Impact of Dietary Recommendations Shift on Chronic Kidney Disease[⋆,⋆⋆]

Sayed Ahmed[a,*,1], Dr. Youcef Derbal[b,**,2]

[a]Data Science Department, Ryerson University, Toronto, Canada
[b]Department of Information Technology Management, Ryerson University, Toronto, Canada

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ABSTRACT

Chronic Kidney Disease (CKD) leading to End-Stage Renal Disease (ESRD) is very prevalent today. Over 37 millions of Americans have CKD. CKD/ESRD and interrelated diseases cause a majority of the early deaths. Many research studies have investigated the effects of drugs on CKD. However, less attention has been given to the study of the dietary patterns on CKD. Additionally, recent dietary recommendations shift is not extensively studied for impact on CKD patients. This research study has uncovered significant correlations between dietary patterns and CKD mortality, also between dietary patterns and CKD diagnostic markers such as the Albumin to Creatinine Ratio (ACR). This study also compared the findings with Dietary Recommendations shift for Impact Analysis on CKD patients. In this project, Dietary surveys from NHANES, and CKD Mortality dataset from USRDS, Food Grouping datasets from USDA, Shift Recommendation study from CDC were utilized. Principal Component Analysis and Regression were utilized to find the effect on CKD mortality. Grains, Fruits, Alcohols showed negative correlations where Vegetables, Other Vegetables showed positive correlations. ACR values were not found strongly correlated with dietary patterns. These finding are compared with Dietary Recommendations Shift.

1. Introduction

Chronic kidney disease (CKD) is very prevalent in today's world and CKD incidents are continually increasing whereby 10 to 13% of the US population are affected by Chronic Kidney Disease. CKD/ESRD and other interrelated diseases such as Hypertension, Heart Diseases, and Diabetes cause the majority of early deaths [31]. In addition to kidney failure, CKD is also a major cause of death from stroke, and heart diseases. On the other hand, hypertension and diabetes are also major causes of CKD. CKD is not reversible, progressive and gradually reduces kidney function.

Primary causes of CKD include High Blood Pressure, and Diabetes. Other causes include infection, kidney stones, genetics, genetical polycystic kidney disease, certain foods and food habits, pain killers, and drug usage/abuse. As CKDs are neither curable nor reversible controlling diabetes and blood pressure with or without medication can slow the progress of CKDs in most cases. As Kidneys filter waste products and our diet produces those waste products controlling diet have an effect on how much work kidney has to perform, and how well kidneys will function. Studies show that drugs as well as lifestyle choices (food, diet, exercise) can prevent CKD, slow the progression of CKD [29], delay dialysis and kidney transplantation; consequently can prevent early deaths. Although there are many studies on the effect of drugs to control CKD and related complications, there are few studies on the effect of diets, dietary patterns, and lifestyles [29]. There are studies on how controlling nutrients/chemicals in food items can help to prevent or to slow the progression of CKD. CKD patients are also provided recommendations on certain chemicals or food items. However, adhering to the recommended amount of nutrients and/or food item is challenging. Hence, there is an emerging trend where the effect is studied utilizing dietary patterns with food groups and food subgroups rather than nutrients/chemicals in food or individual food item. This research analyzes the effect of dietary patterns, using food groups and food subgroups, on the mortality and survival of CKD patients. Also studied in this research is the correlation between dietary patterns and ACR.

As Dietary recommendations are difficult to adhere to in food item or nutrient level, there are studies such as by CDC (health.gov) to shift the recommendations for diet in food group and subgroup level i.e. eating patters. This study also has explored the dietary recommendations shift by CDC and compared the correlation of Food Groups/Subgroups with CKD Mortality and ACR to understand how the shift recommedation affect CKD patients.

1.1. How CKD is Identified and Measured

CKD is identified with one of two measures such as a blood test named Glomerular Filtration Rate (GFR) or a urine test named Albumin to Creatinine Ratio (ACR). ACR val-

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Just another note. Impact of Dietary Recommendations Shift on CKD Patients

*Corresponding author

**Principal corresponding author

sayed.ahmed@ryerson.ca (S. Ahmed); yderbal@ryerson.ca (Y. Derbal)

ryerson.ca, sayed.ahmed@ryerson.ca (S. Ahmed); ryerson.ca, yderbal@ryerson.ca (Y. Derbal)

ORCID(s): 0000-0001-7511-2910 (S. Ahmed)

[1]This is the first author footnote. but is common to third author as well.

