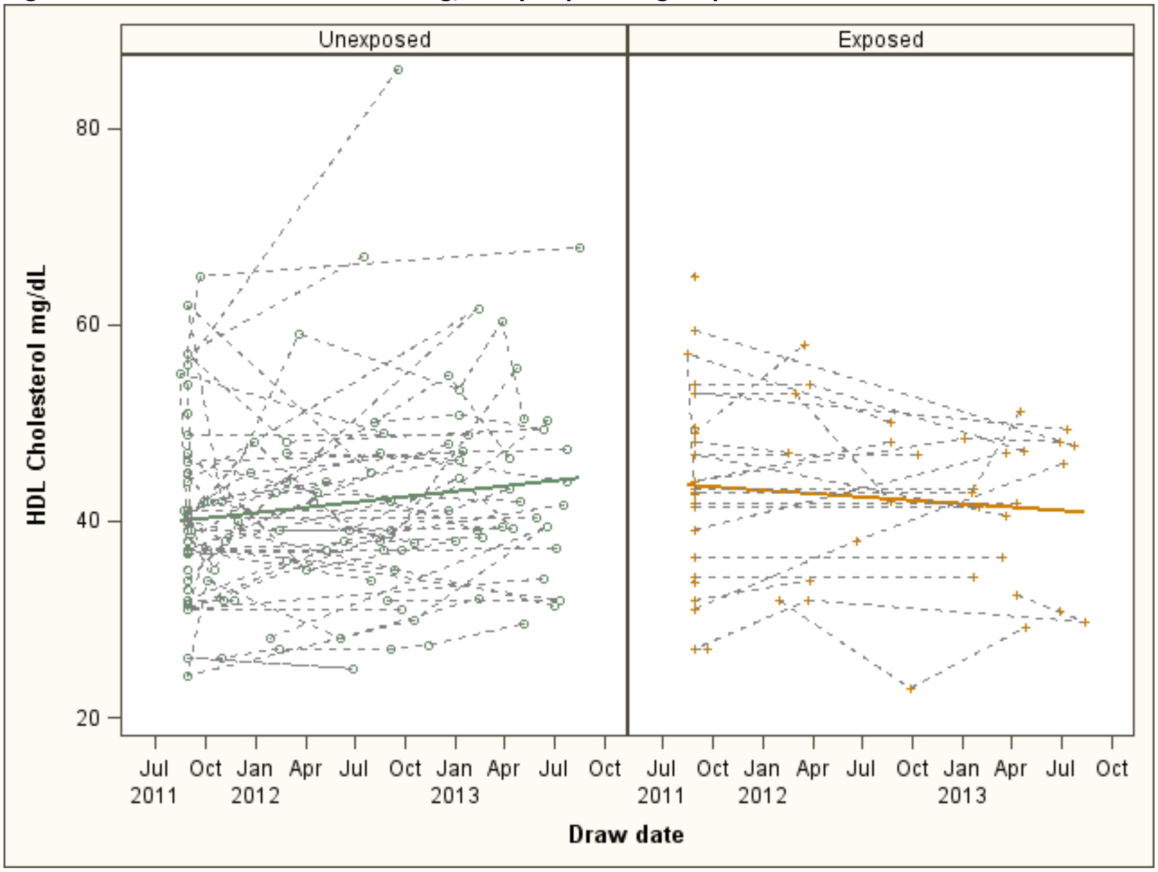
The total cholesterol model described baseline differences between groups. The model fit the data well as assessed from residual plots and influential statistics. One outlying participant was detected (Mahalanobis distance with a p-value <0.025). Excluding the outlier altered the exposure estimate by 17% (-0.14 vs. -0.12). Thus, the difference in total cholesterol between exposure groups at baseline increased to 23.65 mg/dL (X^2

7.32 p-value: <0.01) (Appendix E). The results of the model suggested that a difference exists in the average total cholesterol between women with diabetes residing in the medium and minimum facilities, but exposure to the reduced calorie menu had little impact on total cholesterol.

HDL cholesterol

The mean number of HDL cholesterol measures was 3.0±1.78 among 61 participants during the 24-month medical abstraction period and at intake. The median HDL cholesterol among all participants was 41 mg/dL with an interquartile range of 35 mg/dL to 47.6 mg/dL. The median HDL cholesterol did not significantly vary by exposure group (43 mg/dL among exposed vs. 40.mg/dL among unexposed; p-value: 0.23). However, HDL appeared to decrease over time for exposed women and increase over time for unexposed women (Figure 7). To assess differences in HDL trends between groups, a mixed effect model was fit to the data.

Figure 7: Individual trends of HDL mg/dL by exposure group



Mixed effects model

A random intercept model was fit to describe changes in HDL cholesterol over time between exposure groups. Changes in HDL cholesterol were modeled with a linear slope and random intercept (Table 5). The trends in HDL cholesterol were marginally different between exposure groups (X^2: 3.22 p-value: 0.07). On average, HDL decreased by 0.18 mg/dL per month among exposed women. The amount of time served did not impact the difference in HDL trends between groups. Over time, HDL cholesterol improved by 0.12 mg/dL per month for female inmates with diabetes when the effects of exposure and time served had been adjusted for (X^2 6.21 p-value: 0.01). Exposure to the reduced calorie menu had no effect on changes in HDL cholesterol, but female inmates with diabetes appeared to marginally improve their HDL cholesterol over time at the prison.

Table 5. Mixed effect model of changes in HDL cholesterol mg/dL over time by exposure to Healthy Food Access Project among female inmates with diabetes

Predictor	Coef. β	SE(β)	T*	p	Coef. β	SE(β)	T	p
Intercept	42.74	1.45	29.42	<0.01	44.31	2.18	20.37	<0.01
Exposed	0.29	2.38	0.12	0.90	0.85	2.36	0.36	0.72
Time (months)	0.18	0.06	3.10	<0.01	0.12	0.05	2.45	0.02
Time(months)*Exposed	-0.18	0.10	-1.79	0.08				
Obese at baseline					-2.72	2.42	-1.21	0.26
≤ 12 months time served								

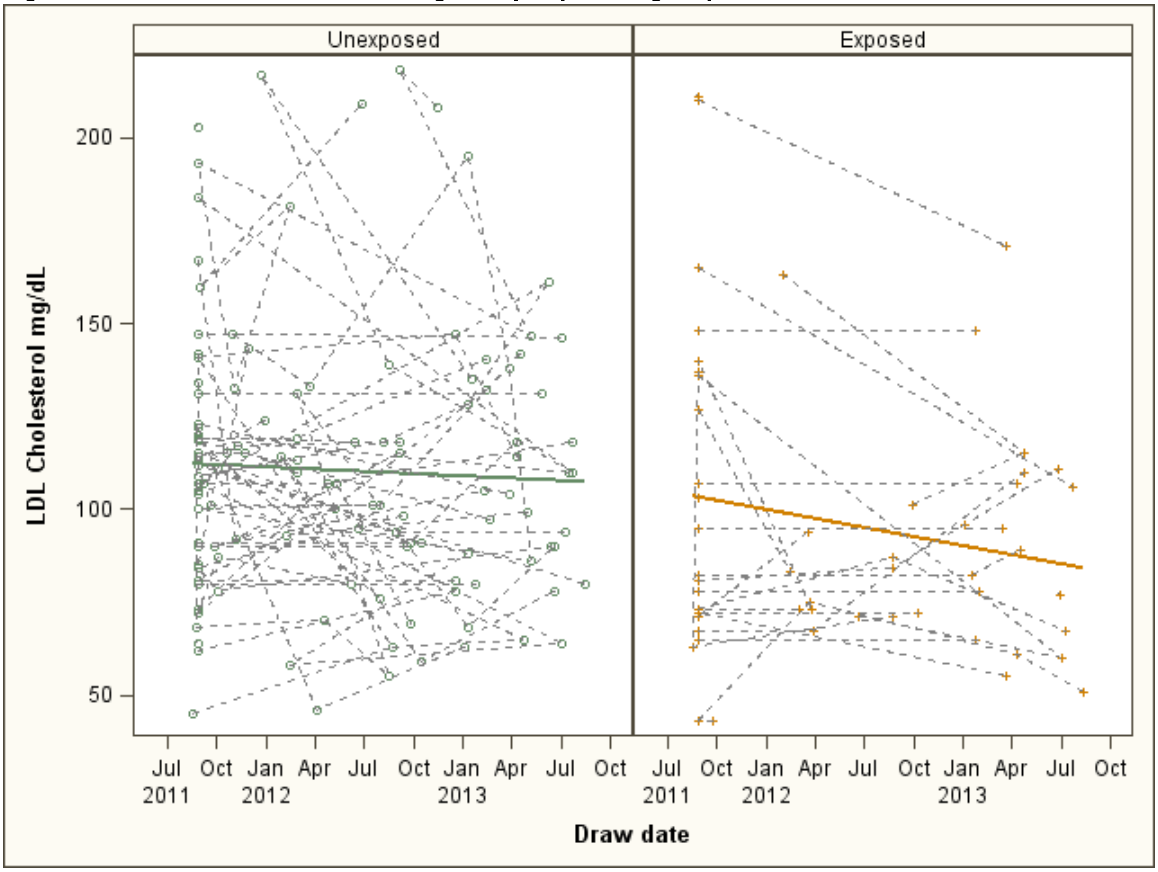
Predictor	Coef. β	SE(β)	T*	p
Intercept	43.24	1.81	23.87	<0.01
Exposed	1.37	2.48	0.55	0.58
Time (months)	0.12	0.05	2.49	0.01
Time(months)*Exposed				
Obese at baseline				
≤ 12 months time served	-1.69	2.41	-0.70	0.49

*T value

LDL cholesterol

An average of 3.0±1.78 LDL cholesterol measures were reported among 61 participants. Twelve LDL measures among 5 participants had invalid results because their triglycerides had exceeded 400 mg/dL. The invalid LDL measures were estimated using the modified Friedewald Formula. The median LDL cholesterol for all participants was 101 mg/dL with an interquartile range of 78 mg/dL to 123 mg/dL. The variance in LDL cholesterol was quite wide (43 mg/dL–218.3 mg/dL). The median LDL cholesterol was significantly lower among exposed women compared to unexposed women (83 mg/dL among exposed vs. 107 mg/dL among unexposed; p-value <0.01). The average LDL cholesterol appeared to decrease over time for both groups, but the magnitude of the slope was larger among exposed women (Figure 8). The variance in LDL measures was different between exposure groups and suggested that LDL cholesterol was not normally distributed (Appendix E). Log transformed LDL was used to model the differences in LDL trends between exposure groups.

Figure 8: Individual trends of LDL mg/dL by exposure group



Mixed effects model

A random intercept model was fit to describe changes in log LDL over time and between exposure groups. There was not a significant difference in the log LDL trends between exposure groups in the unadjusted model (X^2 0.51 p-value:0.47). On average, LDL levels decreased at a similar rate between exposed and unexposed participants. The independent effects of exposure and time were adjusted for baseline obesity and time served. Though adjusting for the amount of time served changed the exposure estimate for log LDL by 10%, the estimate was not significantly different than zero (X^2: 2.03 p-value 0.16). Baseline obesity did not confound the relationship between exposure to the reduced calorie menu and changes in log LDL because the exposure estimate altered by 0.1% when obesity was added to the model (Table 6). Such heterogeneity of LDL cholesterol in the unexposed group made it difficult to detect differences between groups. Thus we concluded, exposure to the reduced calorie menu had no impact on LDL cholesterol over time when adjusted for the amount of time served and baseline obesity.

Table 6. Mixed effect model of changes in LDL cholesterol mg/dL over time by exposure to Healthy Food Access Project among female inmates with diabetes

Predictor	Coef. β	SE(β)	T*	p	Coef. β	SE(β)	T	p
Intercept	4.64	0.04	103.99	<0.01	4.66	0.06	71.86	<0.01
Exposed	-0.11	0.07	-1.50	0.14	0.10	0.07	-1.37	0.17
Time (months)	0	0	-0.53	0.60	0	0	-1.19	0.24
Time(months)*Exposed	0	0	-0.72	0.47				
Obese at baseline					-0.04	0.07	-0.61	0.54
≤ 12 months time served								
Predictor	**Coef. β**	**SE(β)**	**T***	**p**				
Intercept	4.62	0.05	86.26	<0.01				
Exposed	-0.11	0.08	-1.43	0.16				
Time (months)	0	0	-1.13	0.26				
Time(months)*Exposed								
Obese at baseline								
≤ 12 months time served	0.03	0.07	0.44	0.66				

*T value

Canteen Calories

Fifty-four women purchased food items from canteen during the months of June 2012 and June 2013. The most frequently purchased items were Crystal light drink mix (n=320), sugar substitute (n=61), and corn tortillas (n=58). During June 2012, an average of 1,094±765 calories were purchased per day among 36 female inmates with diabetes. A year later, an average of 1,093±695 calories were purchased per day among 53 female inmates with diabetes. The amount of calories purchased per day varied from 11 calories per day to 3,616 calories per day.

A higher proportion of unexposed women purchased canteen. All unexposed women incarcerated prior to June 30th 2012 purchased canteen during June 2012 (27/27) compared to 82% (9/11) of exposed women. A year later, 92% (33/36) of unexposed and 83% (20/24) of exposed women purchased canteen during June 2013.

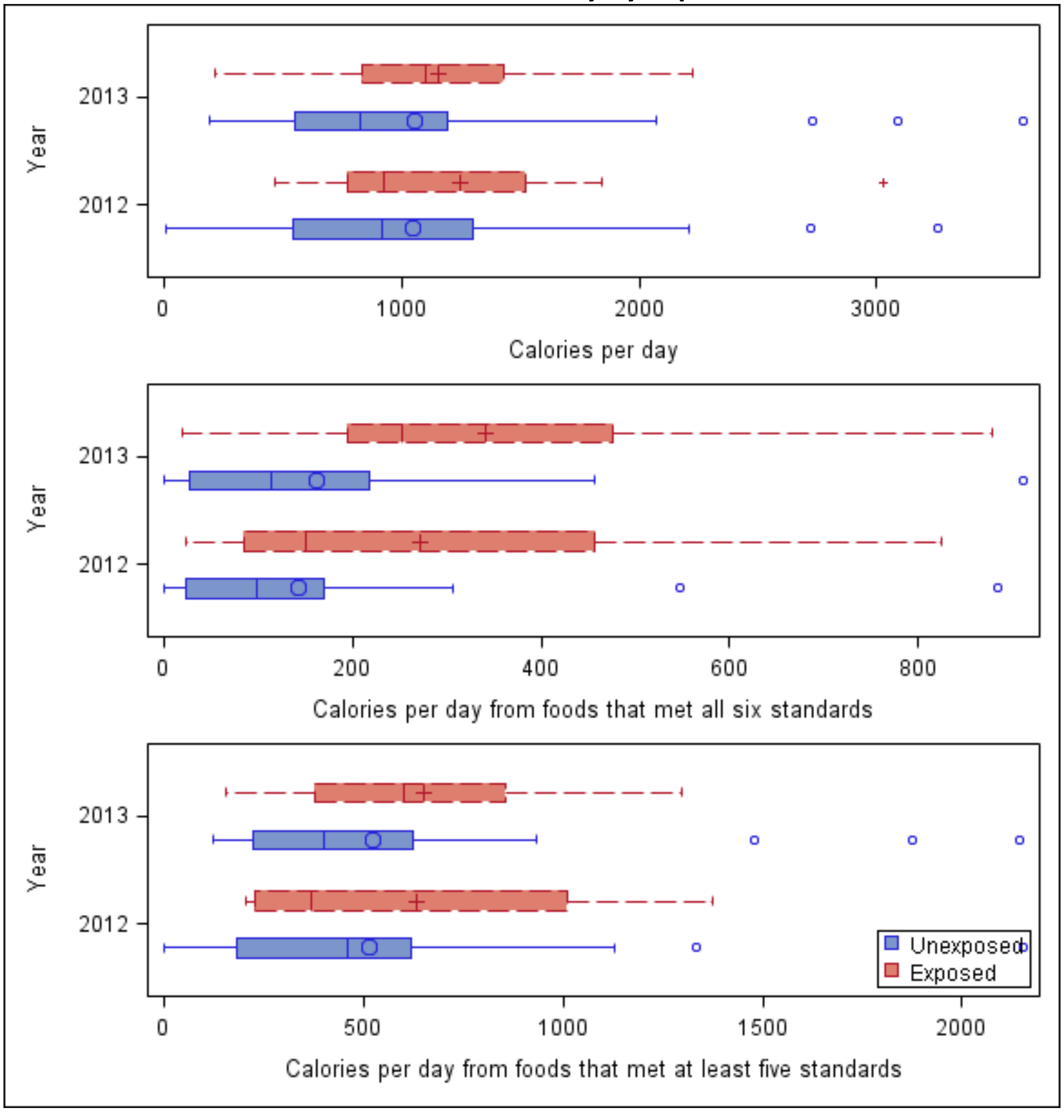
Exposed female inmates with diabetes purchased more calories from canteen each day than unexposed women (Table 7a & Figure 9). For the nine exposed women that purchased food from canteen during both months, an average of 172 fewer calories were purchased each day from canteen after the implementation of the reduced calorie menu (1,244 in 2012 vs. 1,072 in 2013) (Table 7b). Though, the reduction in the amount of daily calories purchased from canteen did not warrant statistical significance. The amount of calories purchased each day varied little between months for the 26 unexposed women that purchased canteen during both months (1,084 in 2012 vs. 1,087 in 2013) (Table 7b).