[2]Another author footnote, this is a very long footnote and it should be a really long footnote. But this footnote is not yet sufficiently long enough to make two lines of footnote text.

ues less than 30 indicates no CKD or mild CKD. ACR values between 30 and 300 indicate moderate CKD. ACR values >300 indicates severe CKD. Patients are diagnosed with a CKD disease if the ACR values persist within the above ranges for three months. GFR is measured in ml/min/1.73 m2. CKDs as measured with GFRs are described in stages such as Stage 1 with normal or high GFR (GFR greater than or equal to 90 mL/min), Stage 2 with Mild CKD (GFR = 60-89 mL/min), Stage 3A with Moderate CKD (GFR = 45-59 mL/min), Stage 3B with Moderate CKD (GFR = 30-44 mL/min), Stage 4 with Severe CKD (GFR = 15-29 mL/min), Stage 5 with End Stage CKD (GFR <15 mL/min) [5]. At stage 5, patients loose complete kidney function. At this point, patient survival will require either dialysis or organ transplantation.

1.2. Dietary Recommendations Shift

2. Literature Review

Kidney patients are commonly given dietary advice about intake of individual nutrients, chemicals, food items, or about their whole eating patterns. However, dietary recommendations are challenging to adhere to for the majority of the patients [2]. Also, there is limited evidence that adherence to such advice prevents clinical complications [23]. Hence, studying the whole dietary patterns rather than single nutrient or food group restrictions is an emerging trend for CKD/ ESRD patient diets [2] [24-26]. This is also easier to adhere to. There are several studies on analyzing the relation between dietary patterns and clinical outcomes for CKD patients [3, 4, 5, 6, 7, 8, 9, 26].

Chen at al [3] studied the association between plant protein intake and mortality in CKD. In the study higher plant protein ratio was found to cause lower mortality for CKD patients in stage 3 or higher (eGFR <60 ml/min/1.73 m2) though not for others (stage 1 and 2) [3]. This study primarily used statistical methods and Regression Models such as Cox regression models to find the association [3]. Hao-Wen et al [26] studied the association between vegetarian diets and CKD. The study found that vegetarian diets including vegan and ovo-lacto vegetarian diets were possible protective factors. The study utilized The multivariable logistic regression analysis [26].

Gutiérrez et al [4] studied 5 empirically derived dietary patterns such as "convenience" (Chinese and Mexican foods, pizza, and other mixed dishes), "plant-based" (fruits and vegetables), "sweets/fats" (sugary foods), "Southern" (fried foods, organ meats, and sweetened beverages), and "alcohol/salads" (alcohol, green-leafy vegetables, and salad dressing) [4]. The study found that dietary pattern rich in processed and fried foods was associated with higher mortality in persons with CKD. On the other hand, a diet rich in fruits and vegetables was found to be protective [4].

Huang et al. [5] studied whether Mediterranean diet can preserve kidney function along with maintaining favorable cardiometabolic profile with reduced mortality risk for individuals with CKD. The study found that adhering to Mediterranean diet has a lower likelihood of having CKD in elderly men. The study also found that a greater adherence to this diet can improve survival for CKD patients [5]. Huang et al [5] in the above study, used unpaired t test, nonparametric Mann–Whitney test, or chi-square test as appropriate for Comparisons between CKD and non-CKD men. To evaluate the association of Mediterranean diet with the presence of CKD, Crude and multiple adjusted logistic regression models were fitted. All tests were two-tailed, and P <0.05 was considered significant [5]. One aspect of Muntner et al [6] study was to find out how Life's Simple 7 factors (Smoke, Activity, BMI, Diet, Blood Pressure, Cholesterol, and Glucose) affect in getting ESRD. For each factor, participants were assigned to one of three levels of compliance to the recommendations. The three levels are ideal, intermediate, and poor. The study shows that people who have ideal scores in more of these factors have lower likelihood of getting ESRD. This study utilized Cox proportional hazards models. Adjustment were made for age, race, sex, stroke-based geographic region of residence, income, education, and history of stroke or coronary heart disease [6].

Ricardo et al [7] studied the association of death to healthy lifestyles especially in relation to CKD. The study found that adherence to healthy lifestyles was associated with lower risk for mortality in CKD patients. In this study, to determine the association between a healthy lifestyle and survival among individuals with CKD, Cox proportional hazards models were used while also adjusting for important covariates. Stratified survival analyses by eGFR and UACR was performed for Sensitivity analyses [7]. Suruya et al. [8] studied dietary patterns in hemodialysis patients in Japan and researched associations between dietary patterns and clinical outcomes. The study found that patients with unbalanced diet were more likely to have adverse clinical outcomes. Hence, such patients when in addition to portion control, maintains a well-balanced diet especially for the food groups meat, fish, and vegetables will have less adverse clinical outcomes [8]. Suruya et al [8] utilized a principal components analysis (PCA) with Promax rotation to reduce to a smaller set of food groups for analysis. PCA was used to find food groups eaten with equal frequencies [8]. Cox regression model was used for the analysis with multiple models where each model had a different combination of covariants [8].

Another study by Ricardo et al [9] estimated the degree of adherence to a healthy lifestyle that decreases the risk of renal and cardiovascular events among adults with chronic kidney disease (CKD). The study found that adherence to a healthy lifestyle was associated with lower all-cause mortality risk in CKD. The greatest reduction in all-cause mortality was related to nonsmoking [9]. This study by Ricardo et al [9], to compare categorical and continuous variables used Chi-squared and analysis of variance tests respectively. To examine the association between healthy lifestyle and outcomes, Cox proportional hazards models were used. Death was treated as a censoring event. Three nested Cox propor-

tional hazards models were fitted and were adjusted sequentially for potential explanatory variables [9]. G. Asghari et al [27] studied the association of population-based dietary pattern with the risk of incident CKD. The study concluded that high fat and high sugar diet pattern is associated with significantly increased (46%) odds of incident CKD where a lacto-vegetarian diet can be protective of CKD by 43%. The study utilized multivariable logistic regression to calculate odds ratio for the association.

Overall, most of the reviewed studies primarily used direct clinical data of patients for several years and applied statistical analysis primarily. This research primarily utilized public datasets from CDC, USRDS. One of the studies above utilized the dietary pattern data from CDC and NHANES like this study. However, this study will differ in the methodology, exploration, and analysis. This study is finding relations between datasets from multiple sources and is focused on finding patterns and relations in general population than specific/selected individuals. Most of the studies above utilized primarily statistical methods and sensitivity analysis where primarily regression models especially Cox regression models were used. In a couple of cases, Principal Component Analysis (PCA) was used. This research primarily utilized public datasets from CDC, USRDS, Health.gov. For association and prediction, PCA, Regression, and several machine learning approaches are utilized. For food groups and subgroups, we utilized the USDA categorization. Recommended amounts for food groups provided by CDC/Health.gov is used. Additionally, ACR values are predicted based on datasets by CDC such as NHANES dietary intake survey, and laboratory data on ACR. For the prediction, machine learning approaches are used. The machine learning approaches used for ACR value prediction are: Regression and Bayesian.

3. Methodology

The research methodology is summarized by the diagram given in Figure 1. The primary purpose of this research is to assess the effect of dietary patterns on the ACR levels, survival and morbidity for chronic kidney disease (CKD)/End Stage Renal Disease (ESRD) patients.

3.1. Methodology Overview

A dataset released by CDC/Health.gov with the dietary habits and ACR values for 10,000 individuals are studied. Also, age group based mortality and survival of CKD/ESRD patients provided by USRDS are studied. Afterwards, utilized Principal Component Analysis to identify the most important food groups and subgroups affecting the ACR value and the Mortality/Survival. Statistical regression and factor analysis was then applied to understand the correlation between ACR, and Mortality/Survival to dietary patterns. Machine learning approaches including Regression, Polynomial Regression, and Bayesian with or without 10 fold cross validations are applied on the datasets to understand if dietary patterns can be used to predict ACR values and mortality.