Table 7a: Canteen purchases among all female inmates with diabetes at Coffee Creek Correctional Facility by exposure status

	Exposed (n=9)	Unexposed (n=27)
Canteen purchased June 2012		
Calories per day	1,244±798	1,044±762
Calories per day from foods that met all 6 standards	272±271	142±192
Calories per day from foods that met at least 5 standards	635±459	516±467

	Exposed (n=20)	Unexposed (n=33)
Canteen purchased June 2013		
Calories per day	1,156±482	1,055±802
Calories per day from foods that met all 6 standards	340±221	163±187
Calories per day from foods that met at least 5 standards	653±319	523±473

Figure 9: Distribution of calories purchased from canteen among female inmates with diabetes at Coffee Creek Correctional Facility by exposure status



Canteen as Smart Snacks

The Institute of Medicine Smart Snack nutrition standards were applied to the 170 items purchased from canteen during June 2012 and June 2013. Eleven foods were exempt from the total fat criteria (≤35% calories from total fat) on the basis that they consisted of nuts, dried fruit, and seeds, or seafood without added fat. Two foods were exempt from the sugar standard (≤35% calories from sugar) because they consisted solely of dried fruit. Exempt items included: sunflower seeds, cashews, health trail mix, mixed nuts, honey roasted peanuts, salted and unsalted peanuts, student trail mix, peanut butter, tuna, prunes, and raisins.

Among the 170 different canteen foods purchased, 40 met all six of the Smart Snack nutrition standards. That is, 24% of all food items purchased were ≤200 calories per snack serving or ≤ 350 calories per entrée serving, ≤35% of calories were from fat or sugar, <10% of calories were from saturated fat, the snack serving had ≤200 mg of sodium or the entrée serving had ≤ 480 mg of sodium, and 0 grams of Trans fat.

For the remaining 130 food items, 47 items fulfilled five of the six Smart Snack standards. Over half of the items that met five standards did not have ≤35% of calories from sugar (57%, 20/47), and a third of the items exceeded the sodium limit (30%, 14/47) (Figure 10). When nutrition standards were considered independently, nearly half of all food items failed to meet all three fat criteria (48% 81/170 items) (Figure 11).

Figure 10: Distribution of the number of Smart Snack standards met by the canteen items purchased during June 2012 & June 2013

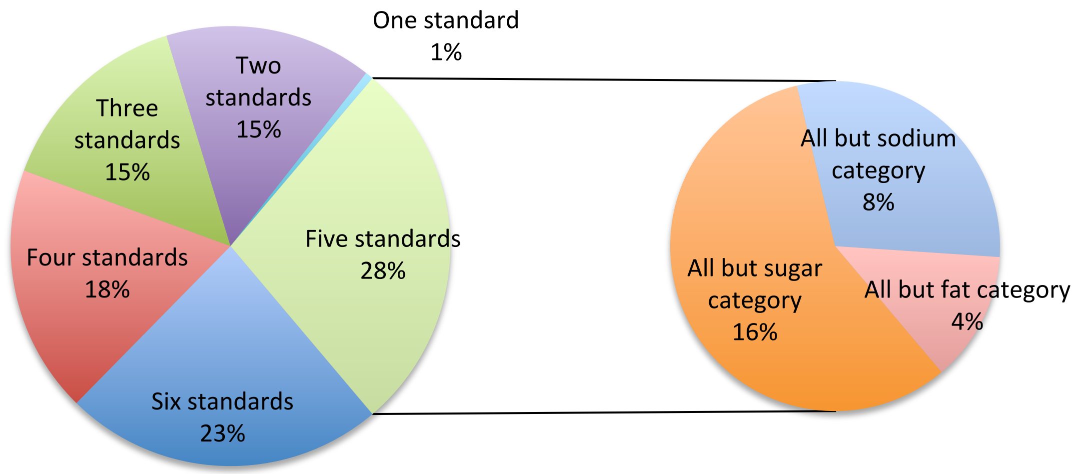
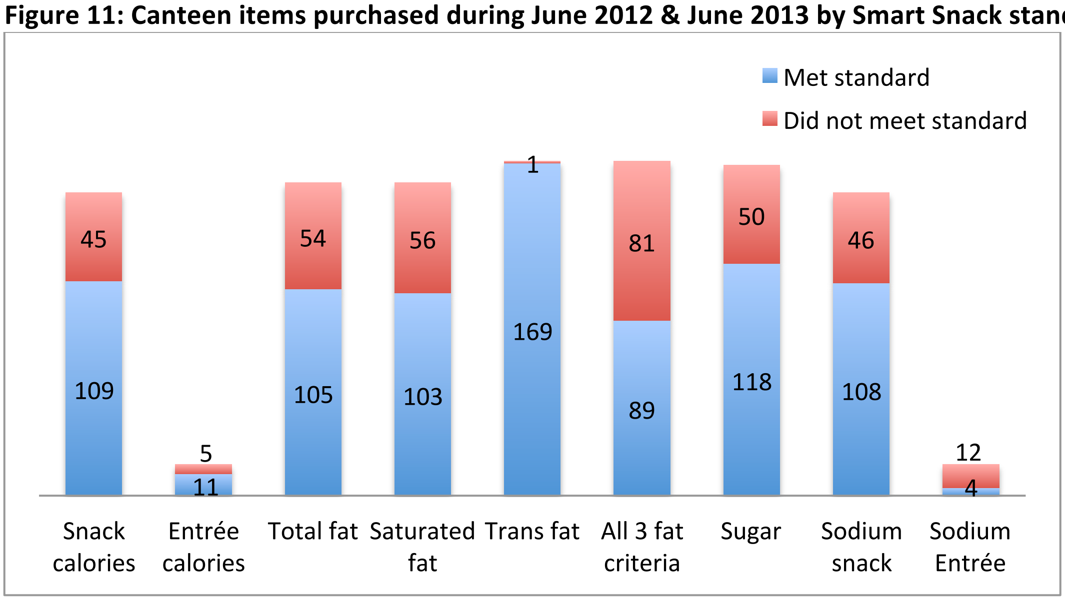


Figure 11: Canteen items purchased during June 2012 & June 2013 by Smart Snack standards



The distribution of calories purchased by the number of Smart Snack standards met varied little between June 2012 and June 2013. Female inmates exposed to the reduced calorie menu purchased more foods that met all six standards during June 2013 when compared to purchases made in June 2012 (Figure 12). For women who purchased canteen during both months, exposed women purchased roughly a quarter of their daily canteen calories from items that met all six Smart Snack standards, from 22% (272 daily calories) during June 2012 to 26% (275 daily calories) during June 2013. By contrast, unexposed women purchased 14% (147 daily calories) of their daily calories from items that met all standards during June 2012 and the proportion increased to 16% during June 2013 (174 daily calories) (Table 7b).

Figure 12: Distribution of calories purchased from canteen by Smart Snack standard by year and exposure to Healthy Food Access Project

Table 7b: Canteen purchases among female inmates with diabetes who purchased canteen during both months (June 2012 and June 2013) at Coffee Creek Correctional Facility by exposure status

	Exposed (n=9)	Unexposed (n=26)
	Mean± SD	
Canteen purchased June 2012		
Calories per day	1,244±798	1,084±748
Calories per day from foods that met all 6 standards	272±271	147±193
Calories per day from foods that met at least 5 standards	635±459	536±465
Canteen purchased June 2013		
Calories per day	1072±284	1087±867
Calories per day from foods that met all 6 standards	275±109	174±193
Calories per day from foods that met at least 5 standards	539±187	571±519
Difference	Mean(95% CI)	
Calories per day	172(-467–810)	-3 (-455–449)
% difference in foods that met all 6 standards	4%(-43%–35%)	2.5%(-22%–17%)
% difference in foods that met at least 5 standards	0.7%(-45%–47%)	3.1%(-30%–24%)

Discussion

This study measured the impact of one year of exposure to the Healthy Food Access Project (HFAP), including the reduced calorie menu, on diabetes management among female inmates with diabetes at CCCF. Overall, we found that exposure to the HFAP supported modest improvement in glycemic control among female inmates with diabetes; these women did not supplement calories from canteen or purchase more unhealthy food after their menu had been reduced by an average of 800 calories a day. The results of the study provide an evaluation of changes in the food environment inside a women's prison facility, and the impact changes in the food environment had on their chronic disease management.

Characteristics of female inmates with diabetes

At intake, the average female inmate with diabetes was 46 years old, obese, and non-hypertensive with acceptable cholesterol. Her diabetes appeared relatively well managed with an average Hba1c of 7.16±1.69 (Table 1). Measuring lipids and BMI were important metrics to capture as modifiable risk factors for developing diabetes-related morbidities. The average female inmate with diabetes was at an elevated risk for cardiovascular disease with an LDL greater than 100 mg/dL and an HDL lower than 50 mg/dL.[40]

Female inmates with diabetes were compared to the non-diabetic female inmates at CCCF. The average female inmate with diabetes was obese, consistent with the findings from the HFAP 2012 baseline survey that found 89% of female inmates in the minimum facility were overweight or obese. Compared to female inmates without diabetes, those with diabetes were older (more likely to be over the age of 40); and of Hispanic ethnicity. These findings are consistent with diabetes trends in the non-institutionalized American population that show an increased risk of diabetes in minority races and older individuals.[3] The odds of serving a life sentence were three times more likely among female inmates with diabetes than non-diabetic female inmates (Appendix F, Table 1). Among the six female inmates with diabetes that were serving a life sentence, four had been diagnosed with diabetes after residing in a correctional facility. Which begs the question; does life in prison exacerbate the risk of diabetes?

The distribution of female inmates with diabetes by race was distinct from that of the non-institutionalized adult females with diabetes in Oregon. The proportion of Hispanic and white female inmates with diabetes was comparable to that of the non-institutionalized adult female Oregon population.[41] American Indian and African American/black female inmates were less likely to have diabetes than non-institutionalized American Indian and African American/black adult females in Oregon.[41] The difference in the distribution of diabetes by race/ethnicity could be attributed to incarcerated female American Indian and African American/blacks are not representative of non-institutionalized American Indian and American Americans/blacks adult females in Oregon.

Healthy Food Environments

This study demonstrated that changes in the food environment inside a women's prison facility could have a positive impact on chronic disease management. Very little literature exists on health promotion programs and changing the food environment inside United States prisons. A wellness program was implemented at a short-term substance abuse prison facility in LaGrange Kentucky.[42] From offering health promotion classes and increasing access to exercise equipment, little change was observed among male inmates. Results indicated a decrease in smoking and depression but little effect on exercise and nutrition.[42] In 2005, women inmates at San Francisco jail #8 evaluated the nutritional and sustainability characteristics for 34 of the 129 food items sold at canteen, and the women provided recommendations for healthier alternatives.[43] Both programs highlight the ability to improve inmates' health while they are incarcerated, but no literature exists on implementing systemic changes in order to improve inmate health and reduce the risk of chronic disease among inmates.

Other countries have implemented health promotion programs in prisons. In Queensland Australia a Women Prisoners' Health Survey was conducted to identify target areas for health promotion among women inmates.[44] England has demonstrated the effectiveness of sport programs in men and women prisons to address physical and mental health needs.[45] A prison participatory health research project was developed inside a minimum and medium prison facility in British Columbia, Canada, where women in prison designed, led and evaluated a nutrition and fitness pilot program.[46]

Implications of the study were to support prison as an opportunity for women inmates to be active in designing health and healing programs.[46] This pilot program only served 16 women, and did not consider the potential effects of implementing the program for the entire prison facility. The design and criminal justice system vary by country, the increase in chronic disease experienced by inmates is not unique to the United States.[29] One motivation behind England's prison sports programs was to reduce the prevalence of cardiovascular disease among prison inmates.[45] Regardless, little work has been done to conduct institutional changes to support inmate health in international prisons.

Outside of prisons, community-based and school district interventions have been successful in altering food environments. The Smart Snack Standards for competitive foods sold in schools was enacted to limit the availability of unhealthy food choices at school.[1] Case studies have suggested that implementing strong nutritional standards in schools has been relatively successful.[47] Schools across the nation have implemented new vending machine policies, integrated produce from school gardens, and taught farm-to-school curriculums.[47] Such innovative work as the Full Yield program has demonstrated the effectiveness of improving diet and health by targeting employers to support better diets for their employees.[48] Successful programs targeted at altering the food environment have provided the tools and support to implement the Healthy Food Access Project at the women's prison in Oregon.

Hba1c

The average Hba1c for female inmates with diabetes upon intake into CCCF was 7.16 and varied little by exposure group (7.32 among exposed vs. 7.08 among unexposed). This was an important finding as it suggested that women exposed to the intervention did not have an “upper hand” in diabetes management before coming to the prison. The lack of a difference in baseline Hba1c between exposure groups validated our conclusion drawn from modeling trends in Hba1c. A modest difference in the trends of Hba1c between exposed and unexposed female inmates with diabetes was detected (X^2:4.22 p-value: 0.04). For every month a female inmate with diabetes in in the minimum facility was exposed to the reduced calorie menu, her average Hba1c decreased by 0.03 units compared to changes in Hba1c among female inmates with diabetes in the medium facility.

The results of the mixed effects model and plotting individual trends of Hba1c did not indicate a drastic change in the slope of Hba1c after implementation of the reduced calorie menu (August 1st 2012) in the minimum facility. This could be attributed to an insufficient amount of exposure to the reduced calorie menu,[49] and that Hba1c measures average blood sugar control over a few month window.[14] Thus, with differences in the number and timing of Hba1c measures for each participant, it would be more reasonable to assess changes in the slope of Hba1c after ample exposure to the reduced calorie menu.

Even prior to implementation of the reduced calorie menu, female inmates with diabetes in the minimum facility had an average 7% reduction in Hba1c since intake (6.78 vs. 7.32) compared to a 2% reduction in Hba1c among unexposed women since intake (6.91 vs. 7.08). At the time of implementing the new menu, there was a 1.3% difference in Hba1c between exposure groups. These differences do not warrant statistical significance, but highlight potential environmental differences that may support better glycemic control[50] in female inmates with diabetes in the minimum facility compared to female inmates with diabetes in the medium facility. The minimum facility offers more physically demanding jobs for female inmates cleared to leave the facility. The medium facility includes a mental health unit, and mental illness among female inmates with diabetes can be a barrier to achieving glycemic control.[51]

With a modest difference in the trends of Hba1c between exposure groups, there was concern that the observed difference was due to chance or bias from a confounding factor. Potential confounding factors were considered when modeling differences in Hba1c trends. Obesity at intake; the amount of time served at the prison; or oral diabetes medication did not confound the association between exposure to the HFAP and changes in Hba1c. Furthermore, inclusion of obesity into the model lacked biologic plausibility because the estimate suggested that obese women at intake had better glycemic control. This association between changes in Hba1c and intake obesity appeared spurious since obesity at intake does not measure changes in weight over time. Nonetheless, we believe that the HFAP had a modest but real effect in improving glycemic control in inmates with diabetes.

Body Mass Index

Female inmates in the minimum facility identified weight gain and unhealthy eating as priority health concerns. The HFAP proposed reducing the amount of calories offered each day to 1) offset the amount of weight gain incarcerated women experience and 2) decrease the prevalence of obesity-related conditions. Measuring changes in BMI prior to and after implementation of the reduced calorie menu in the minimum facility was an appropriate method to assess if dietary changes impacted weight trends in female inmates with diabetes.[49] Even upon entry into CCCF, the average female inmate with diabetes was obese. Over time, BMI appears to increase among women exposed to the reduced calorie menu (Figure 3). With a reduction in the amount of calories served, and female inmates with diabetes not compensating with additional calories from canteen, an increase in BMI did not seem reasonable. A plausible explanation was that an unmeasured factor was confounding the relationship between changes in BMI and exposure to the HFAP.