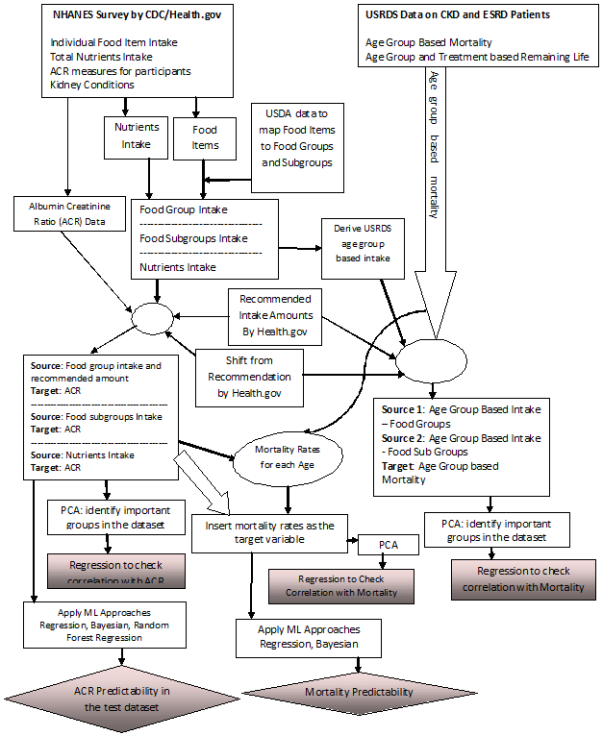

Figure 1: Methodology in a Diagram

In addition to studying the association of CKD mortality and ACR values with ratios from the recommended high, we have explored the potential impact of diet recommendation shift [11], on the incidence of CKD in the general population.

3.2. Study Selection

For dietary patterns, CKD measures (such as Albumin to Creatinine Ratio - ACR), and Kidney condition measures, a dataset from the National Health and Nutrition Examination Survey on dietary habits conducted by the CDC [10] was used. The survey has data from 1996 to 2016 [10]. This study primarily utilized data for 2015-2016. The survey recorded 24 hours individual food item intake amount. Two surveys were taken within 3 to 10 days apart. Each survey provided food item intake amounts in a day and recorded the diet style as well as diet-restrictions. Individual food items are represented using USDA food code. The survey also provided total nutrients data. CDC also released examination, laboratory, demographics, and other related data for those participants. This study explored and utilized examination data such as Kidney Condition data, laboratory data such as ACR data & Blood Pressure data, and demographics data for age.

For mortality and survival information, dataset from the United States Renal Data System (USRDS) on CKD and ESRD [16, 17] were utilized. "USRDS investigates the transition of care from CKD to ESRD and end-of-life care for those with advanced kidney disease" [19]. USRDS also releases data on the Incidence, Prevalence, Patient Characteristics, and

Treatment Modalities on CKD, and ESRD patients. USRDS reports survival and mortality using metrics such as Mortality rates, Total Mortality Count, 90 day survival for dialysis and/or transplantation patients, 10 year survival for dialysis and/or transplantation patients, Average Expected remaining lifetime with or without pre-condition and treatment options used. The data are either aggregated or patient specific detail data. However, only aggregated data are public where patient specific data access requires special request and permission. This research utilized only the public dataset i.e. age-group based aggregated data. In couple of experiments, aggregated age-group based data from USRDS was mapped to specific age for NHANES data for each age and participants.

The dietary survey data (NHANES) represented the food items taken by the participants using USDA food codes [14, 12, 13]. Hence, USDA food codes [14, 12, 13] are used to assign food groups and subgroups to the NHANES [10] survey data to properly group/subgroup the dietary intake of the participants with some customizations.

3.3. Data Synthesis

NHANES survey data as provided for two days are averaged to get the intake amount for one day. Both individual food item data and nutrients intake data are averaged. USDA food codes are used to map food items to food groups and subgroups.

ACR and Kidney condition data for each individual are merged with the averaged food groups, subgroups, and nutrients data. This data was further complemented with the food group recommendations data from health.gov, and mortality rate by age from the USRDS. ACR values and mortality rate are used as the target variables.