The amount of time served when the reduced calorie menu was implemented confounded the association between exposure to the new menu and changes in BMI. Female inmates with diabetes gained more weight within their first year at the prison (Appendix D). Half of women exposed to the intervention were within their first year at the prison and gained an average of 0.23 BMI units each month (or 17 pounds/year for a 5'5" 150 pound woman). If a woman exposed to the intervention had lived at the prison for more than a year, she lost an average of 0.11 BMI units each month (or 8 pounds/year for a 5'5" 150 pound woman).

Assessing changes in BMI by the amount of time served did not consider the length of sentence or the impact the amount of time left on her sentence may influence these estimates. Particularly, women with longer sentences residing in the medium facility may be less inclined to lose weight because their release date was farther down the road, if ever (six participants were serving life sentences).[52] Women within their first year at the prison had most likely resided in county jail for a significant amount of time prior to being transferred to the prison. Thus, weight changes observed at the prison may not describe the true amount of weight change experienced by female inmates acclimating to living in an institution.

A mixed effects model was built to describe changes in BMI over time by exposure to the HFAP. There was not a significant difference in the trends of BMI between exposure groups, which suggested that acclimating to prison might have a stronger effect on BMI than exposure to the reduced calorie menu and the HFAP.[8] When the effects of exposure to the intervention and the amount of time served were adjusted for, female inmates with diabetes were still gaining an average of 0.03 BMI units each month or 3 pounds/year for a 5'5" 150 pound woman).

Lipids

Exposure to the reduced calorie menu and the HFAP appeared to have little effect on total cholesterol, HDL cholesterol, and LDL cholesterol. Changes in the trends of cholesterol were modeled by exposure to the HFAP and adjusted for the effects of time served and obesity at intake. Despite the lack of a treatment effect, a significant difference in the average total cholesterol existed between female inmates with diabetes residing in the minimum and medium facilities. This may be indicative of poorly managed cholesterol among unexposed women, which resulted in extremely heterogeneous data and made detecting group differences rather difficult within a two-year window. The lack of a treatment effect may be explained by the insufficient amount of exposure to the reduced calorie menu that resulted in minimal changes in food choices.[49] The results of canteen indicated there was little change in the type of food female inmates with diabetes were choosing to purchase. The results of the lipid analysis could be biased due to unmeasured confounding factors such as access to exercise equipment or medication use. Medications prescribed for non-diabetes purposes were not recorded in the medical abstraction. Female inmates with diabetes may be taking Statins or other medication to lower cholesterol, which could impact changes in cholesterol over time.[53]

Canteen purchases

Weekly canteen provides an opportunity for inmates to purchase supplementary food, toiletries, and basic amenities. The food offered from canteen is comparable to convenient store snacks without the single serving packaging. Cookies are sold in a box and ice cream comes in a pint-sized container. A handful of items offered each week were instant meals consistent of dehydrated beans, meat, or eggs. Canteen was purchased from money that inmates earn or was added to their account by family and friends. A weekly ordering sheet was submitted in advance and the order was filled and picked up by inmates on a weekly basis. Among the 56 female inmates with diabetes who purchased canteen, an average of 1,094 calories were purchased per day during June 2012 and June 2013. One inmate purchased as few as 11 calories per day while another purchased 3,616 per day.

The amount of calories served at mealtimes each day was reduced by 800 in the minimum facility on August 1st 2012 (from 3,000 to 2,200). The following June, women who had been exposed to the reduced calorie menu purchased on average of 172 fewer calories a day from canteen (1,244 in 2012 vs. 1,072 in 2013). Female inmates exposed to the reduced calorie menu were not compensating by purchasing more calories from canteen.

Even though female inmates with diabetes exposed to the reduced calorie menu were not compensating with calories from canteen, were they really eating 1,000+ additional calories a day from canteen? Difficulties in accurately estimating the number of calories an inmate consumed on a daily basis included: determining who consumed the purchased food and who attended mealtime. Canteen food is used as currency in prison.[54] Food is commonly offered as payment for a variety of services. The number of inmates who attend mealtime and the amount of food left on trays was not considered in this analysis. This missing information can substantially bias the results of the amount of calories that are consumed each day. Though, regardless of who purchased the food, someone is consuming the calories.

The design of the canteen business in prisons may support overeating. Pragmatically speaking, without the ability to balance a checkbook or handle cash, buyer's remorse may play a role in excessive purchases.[55] Out of the 200 food items offered each week, only a few are offered in individual serving packages. The inability to purchase a single serving can leave inmates vulnerable to the stockpile phenomenon that increases post-purchase consumption.[56] The design of the prison facility may influence food consumption as inmates reside in confined quarters, and canteen food is readably accessible since inmates sleep next to their foot locker/wardrobe/pantry. There is no refrigeration on the units, and perishable items must be immediately consumed. The process of purchasing and storing canteen food may influence excess consumption, but why are inmates purchasing additional calories from canteen in the first place?

Comfort foods are consumed by inmates as a coping mechanism and to foster a sense of control in the prison environment.[52] Emotional eating is a common stress coping strategy for women adjusting to prison life.[57] A high prevalence of emotional eating, mental health needs and substance abuse have resulted in an increased risk for eating disorders among female inmates.[58] The mental health needs for female inmates at CCCF far exceed the needs for men in Oregon state prisons (Appendix F, Table 2). The role canteen plays for female inmates should be considered when implementing healthy coping strategies for women living behind bars. Limiting access to canteen food is not an appropriate response since canteen offers a source of autonomy for inmates. Instead, emphasis should be placed on the type and packaging of food sold in canteen in order to improve diabetes management and reduce the risk of diabetes-related morbidities.

Canteen foods & Smart Snack Standards

The quality of the food sold in canteen was assessed using the Smart Snack rubric. The Smart Snack standards were implemented as a part of the Healthy, Hunger-free Kids Act, 2010, for all competitive foods sold in schools.[1] Competitive foods are defined as all foods not covered under the federally reimbursable school breakfast and lunch programs. Due to the timeliness of the standards and parallels between competitive foods and canteen, the school standards were an appropriate metric to be applied to prison canteen. Smart Snack standards require competitive foods to contain only specific ingredients (multigrain, low-fat, limited added sugar, etc.) and to be sold in single serving packages.[1] Neither of these requirements was fulfilled in most canteen purchases. Most canteen items were offered in multi-serving packages and analyzing ingredient information was not feasible. Instead, the Smart Snack standards were applied to a single serving size as denoted on the food packaging or the packaging of a surrogate item. This was an obvious limitation since the package size was not restricted to a single serving and certain ingredients can be detrimental to health. Despite this caveat, the objective of the analysis was to categorize canteen foods by the number of Smart Snack standards met in order to describe the quality of food offered by canteen.

The results indicated that women exposed to the reduced calorie diet were not compensating with calories from canteen or purchasing more unhealthy foods (a food that met ≤ 4 standards). Nearly half of all calories were purchased from items that met at least five of the six standards. The most popular items that met all six standards were peanut butter (purchased 38 times), sugar substitute (purchased 38 times), low-calorie Crystal Lite drink mix (purchased 35 times), and plain instant oatmeal (purchased 30 times). The most popular less healthy items included top ramen (purchased 59 times), bakery items (purchased 38 times), pint of ice cream (purchased 27 times), and cheddar cheese squeeze packets (purchased 25 times). A limitation of the Smart Snack standards was the method used to describe the quality of food. Food quality was restricted to the proportion of calories attributed to specific macro/micronutrients.[1] Sugar substitute and low-calorie Crystal Lite met all six standards and soda pop meet all but the sugar standard. As the Smart Snack standards are applied in schools, only foods that contain a limited number of empty calories are even eligible (soda pop not being one of them).[1]

Despite this limitation, categorizing canteen foods by Smart Snack standards can begin the discussion on the quality of supplemental food available to inmates. A result of categorizing canteen foods could be to label canteen foods with a color scheme that provides inmates a visual tool to assess the healthiness of their food choices.

Making a difference: Implications for the Healthy Food Access Project

The results of conducting a quasi-experimental study on female inmates with diabetes supported efforts made by the HFAP to change the food environment in the minimum facility at CCCF. The high prevalence of obesity among female inmates with diabetes was not unique to diabetics. The result of the HFAP baseline survey in June 2012 found 89% of female inmates in the minimum facility were overweight or obese. Describing changes in BMI by the amount of time served was supported from the results of the HFAP baseline survey that found female inmates reported gaining an average of 17 pounds within their first two years at the prison, and female inmates who had served less time at the prison were gaining more weight. Implementing policy change and programs that support weight loss and maintenance of a healthy weight could benefit the majority of female inmates at the institution.

This study provided insight into the quantity and quality of food purchased by female inmates with diabetes from canteen. The canteen analysis demonstrated that collecting canteen receipts and applying nutrition standards was a feasible method to begin the discussion of the impact canteen purchases have on female inmates with diabetes. The sheer number of calories purchased from canteen among female inmates with diabetes spurred interest in describing canteen purchases among a random sample of female inmates in the minimum facility. Concern existed that the canteen estimates among female inmates with diabetes was not generalizable to the entire institution because of female inmates with diabetes preference towards purchasing low-calorie or sugar free foods. Canteen analysis will be conducted among female inmates that participated in either the 2012 or 2014 survey. This will estimate the impact the HFAP has had on canteen food choices after two years of exposure to the intervention. The June 2014 survey will include questions related to canteen purchasing that address substituting cafeteria meals with food purchased from canteen. Including canteen questions in the survey can provide insight into the actual amount of calories female inmates are consuming by considering the number of women that prefer eating meals from canteen instead of in the cafeteria.

Most importantly, results of the study support modest improvement in glycemic control among female inmates exposed to changes in their nutritional environment. Such modest changes have the ability to support further assessment of the impact changes in the food environment can have on the cost of chronic disease management. Reducing the risk for chronic disease can improve women’s health and success while in prison and when they return home.

Limitations

This study provides a preliminary assessment of the effects the HFAP had on female inmates with diabetes. Several limitations of the study may have inhibited the ability to detect significant group differences and bias the results. The study design was quasi-experimental and female inmates with diabetes were not randomized to changes in their food environment. Exposure assignment was determined from an inmate's medical acuity and needs, severity of crime, and length of sentence. Inmates serving shorter sentences or serving the end of their sentence with good time were more likely to reside in the minimum facility and be exposed to the HFAP. Facility assignment is not static and movement between facilities in relatively common for disciplinary actions or changes in an inmate's needs. For instance, among the 63 participants, only six had resided in minimum for the entirety of HFAP, and an additional seven unexposed women had resided in minimum but were not sufficiently exposed to the HFAP (< 90 days of exposure). Movement between facilities during exposure to HFAP had the potential to bias results towards the null. If the analysis had been adjusted for participants' movement between facilities, the results may still be biased under assumption that sufficient exposure to the HFAP will influence dietary choices regardless of the facility she is residing in. Thus, the observed differences in biometric measures between groups could easily be an underestimate of the true impact the HFAP has had on female inmates with diabetes.

Unmeasured metrics may suggest systemic differences between women in either facility that are related to diabetes management. For instance, the medium facility provides an inpatient mental health ward and a housing unit dedicated to women with mental health needs, while the minimum facility provides substance abuse treatment programs. Differences in inmate needs by facility were supported by the report that more female inmates in the medium facility 79% (514/647) would benefit from mental health treatment compared to female inmates in the minimum facility 74% (454/611) (Appendix F, Table 2), and more female inmates in the minimum facility 88% (539/611) suffer from substance abuse addiction compared to female inmates in the medium facility 79% (512/647) Such differences could affect diabetes management. A limited number of potential confounding factors were considered in this study since emphasis was placed on diabetes management and canteen purchases. Such factors related to differential diabetes management and facility exposure can be a topic of further research.

The specificity of exposure was another limitation of the study. The analysis of the study was centered on the implementation of the reduced calorie menu. The effects of other Healthy Food Access programs like expanding the prison garden and offering education and training courses were not measured in this analysis. Thus, the results of the study may underestimate the true effect changes in the food environment have had on female inmates with diabetes.

The remaining limitations address the role the prison environment has on diabetes management. All women diagnosed with diabetes at the time the sample was pulled were included in this study in order to bolster sample size. An exposed woman only needed to reside in the minimum facility for a cumulative of 90 days since August 1st 2012. For some participants, they were admitted into the institution just months before the sample was pulled. Those new to the prison environment may bias the results because changes in biometric measures may better reflect acclimating to a prison environment than changes in the food environment. This was apparent from the increase in BMI observed among female inmates with diabetes that had served less than a year of their sentence. In addition to acclimating to living inside a prison, the physical environment of the medium and minimum facility may differentially affect diabetes management.

Despite these limitations, this study provided important insight on the impact altering the food environment inside Coffee Creek Correctional Facility could have on a subset of women living with a chronic disease.

Future research

The results of this study support further assessment of the impact changes in the food environment at Coffee Creek Correction Facility have had on female inmates. Future observational studies could implement the use of propensity scores to match exposed and unexposed female inmates by their probability of exposure. This would increase the power to detect changes in biometrics or behavior among female inmates exposed to the Healthy Food Access Project. Goals of future studies should describe: 1) the role canteen purchases play in an inmate's life and 2) the effects of improving the food environment and the addition of the garden on mental health and exercise. An additional canteen analysis should be conducted on a random sample of inmates to provide a generalizable estimate of canteen purchases for female inmates living at Coffee Creek Correctional Facility. Ideally, a cohort of female inmates would be prospectively followed to assess changes in biometrics, food choice, and exercise among women exposed to the Healthy Food Access Project.

Conclusion

This study measured the impact of one year of exposure to the Healthy Food Access Project, including the reduced calorie menu, on diabetes management among female inmates with diabetes at Coffee Creek Correction Facility-Minimum. Overall, we found that exposure to the intervention supported modest improvement in glycemic control among female inmate with diabetes. Female inmates with diabetes exposed to the reduced calorie menu did not compensate with calories from canteen or purchase more unhealthy food after their menu had been reduced by an average of 800 calories a day. The results of this study supported modest improvement in chronic disease management among female inmates with diabetes exposed to changes in their food environment at Coffee Creek Correction Facility-Minimum. Changes in the food environment can improve chronic disease management, quality of life, and reduce the dependency on costly pharmaceuticals while incarcerated and once female inmates return home.

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APPENDICES TABLE OF CONTENTS

Appendix A: Medical chart abstraction and canteen variable dictionary

Face Sheet

Label	Variable	
Participant ID	Part_ID	
Facility at abstraction	Facility_A	
Date of Abstraction MM/DD/YY	DOA	____/____/____
Date of Birth MM/DD/YY	DOB	____/____/____
Date of Diabetes diagnosis MM/DD/YY	DODM	____/____/____
Age (in years)	Age	
Intake date at CCCF MM/DD/YY	Int_D	____/____/____
Race 1: White, non-Hispanic 2: Black, non-Hispanic 3: Hispanic 4: AI/NA 5: Other	Race	
Earliest release date	Release	____/____/____
Length of sentence (months)	Sent	
Length of time served in months (institution admit date-abstraction)	Time_serv	
Height (in inches)	Ht_I	
Weight (in pounds)	Wt_I	
BMI (kg/m^2)	BMI_I	
Systolic BP (mm Hg)	Sbp_I	
Diastolic BP (mm Hg)	Dbp_I	
Diet restrictions ordered (snack, condiments)	Cond_V	Facility Value
HbA1c (% of total hemoglobin)	Hba_V	___/____/____
Total cholesterol (mg/dL)	Chol_V	___/____/____
HDL cholesterol (mg/dL)	HDL_V	
LDL cholesterol (mg/dL)	LDL_V	

Medical Visit

Part_ID______
_____ of _____

Label	Variable	
Medical visit date (medical visit and/or blood draw)	Vis_V	____/____/____
Facility at medical visit	Facility_V	
Weight (in pounds)	Wt_V	
BMI (kg/m^2) use Ht_I	BMI_V	
Diabetic oral medication** Yes=name; No=.	Medo_V	
Diabetic injection medication Yes=name; No=.	Medi_V	
Insulin Yes=1; No=0	Insulin_V	
Insulin Dose (daily units)	InsulinD_V	
Discontinue medication Yes=name; No=.	DMed_V	
If yes. Date discontinued medication	DateM_V	____/____/____
Systolic BP (mm Hg)	Sbp_V	
Diastolic BP (mm Hg)	Dbp_V	
HbA1c (% of total hemoglobin)	Hba1c	Facility Value ___/____/____ ___/____/____ ___/____/____
Total cholesterol (mg/dL)	Chol	___/____/____ ___/____/____
HDL cholesterol (mg/dL)	HDL	
LDL cholesterol (mg/dL)	LDL	
Assessment/plan (weight loss, diet, exercise)	Assess	

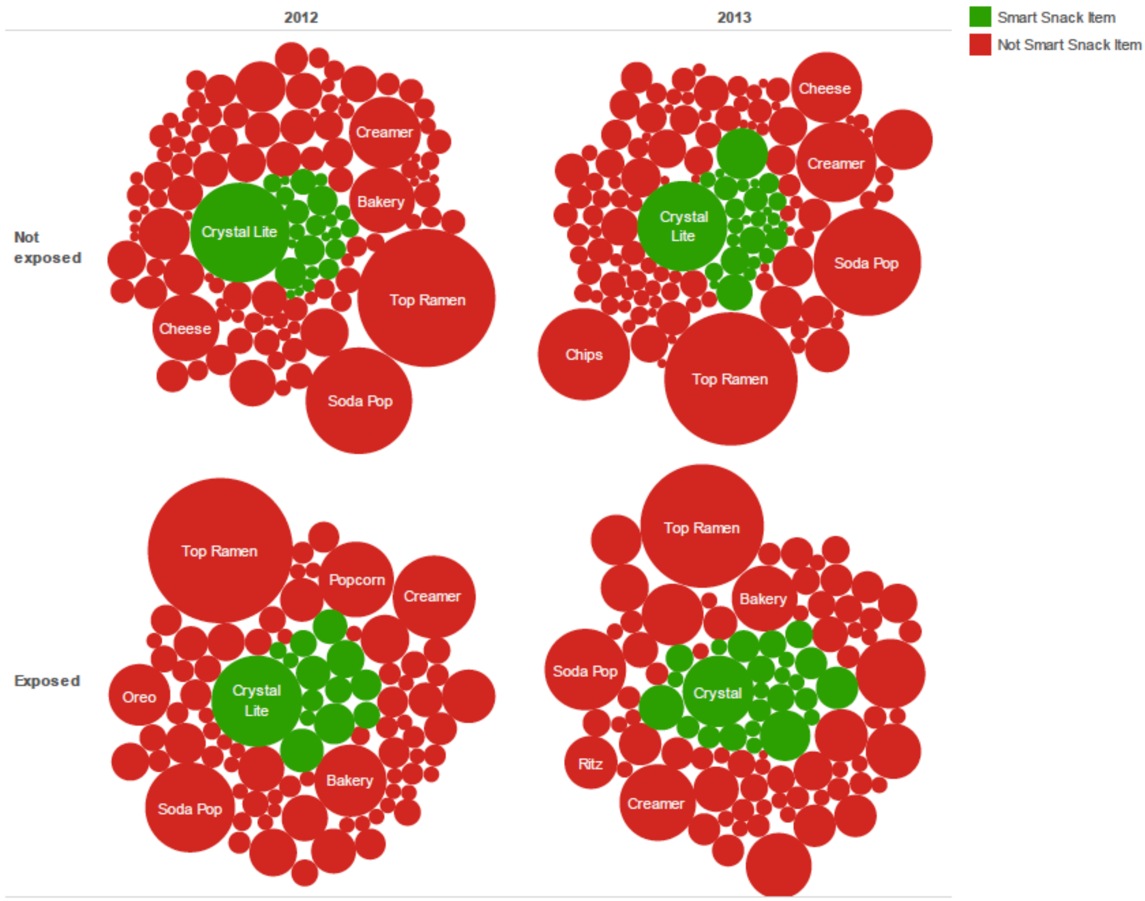
**Includes: Meglitinides: Prandin, Starlix, Sulfonylureas: Glucotrol, Amaryl, DiaBeta, Glynase, Dipeptidy peptidase-4 (DPP-4) inhibitors: Onglyza, Januvia, Tradjenta, Biguanides: Metformin, Thiazolidinediones: Avandia, Actos, Alpha-glucosidase inhibitors: Precose, Glyset

Canteen variable dictionary

Label	**Variable**
Name on food item	Canteen
Year of purchase June 2012 or June 2013	Year
How many months of canteen purchases (1 or 2)	Canteenyrs
Calories in a serving	Cal_serv
Calories per package (cal_serv x servings)	Cal_total
Quantity received	Quantity
Total calories purchased per item	Cal_totalxq
Grams of total fat per serving	Fat_serv
Calories from total fat per serving (fat_serv x 9)	Fat_cal
≤ 35% of calories from total fat	Fat_score
Grams of saturated fat per serving	Sat_serv
Calories from saturated fat per serving (sat_serv x 9)	Sat_cal
< 10% of calories from saturated fat	Sat_score
Grams of Trans fat per serving	Trans_serv
0 grams from Trans fat	Trans_score
Grams of sugar per serving	Sugar_serv
Calories from sugar per serving (sugar_serv * 4)	Sugar_cal
≤ 35% of calories from sugar	Sugar_score
Snack item (if item is assumed to be a snack)	Snack
Entrée item (if item is assumed to be an entrée)	Entree
Milligrams of sodium per serving	Na_serv
Less than ≤200mg for snack or ≤480mg for entrée	Na_score
Less than 200 calories per serving for snack or 350 calories for entrée	Cal_score
Number of standards met (0-6)	Score

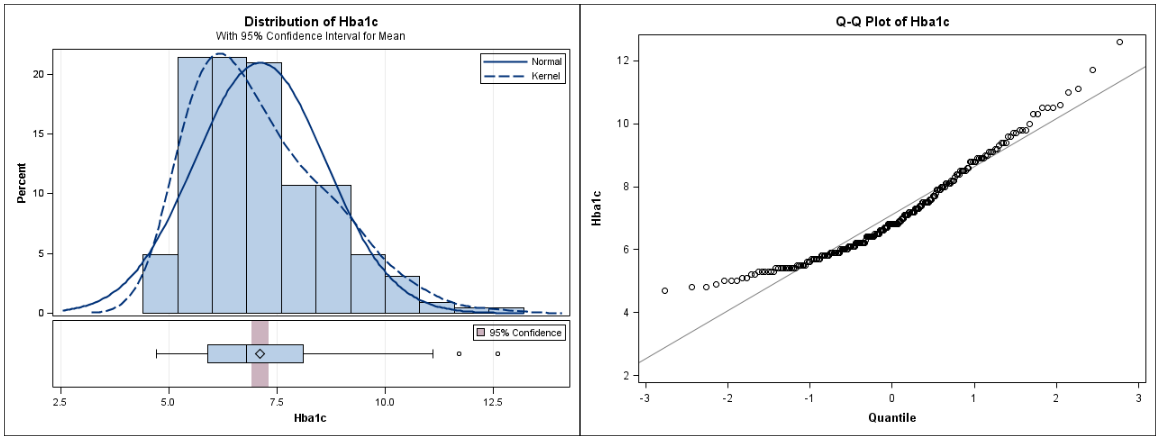
Appendix B: Canteen plots

Figure 1: Canteen purchases among female inmates with diabetes who purchased canteen during June 2012 & June 2013



Appendix C: Hba1c model

Distribution of Hba1c:



Hba1 random intercept model AIC 715.1:

Effect	Estimate	SE	df	T value	p-value
Intercept	6.909	0.218	59	31.77	<0.0001
Exposed	-0.125	0.364	161	-0.34	0.7322
Time (months)	-0.005	0.009	161	-0.59	0.5565
Time(months)*Exposed	-0.033	0.016	161	-2.05	0.0416

Fitted equations for Hba1c random intercept model:

$Y_{ij} = \beta_0 + \beta_1 exposed_i + \beta_2 time_{ij} + \beta_3 exposed*time_{ij} + b_{1i} + \varepsilon_{ij}$

Unexposed:

$Y_{ij} = (\beta_0 + b_{1i}) + \beta_2 time_{ij} + \varepsilon_{ij}$

$Y_{ij} = (6.909 + b_{1i}) – 0.0053 time + \varepsilon_{ij}$

$SD(b_{1i}) = 1.248$

95% CI b_{1i} : $6.909 \pm 1.96*1.248 = (4.463–9.355)$

Exposed:

$Y_{ij} = (\beta_0 + b_{1i} + \beta_1 exposed_i) + \beta_2 time + \beta_3 exposed*time_{ij} + \varepsilon_{ij}$

$Y_{ij} = (6.909 – 0.1249 exposed + b_{1i}) + (-0.0053 + -0.0331 exposed)\ time + \varepsilon_{ij} =$

$Y_{ij} = (6.7841 + b_{1i}) - 0.0384 time + \varepsilon_{ij}$

$SD(b_{1i}) = 1.248$

95% CI b_{1i} : $6.784 \pm 1.96*1.248 = (4.338–9.230)$

Hba1 random intercept model when outlier participants 14 & 63 were excluded:

Effect	Estimate	SE	df	T value	p-value
Intercept	6.870	0.219	57	31.38	<0.0001
Exposed	-0.164	0.369	153	-0.44	0.6577
Time (months)	-0.004	0.008	153	-0.45	0.6503
Time(months)*Exposed	-0.030	0.015	153	-1.97	0.0501

Fitted equations for Hba1c random intercept model when outlier Participant 14 & 63 are excluded AIC 652.7:

$Y_{ij} = \beta_0 + \beta_1 exposed_i + \beta_2 time_{ij} + \beta_3 exposed*time_{ij} + b_{1i} + \varepsilon_{ij}$

Unexposed:

$Y_{ij} = (\beta_0 + b_{1i}) + \beta_2 time_{ij} + \varepsilon_{ij}$

$Y_{ij}= (6.87 + b_{1i}) – 0.004time + \varepsilon_{ij}$

$SD(b_{1i}) = 1.257$

95% CI b_{1i} : 6.87 ± 1.96*1.257 = (4.406–9.334)

Exposed:

$Y_{ij} = (\beta_0 + b_{1i} + \beta_1 exposed_i) + \beta_2 time + \beta_3 exposed*time_{ij} + \varepsilon_{ij}$

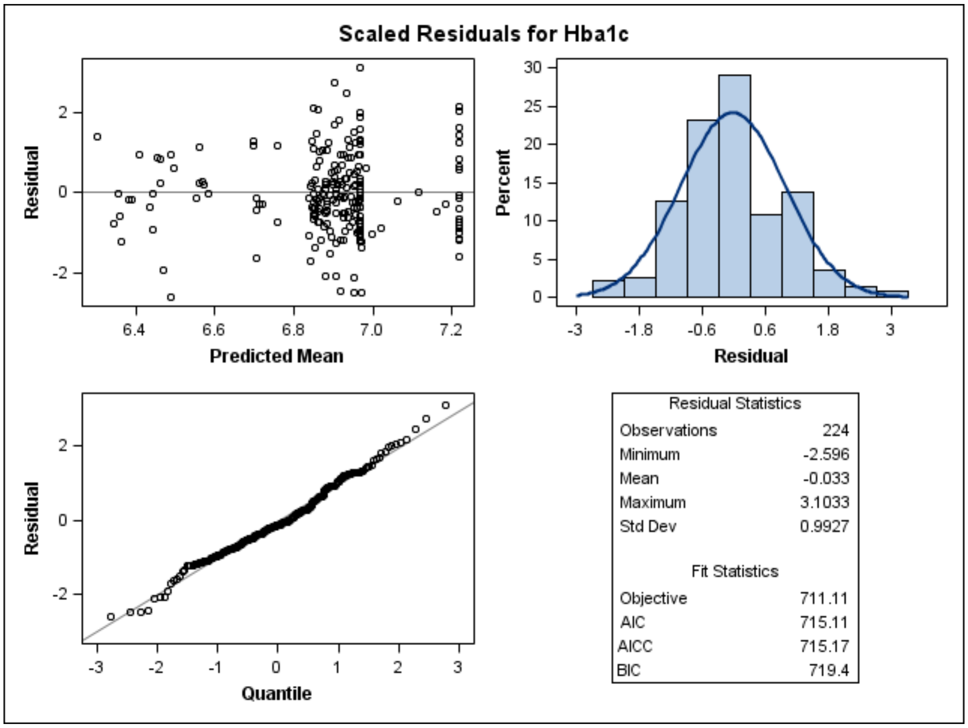
$Y_{ij}= (6.87– 0.164exposed+ b_{1i}) + (-0.004+ -0.030exposed)\ time + \varepsilon_{ij} =$

$Y_{ij}= (6.706 + b_{1i}) - 0.034time + \varepsilon_{ij}$

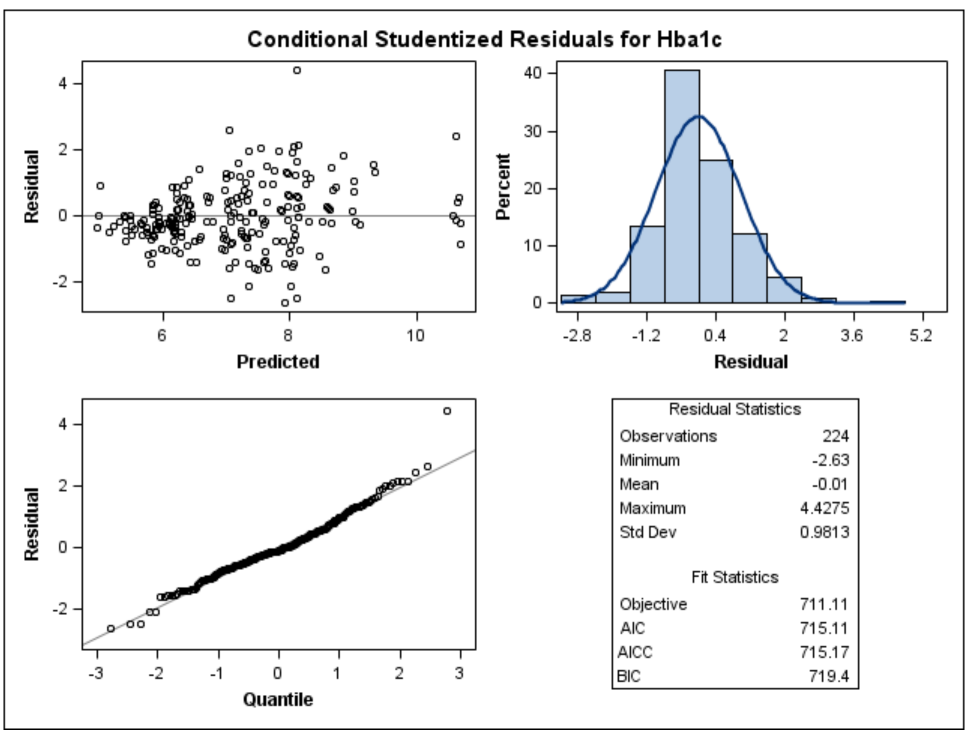
$SD(b_{1i}) = 1.257$

95% CI b_{1i} : 6.706 ± 1.96*1.257 = (4.242–9.170)

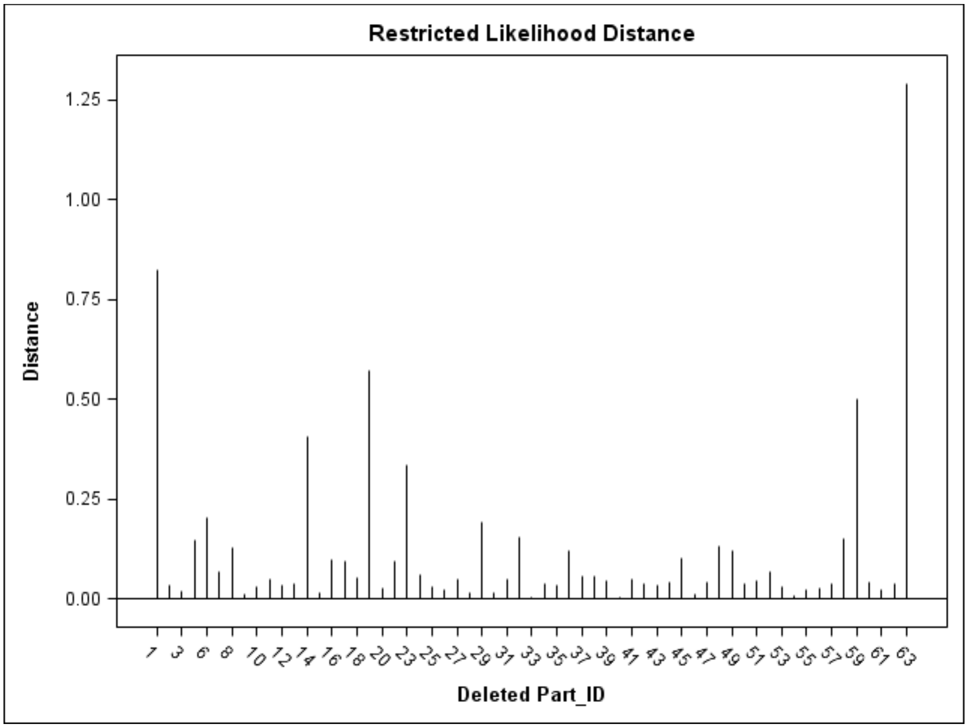
Model diagnostics for Hba1c random intercept model:
Transformed residuals:



Conditional Studentized residuals:

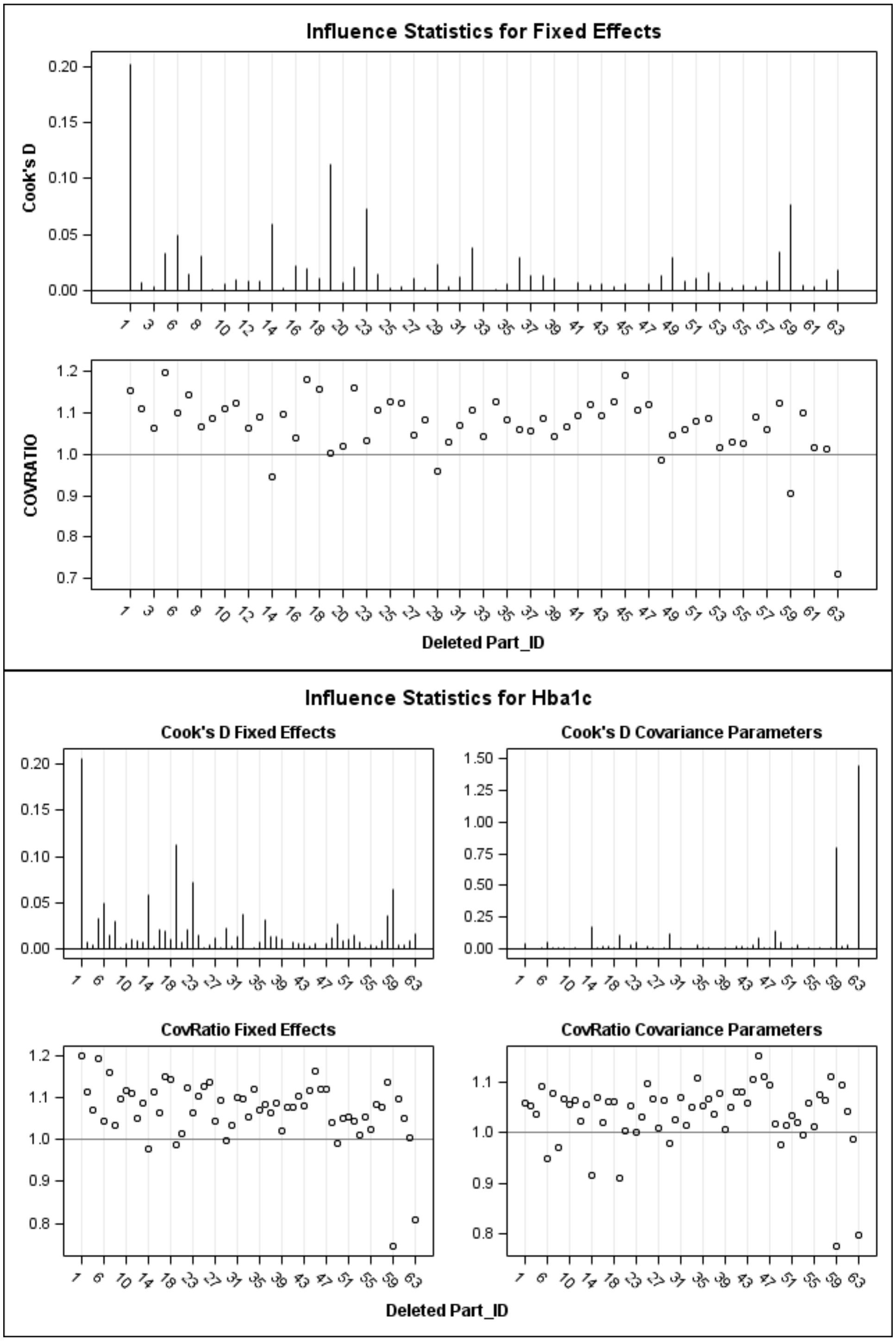


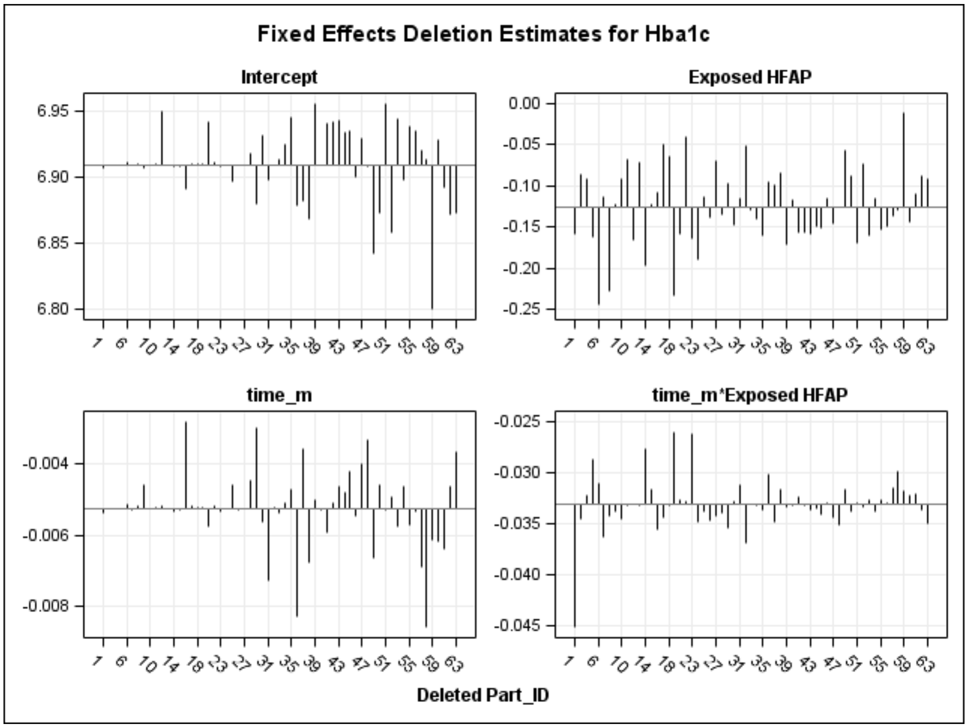
Mahalanobis Distance:

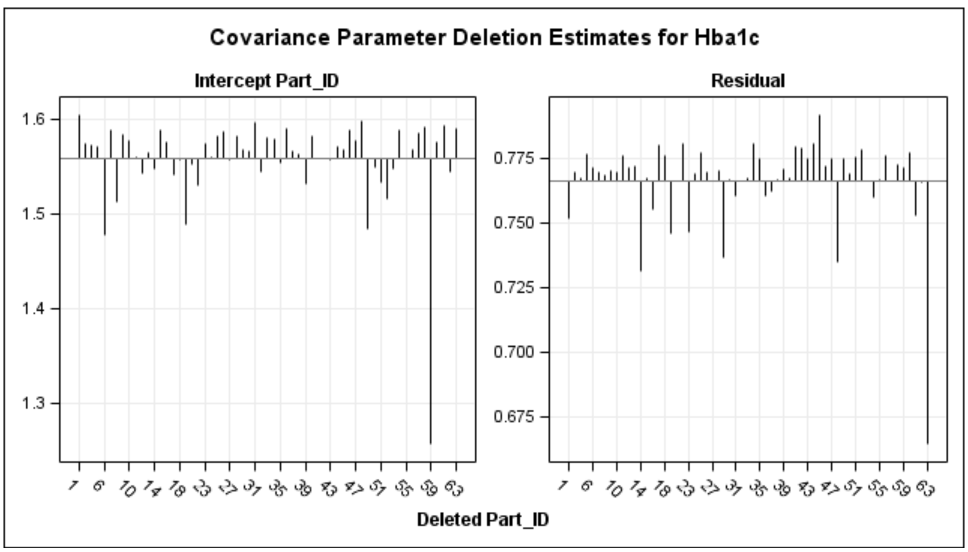


Variables	Full model	Excluding Mahalanobis < 0.025 (n=2)	% difference
Intercept	6.909	6.870	0.5%
Exposed	-0.125	-0.164	31%
Time (months)	-0.005	-0.004	25%
Time(months)*Exposed	-0.033	-0.030	10%

Cook's Distance and participant influence on Beta estimate and covariance parameters:

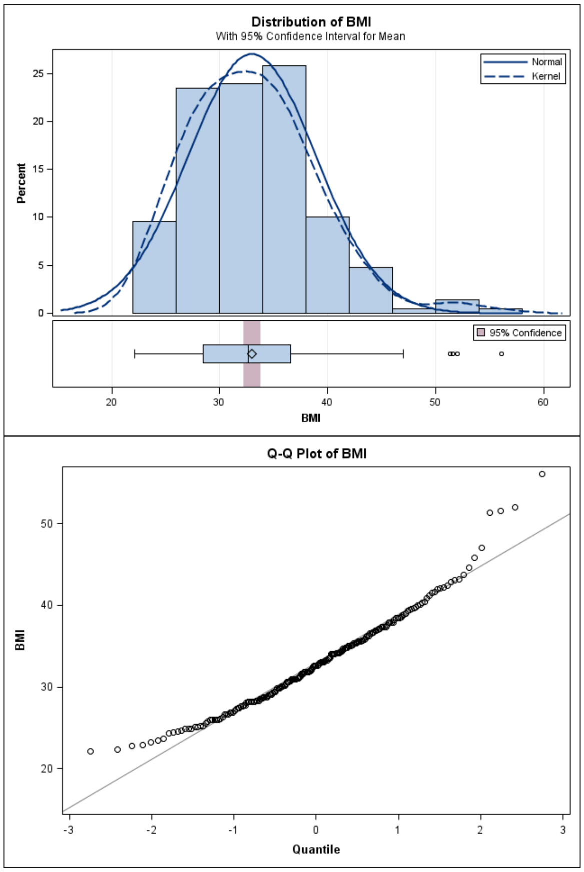



Fixed Effects Deletion Estimates for Hba1c
Intercept
Exposed HFAP
time_m
time_m*Exposed HFAP
Deleted Part_ID


Covariance Parameter Deletion Estimates for Hba1c
Intercept Part_ID
Residual
Deleted Part_ID

Appendix D: BMI model

Distribution of BMI:



BMI random intercept model:

Effect	Estimate	SE	df	T value	p-value
Intercept	33.328	1.242	60	26.82	<0.0001
Exposed	-3.799	1.626	145	-2.34	0.0209
Time (months)	0.032	0.018	145	1.73	0.0859
Timeserved	3.414	1.602	145	2.13	0.0348

Fitted equations for BMI random intercept model:

$Y_{ij} = \beta_0 + \beta_1 exposed_i + \beta_2 time_{ij} + \beta_3 timeserved(\leq 12\ months)_i + b_{1i} + \varepsilon_{ij}$

Unexposed when > 12 months served:

$Y_{ij} = (\beta_0 + b_{1i}) + \beta_2 time_{ij} + \varepsilon_{ij}$

$Y_{ij} = (33.33 + b_{1i}) + 0.032time + \varepsilon_{ij}$

$SD(b_{1i}) = 5.90$

95% CI b_{1i} : 33.33 ± 1.96*5.90 = (21.77–44.89)

Unexposed when ≤ 12 months served:
$Y_{ij} = (\beta_0 + b_{1i}) + \beta_2 time_{ij} + \beta_3 timeserved + \varepsilon_{ij}$
Y_{ij}= (33.33 + 3.414timeserved + b_{1i}) – 0.032time + ε_{ij}
Y_{ij}= (36.74+ b_{1i}) + 0.032time + ε_{ij}
SD(b_{1i}) = 5.90
95% CI b_{1i} : 36.74 ± 1.96*5.90 = (25.18–48.31)

Exposed when > 12 months served:
$Y_{ij} = (\beta_0 + b_{1i} + \beta_1 exposed_i) + \beta_2 time + \varepsilon_{ij}$
Y_{ij}= (33.33– 3.799 exposed+ b_{1i}) –0.032time + ε_{ij} =
Y_{ij}= (29.53+ b_{1i}) + 0.032time + ε_{ij}
SD(b_{1i}) = 5.90
95% CI b_{1i} : 29.53 ± 1.96*5.90 = (17.97–41.09)

Exposed when ≤ 12 months served:
$Y_{ij} = (\beta_0 + b_{1i} + \beta_1 exposed_i) + \beta_2 time_{ij} + \beta_3 timeserved + \varepsilon_{ij}$
Y_{ij}= (33.33– 3.799 exposed+ 3.414timeserved + b_{1i}) – 0.032time + ε_{ij}
Y_{ij}= (32.95+ b_{1i}) + 0.032time + ε_{ij}
SD(b_{1i}) = 5.90
95% CI b_{1i} : 32.95± 1.96*5.90= (21.381–32.945)

Linear spline model of BMI by time served:

When BMI measures were plotted by time served (in months) the mean slope in BMI changed just after
t* = 12 months
When timeserved ≤ 12, $(timeserved-12)_+ = 0$
When time > 12, $(timeserved-12)_+$ = timeserved-12
β_0 = 34.586
β_1 $exposed_i$= -3.054
β_2 $timeserved_{ij}$= 0.149
$\beta_3(timeserved_{ij} – t^*)_+$= -0.167
$\beta_4 exposed_i * timeserved_{ij}$ = 0.082
$\beta_5 exposed_i * (timeserved_{ij} – t^*)_+$= -0.171

$Y_{ij} = \beta_0 + \beta_1 exposed_i + \beta_2 timeserved_{ij} + \beta_3 (timeserved_{ij} – t^*)_+ + \beta_4 exposed_i * timeserved_{ij} + \beta_5 exposed_i * (timeserved_{ij} – t^*)_+ + \varepsilon_{ij}$
Where $exposed_i$ =1 for exposed to HFAP group and $exposed_i$ =0 for unexposed to HFAP group

Linear spline model when $exposed_i = 0$
When time ≤ 12: $Y_{ij} = (\beta_0 + b_{1i}) + \beta_2 timeserved_{ij} + \varepsilon_{ij}$
$Y_{ij} = (34.586 + b_{1i}) + 0.149 timeserved_{ij} + \varepsilon_{ij}$

When time > 12: $Y_{ij} = (\beta_0 - \beta_3 t^*) + (\beta_2 + \beta_3)*timeserved_{ij} + \varepsilon_{ij}$
$Y_{ij} = (34.586 - 0.167 + b_{1i}) + (0.149 - 0.167)*timeserved_{ij} + \varepsilon_{ij}$
$= (34.419 + b_{1i}) - 0.018\ timeserved_{ij} + \varepsilon_{ij}$

Linear spline model when $exposed_i = 1$
When time ≤ 12: $Y_{ij} = (\beta_0 + \beta_1 exposed_i + b_{1i}) + (\beta_2 + \beta_4 exposed)*timeserved_{ij} + \varepsilon_{ij}$
$Y_{ij} = (34.586 – 3.054 + b_{1i}) + (0.149 + 0.082)*timeserved_{ij} + \varepsilon_{ij}$
$= (31.532 + b_{1i}) + 0.231\ timeserved_{ij} + \varepsilon_{ij}$

When time > 12: $Y_{ij} = \{(\beta_0 + \beta_1 exposed_i) - (\beta_3 + \beta_5)t^* + b_{1i}\} + (\beta_2 + \beta_3 + \beta_4 + \beta_5)*timeserved_{ij} + \varepsilon_{ij}$
$Y_{ij} = \{(34.586 – 3.054) + (0.167 + 0.171)t^* + b_{1i}\} + (0.149 - 0.167 + 0.082 - 0.171)timeserved_{ij} + \varepsilon_{ij}$
$= (31.87 + b_{1i}) - 0.107\ timeserved_{ij} + \varepsilon_{ij}$

Estimates

Label	Estimate	Standard Error	DF	t Value	Pr > |t|
control group, time served > 12 months, coefficient	-0.01798	0.007702	142	-2.33	0.0210
control group, time served <= 12 months, coefficient	0.1490	0.05851	142	2.55	0.0120
treat group, time served <= 12 months, coefficient	0.2312	0.07711	142	3.00	0.0032
treat group, time served > 12 months, coefficient	-0.1063	0.03999	142	-2.66	0.0087

To test if slope is different among unexposed women after 12 months time served:
H_0: $\beta_3 = 0$ where $\beta_3(timeserved_{ij} – t^*)_+$
β_3 -0.1669 SE: 0.06438 df: 142 X^2: 16.02 p-value: <0.0001

Reject the null and conclude that among unexposed women, the slope is significantly different after 12 months of time served when compared to a year or less of time served (X^2: 16.02 p-value: <0.0001).

To test if the slope is different among exposed women after 12 months time served:
H_0: $\beta_3 + \beta_5 = 0$ where $\beta_3(timeserved_{ij} – t^*)_+ \beta_5 exposed_i*(timeserved_{ij} – t^*)_+$

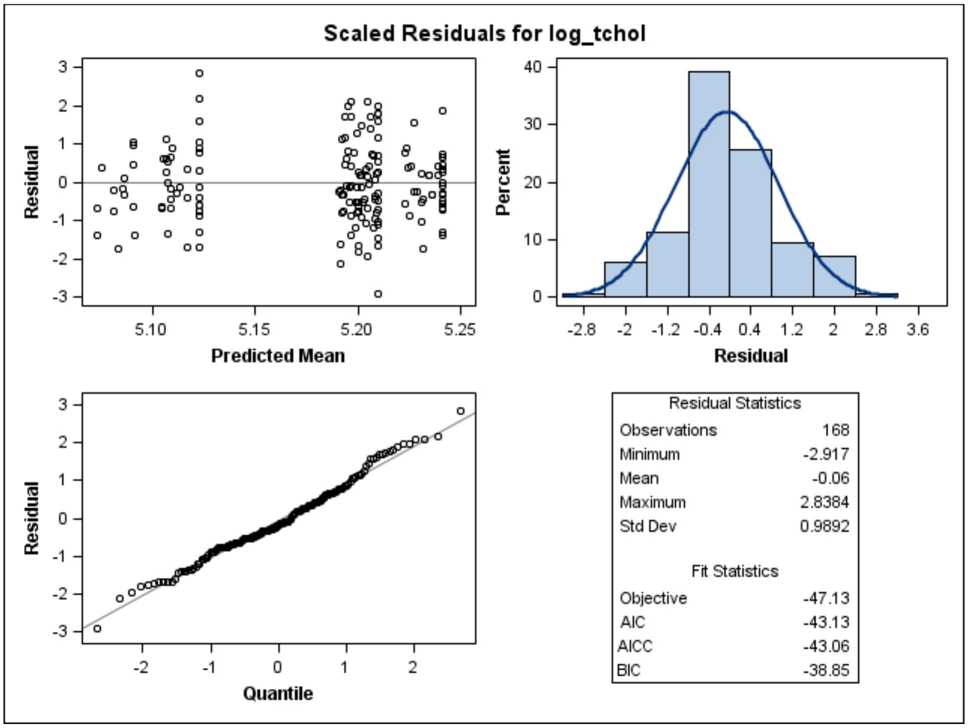
To test if the trends are different between women exposed and unexposed:

H_0: $\beta_4 exposed_i * timeserved_{ij} = \beta_5 exposed_i * (timeserved_{ij} - t^*)_+ = 0$

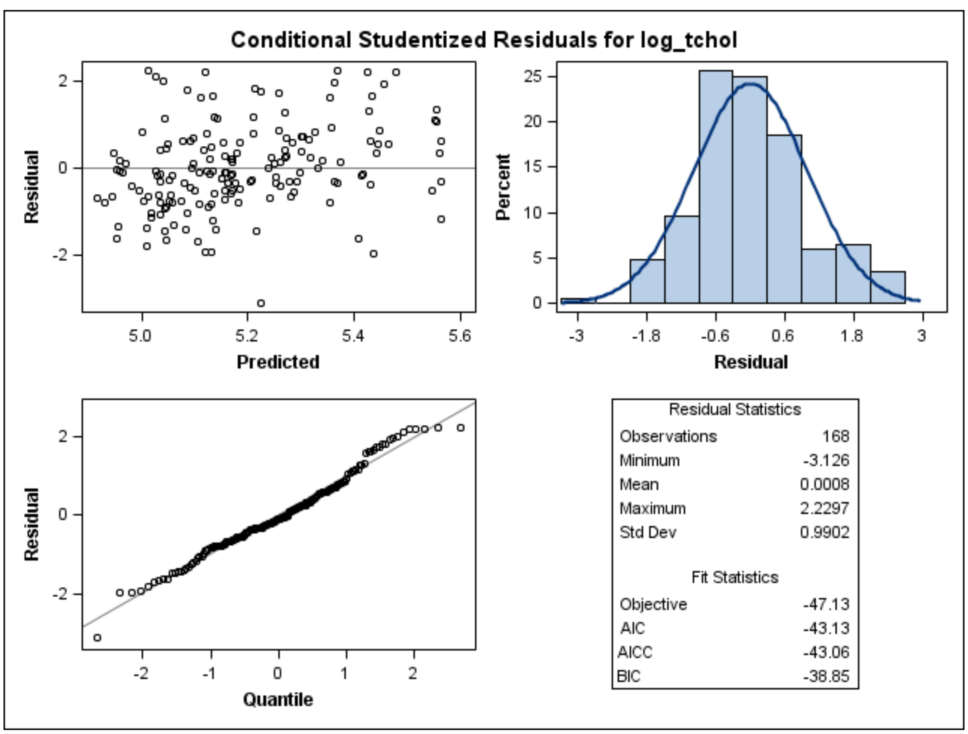
To test whether there is a difference in changes of mean BMI over time between exposure groups, the post hoc contrast statement is used. The null hypothesis assumes the interaction between exposed group and time served ≤ 12 months is equivalent to zero and the interaction between exposed group and time served > 12 months is also equivalent to zero. We reject the null and conclude that time served trends are significantly different between exposure groups (F: 4.85 p-value: 0.0091).

Model diagnostics for BMI random intercept model:

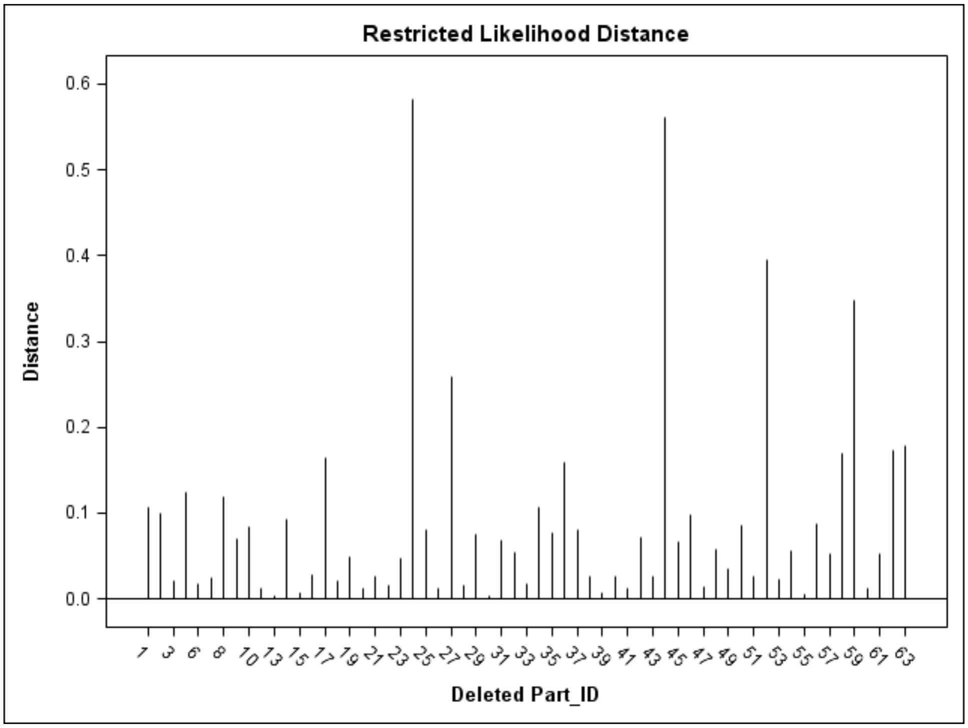
Transformed residuals:



Conditional Studentized residuals:

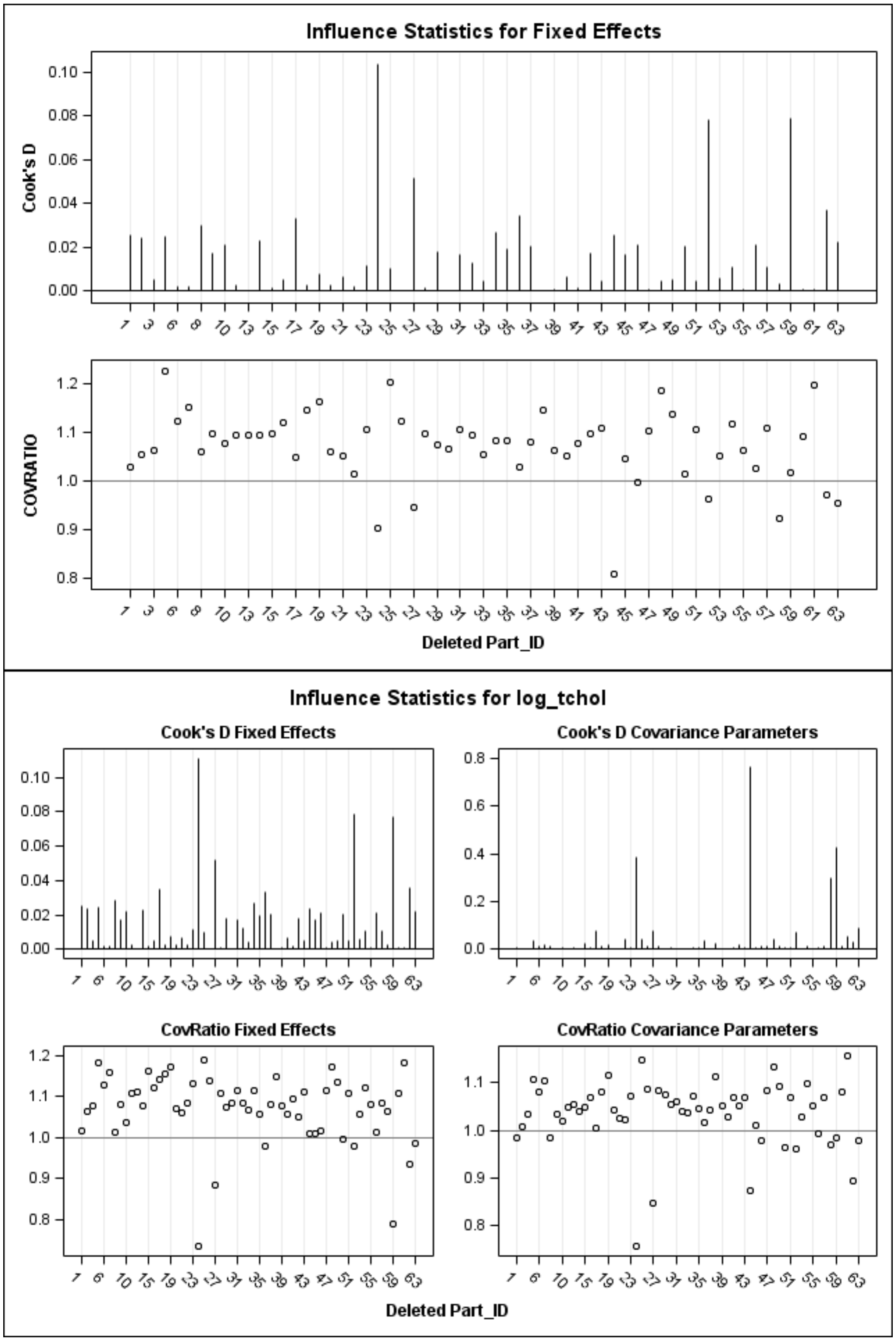


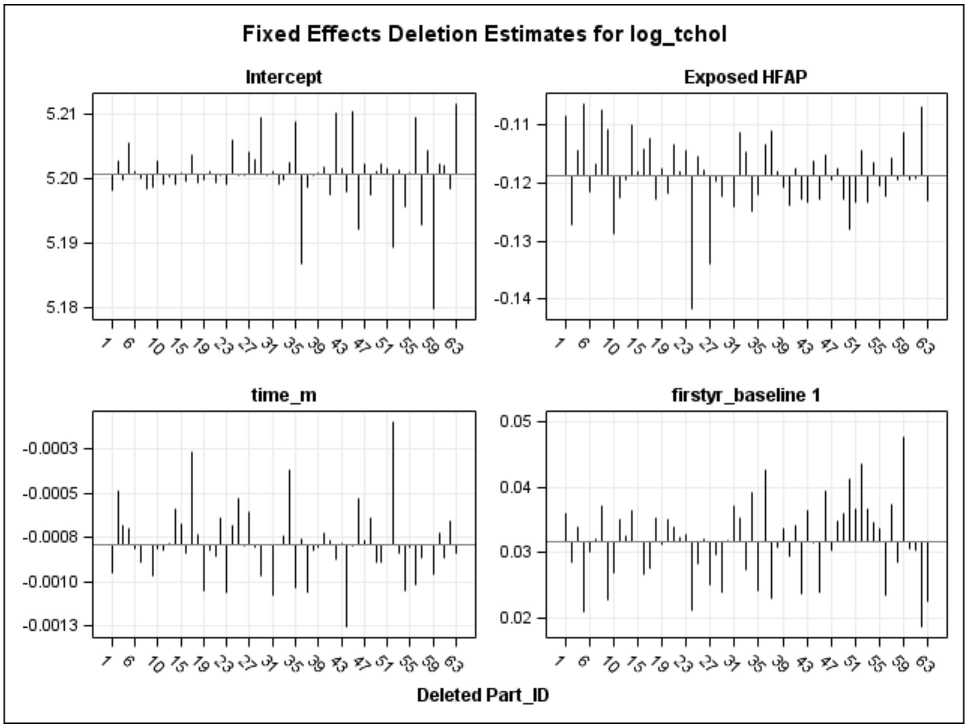
Mahalanobis Distance:

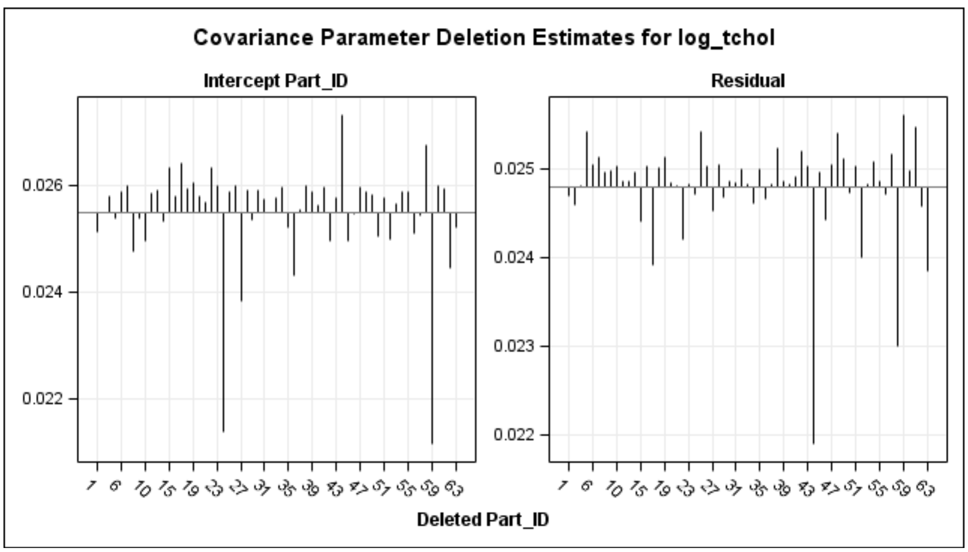


Variables	Full model	Excluding Mahalanobis < 0.025 (n=5)	% difference
intercept	33.3283	32.4666	3%
Exposure	-3.7987	-3.1008	18%
Time	0.03160	0.01364	57%
Firstyr_baseline	3.4136	3.1574	8%

Cook’s Distance and participant influence on Beta estimate and covariance parameters:

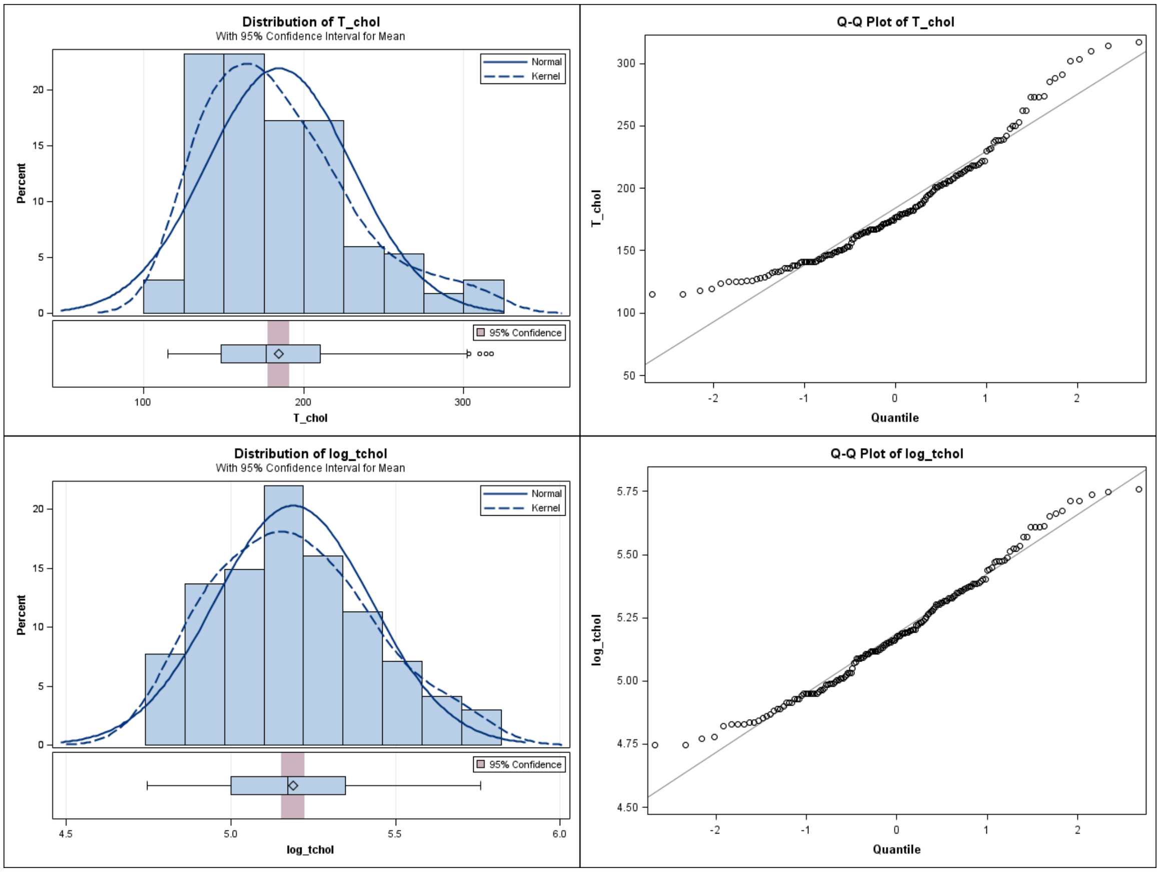



Fixed Effects Deletion Estimates for log_tchol
Intercept
Exposed HFAP
time_m
firstyr_baseline 1
Deleted Part_ID

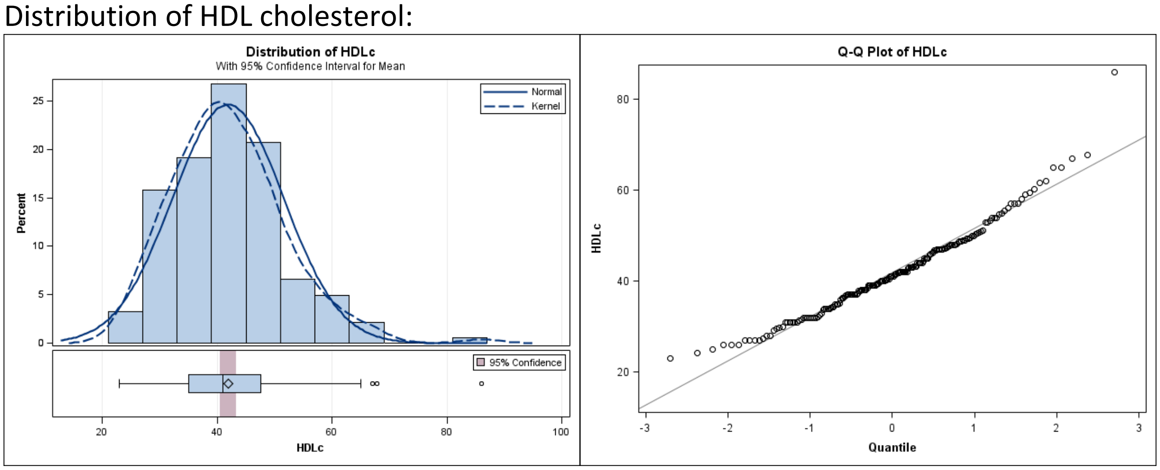

Covariance Parameter Deletion Estimates for log_tchol
Intercept Part_ID
Residual
Deleted Part_ID

Appendix E: Lipid models

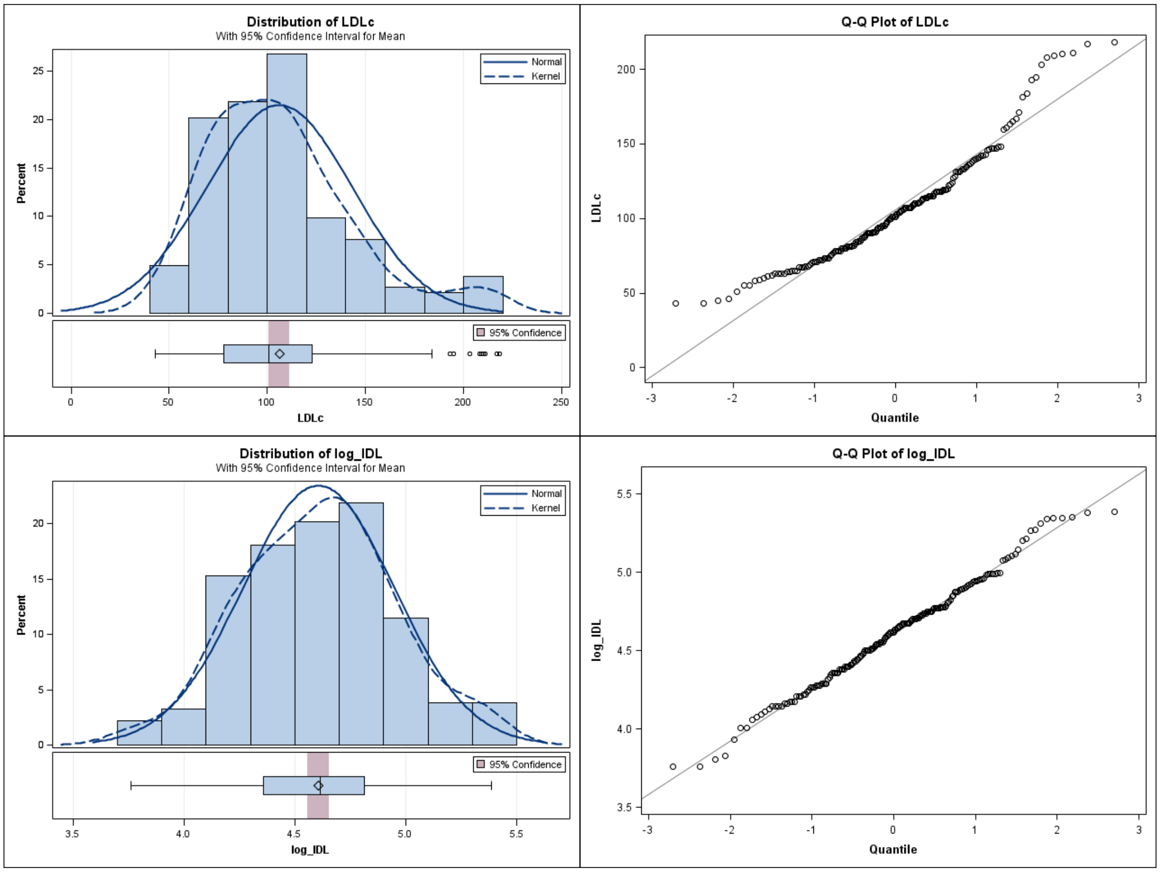
Distribution of Total cholesterol:



Distribution of HDL cholesterol:



Distribution of LDL cholesterol:



Log(total cholesterol) random intercept model:

Effect	Estimate	SE	df	T value	p-value
Intercept	5.201	0.038	58	137.02	<0.0001
Exposed	-0.119	0.054	106	-2.21	0.0295
Time (months)	-0.001	0.002	106	-0.51	0.6133
Timeserved	0.032	0.052	106	0.61	0.5441

Fitted equations for log(total cholesterol) random intercept model:

$Log(Y_{ij}) = \beta_0 + \beta_1 exposed_i + \beta_2 time_{ij} + \beta_3 timeserved(\leq 12\ months)_i + b_{1i} + \varepsilon_{ij}$

Unexposed:

$Log(Y_{ij}) = (\beta_0 + b_{1i}) + \beta_2 time_{ij} + \beta_3 timeserved(\leq 12\ months)_i + \varepsilon_{ij}$

$Log(Y_{ij}) = (5.20 + b_{1i}) – 0.001time + 0.032timeserved(\leq 12\ months) + \varepsilon_{ij}$

$SD(b_{1i}) = 0.16$

Log[95% CI b_{1i} : 5.20 ± 1.96*0.16 = (4.89–5.51)] =β_0 & 95% CI b_{1i} : 181.27 (132.95–247.15)

Exposed:

$Log(Y_{ij}) = (\beta_0 + b_{1i} + \beta_1 exposed_i) + \beta_2 time + \beta_3 timeserved(\leq 12\ months)_i + \varepsilon_{ij}$

$Log(Y_{ij}) = (5.20 – 0.119exposed + b_{1i}) – 0.001time + 0.032timeserved(\leq 12\ months) + \varepsilon_{ij} =$

$Log(Y_{ij}) = (5.08 + b_{1i}) - 0.001time + 0.032timeserved(\leq 12\ months) + \varepsilon_{ij}$

$SD(b_{1i}) = 0.16$

Log[95% CI b_{1i} : 5.08 ± 1.96*0.16 = (4.77–5.39)] =β_0 & 95% CI b_{1i} : 160.77 (117.92–219.20)

Multicollinearity between time served and obesity in the prediction of log(total cholesterol)

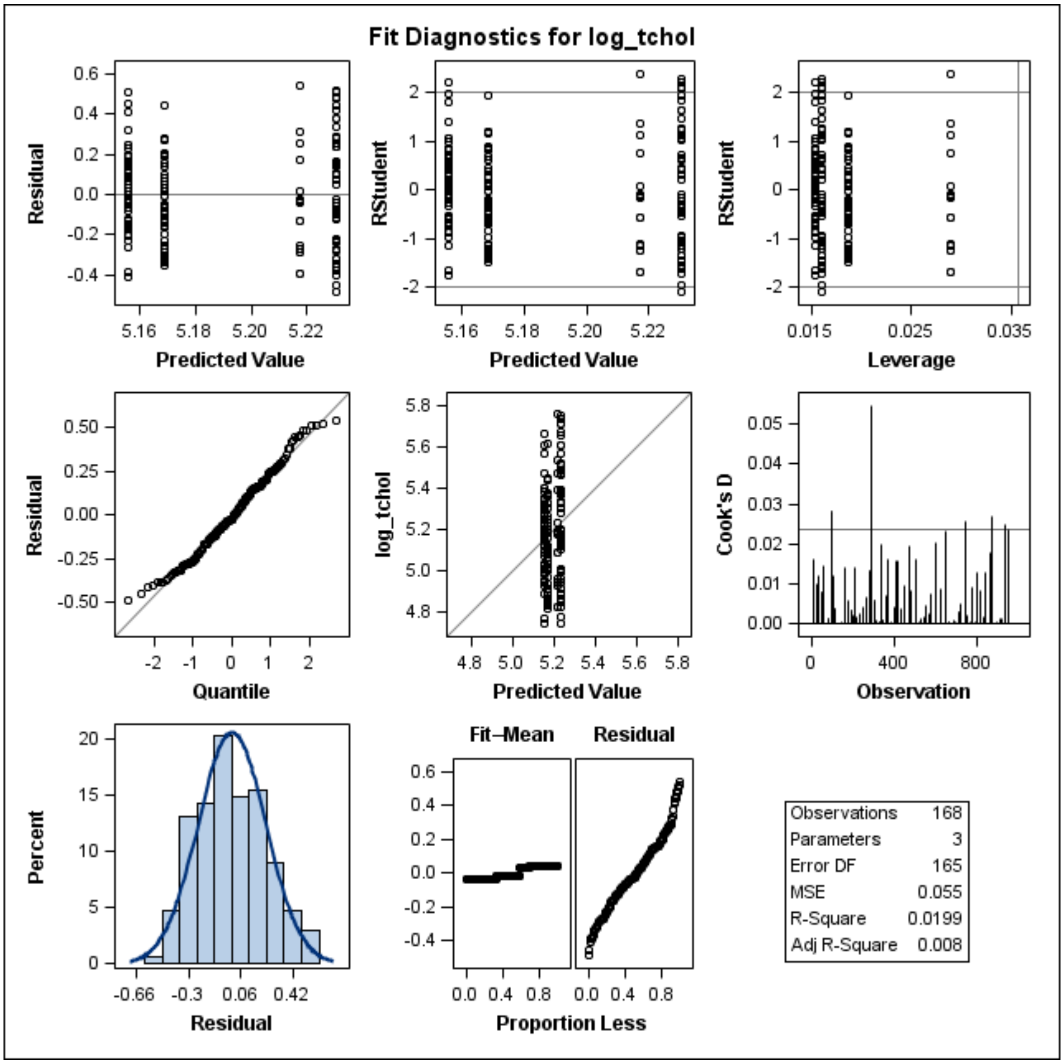
$Log(total\ cholesterol) = \beta_0 + \beta_1 exposed + \beta_2 time + \beta_3 firstyr\_baseline$

Log (total cholesterol)= 5.20 – 0.119exposed – 0.001time + 0.032firstyr_baseline

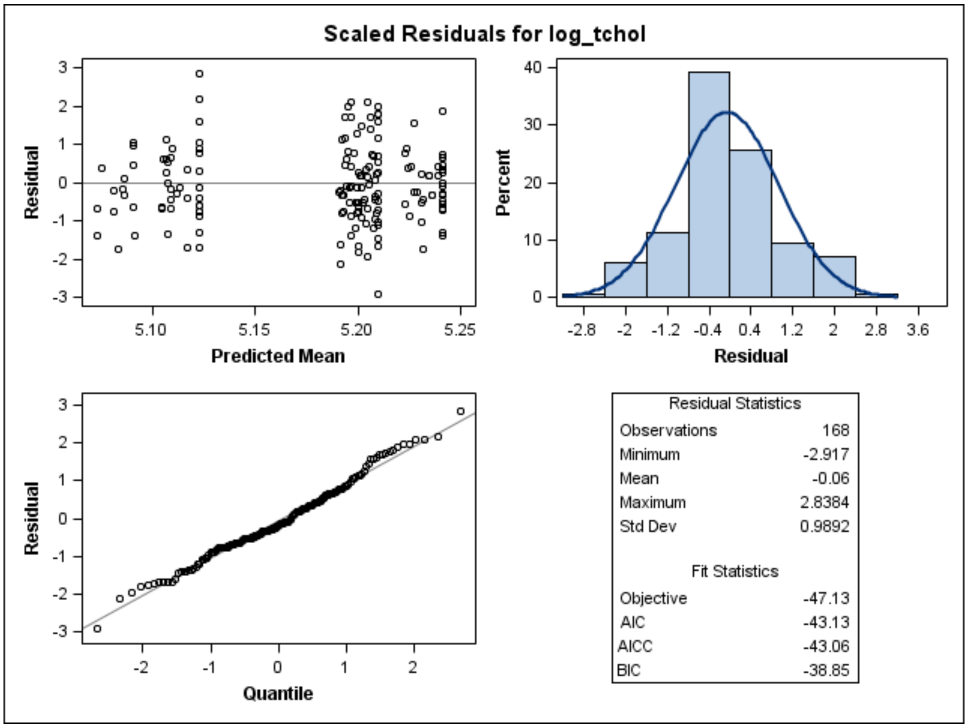
$Log(total\ cholesterol) = \beta_0 + \beta_1 exposed + \beta_2 time + \beta_3 obese\_baseline$

Log(total cholesterol) = 5.234 - 0.109exposed – 0.001time -0.031obese_baseline

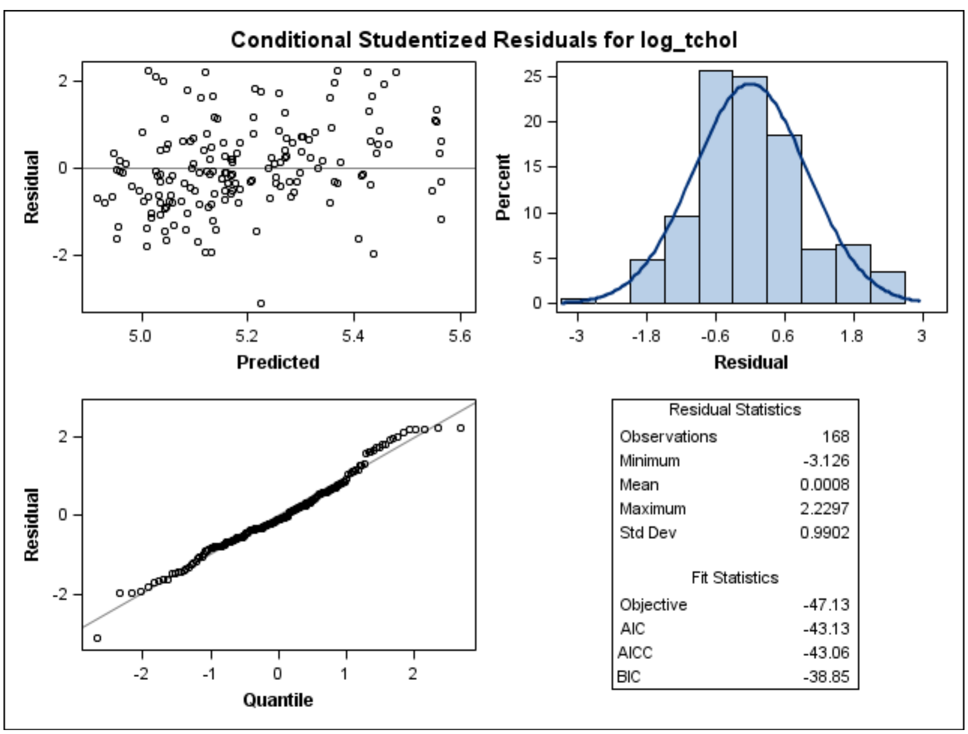
Linear Regression Parameter Estimates					
Variable	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|
Intercept	1	5.23059	0.02972	176.00	<.0001
firstyr_baseline	1	-0.01315	0.03831	-0.34	0.7319
obese_baseline	1	-0.06199	0.03852	-1.61	0.1094


Fit Diagnostics for log_tchol
Residual
Predicted Value
RStudent
Predicted Value
RStudent
Leverage
Residual
Quantile
log_tchol
Predicted Value
Cook's D
Observation
Percent
Residual
Fit–Mean
Residual
Proportion Less
Observations 168
Parameters 3
Error DF 165
MSE 0.055
R-Square 0.0199
Adj R-Square 0.008

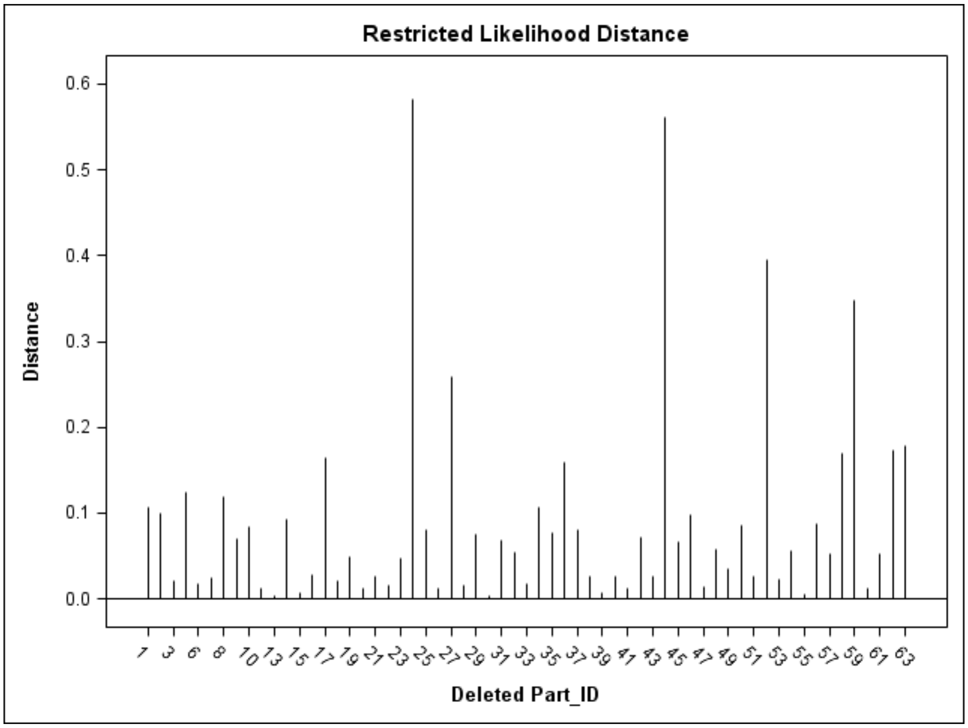
Model diagnostics for log(total cholesterol) random intercept model:
Transformed residuals:



Conditional Studentized residuals:

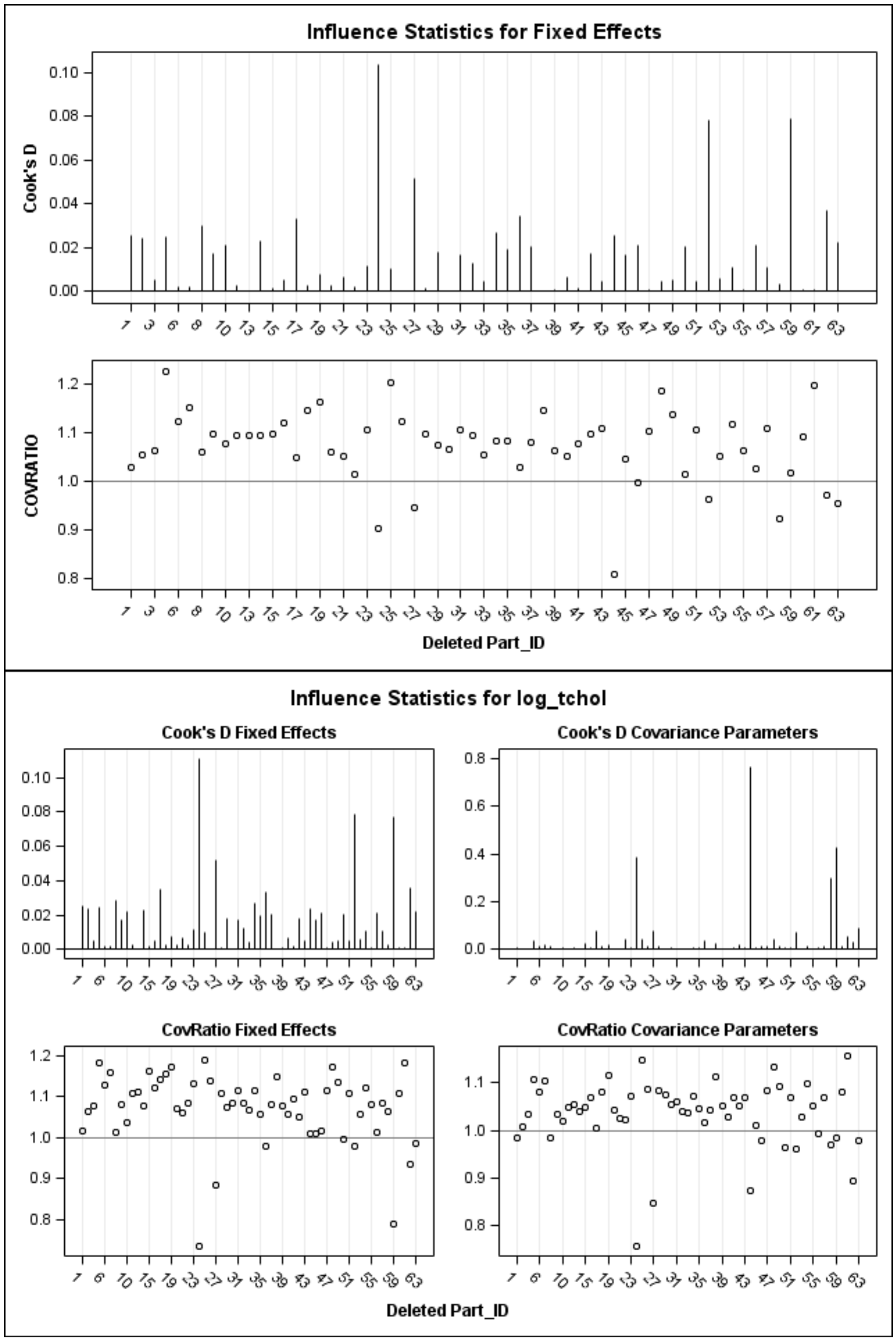


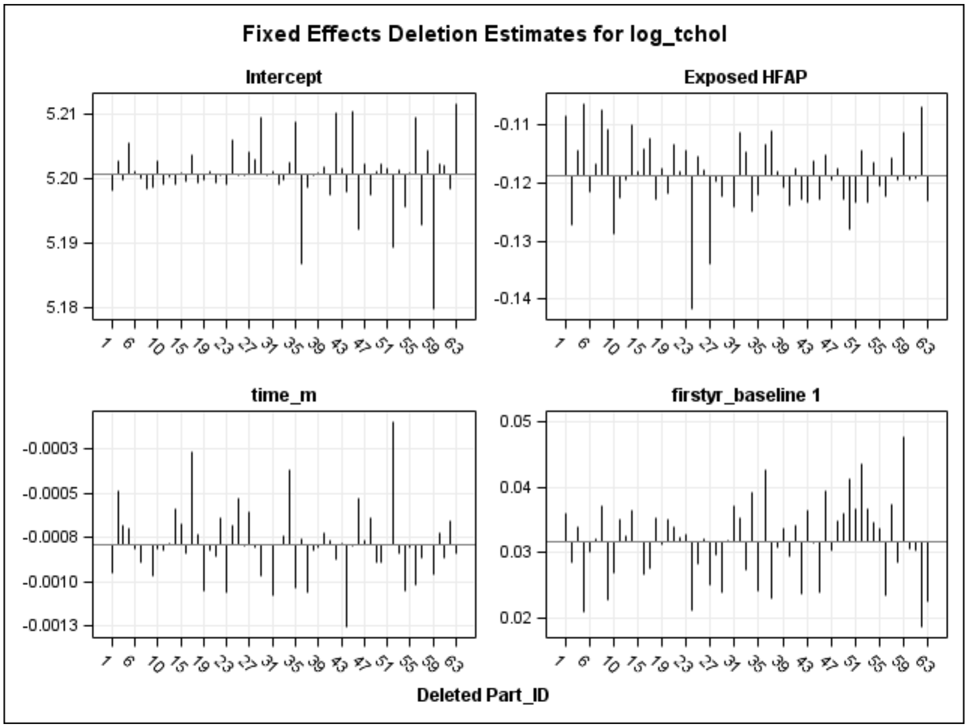
Mahalanobis Distance:



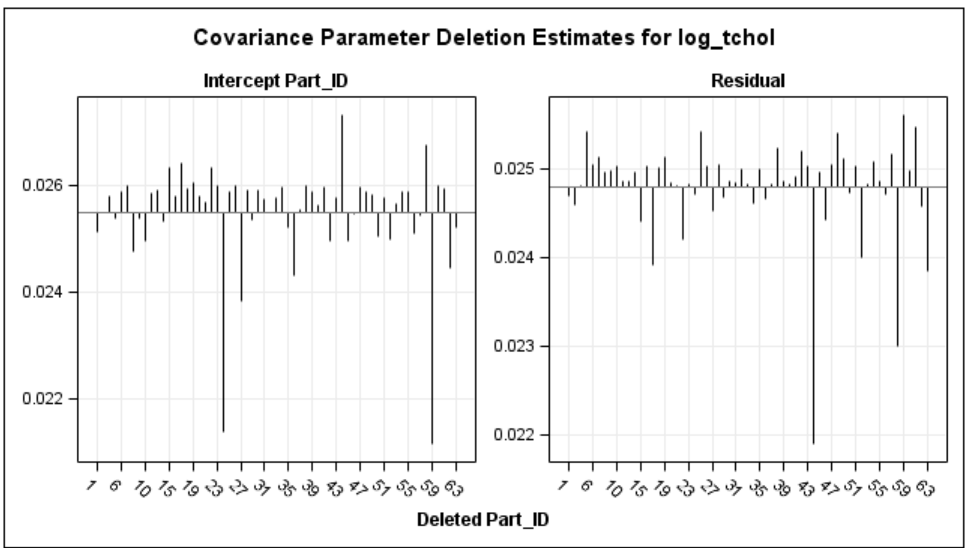
Variables	Full model	Excluding Mahalanobis < 0.025 (n=2)	% difference
intercept	5.2006	5.2035	0%
Exposure	-0.1187	-0.1393	17%
Time	-0.0008	-0.0011	38%
Firstyr_baseline	0.0316	0.0208	34%

Cook's Distance and participant influence on Beta estimate and covariance parameters:





Fixed Effects Deletion Estimates for log_tchol
Intercept
Exposed HFAP
time_m
firstyr_baseline 1
Deleted Part_ID



Covariance Parameter Deletion Estimates for log_tchol
Intercept Part_ID
Residual
Deleted Part_ID

Appendix F: Discussion tables

Table 1: Female inmate characteristics by facility and diabetes diagnosis, Coffee Creek Correctional Facility, August 2013

	Medium: Unexposed		Minimum: Exposed		Total:	
	Not Diabetic	Diabetic	Not Diabetic	Diabetic	Not Diabetic	Diabetic
Total population	608	39	587	24	1195	63
Age						
18–24	105(16)	1(3)	46(8)	1(4)	151(12)	2(3)*
25–30	150(23)	4(10)	113(18)	0	263(21)	4(6)*
31–45	237(37)	14(36)	289(47)	10(42)	526(42)	24(38)
46–60	104(16)	16(41)	126(21)	12(50)	230(18)	28(44)*
60+	12(2)	4(10)	13(2)	1(10)	25(2)	5(8)*
Race						
Asian	12(2)	1(3)	2(0)	1(4)	14(1)	2(3)
Black	48(7)	4(10)	37(6)	1(4)	85(7)	5(8)
Hispanic	22(3)	3(8)	18(3)	3(13)	40(3)	6(10)*
American Indian	20(3)	3(8)	15(2)	0	35(3)	3(5)
White	506(78)	28(72)	515(84)	19(79)	1021(81)	47(75)*
Time to release						
≤3 months	40(6)	3(8)	61(10)	5(21)	101(8)	8(13)*
3–6 months	42(6)	4(10)	73(12)	4(17)	115(9)	8(13)
6–9 months	49(8)	0	85(14)	3(13)	134(11)	3(5)
9–12 months	37(6)	1(3)	75(12)	2(8)	112(9)	3(5)
12–24 months	122(19)	5(13)	170(28)	6(25)	292(23)	11(17)
24+ months	310(48)	26(67)	123(20)	4(17)	433(34)	30(48)
Life sentence	41(7)	6(15)	3(0)	0	44(4)	6(10)

*A significant difference between non-diabetic and diabetic groups (α 0.05). A X^2 Test of two proportions was conducted unless the expected cell count fell below 1 then a Fisher Exact test was used.

Table 2. Reported mental health need among inmates in Oregon Department of Corrections by gender, August 2013

	Medium	Minimum	Total female	Total male
n	647	611	1,258	13,344
Mental Health:				
Highest treatment needed	106(16)	22(4)*	128(10)	848(6)**
Severe mental health problems	270(42)	192(31)*	462(37)	1820(14)**
Moderate treatment needed	79(12)	138(23)*	217(17)	1150(9)**
Benefit from treatment	59(9)	102(17)*	161(13)	2506(19)**
No need for treatment	43(7)	52(9)	95(8)	2731(20)**
No reported mental health need	90(14)	105(17)	195(16)	4289(32)**

* A significant difference between Coffee Creek Correctional Facilities (α 0.05).

** A significant difference between female and male inmates (α 0.05).

Figure 1: Hba1c plotted over time by exposure and oral medication use