PCA was applied to find out important food groups and subgroups while regression was applied to find potential associations with ACR and Mortality. Linear Regression, Polynomial Regression, Random Forest Regression, Bayesian prediction with or without 10 fold cross validations were applied to study the predictability of ACR Values and Mortality in the test dataset.

In another mortality experiment, the above synthesized datasets were aggregated for USRDS age groups to calculate average food group/subgroup intake by age groups.

4. Results

Associations of Food Groups, Food Subgroups, Food Nutrients with CKD mortality as discovered by the experiments above are provided in this section. Outcome of ACR value prediction in the test data are also provided.

4.1. Food Groups, Food Subgroups, Food Nutrients and CKD Mortality

Food Groups and Mortality

Experiments (Set 1) with aggregated NHANES and USRDS data to find associations between food groups and CKD mortality using PCA and Regression show that Grains (-0.84) and Fruits (-0.43) have negative correlations with CKD mortality i.e. mortality is high for the patients who took significantly lower amount of Grains and Fruits than recommended amounts. Data exploration (plots below) also reflects the negative relation. As the correlation for fruits is -0.43 i.e. not very high, hence, Fruits can be thought of mildly/moderately associated.

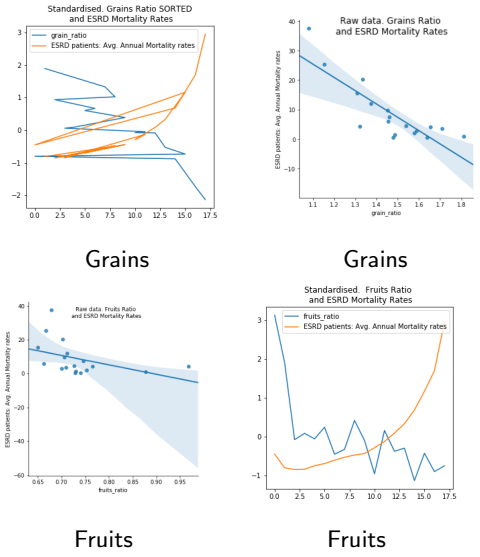

Figure 2: Food Groups and Mortality - Negative Correlations

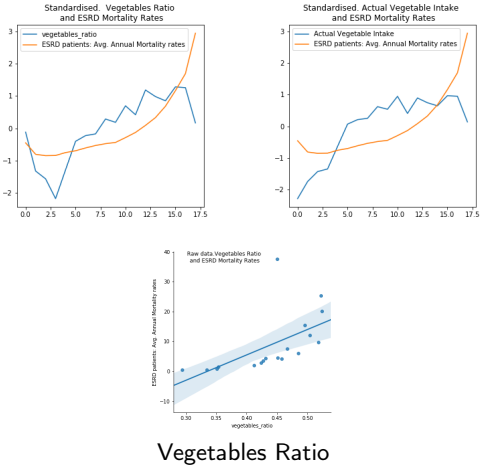

Figure 3: Food Groups and Mortality - Positive Correlations (Vegetables)

Vegetables show positive (0.58) correlation i.e. mortality is high for the patients who took more vegetables. The correlation of 0.58 does not provide a very strong conclusion. Data shows such correlations in older adults. Even though ratios of food intake amount to high end of recommended amounts (actual intake amounts also show positive relation) were used; age might have biased the correlation. This does not show conformity with the general recommendation to take more vegetables for CKD patients. However, as exper-

iments with food subgroups show that vegetable subgroups such as Other vegetables (0.68), Red and Orange vegetables (0.55), and Starchy vegetables (0.44) show positive correlations that have an impact on the Vegetable group correlation. Although more vegetable intake is a general recommendation for CKD patients, certain vegetables with more carbohydrates (and sugars) such as Starchy Vegetables as well as Vegetables with more Potassium and Calcium such as Tomatoes, and Spinach are recommended to be taken at a lower amount. For diabetes induced CKD, starchy vegetables are not highly recommended in general. Considering the subgroups, the moderate positive correlation as this study found for vegetables food group is in conformity with the general recommendations for CKD patients.

Experiments (Set 2) with aggregated NHANES and USRDS data to find associations between food subgroups and CKD mortality using PCA and Regression show that Other vegetables (0.68), Red and orange vegetables (0.55), and Starchy vegetables (0.44) have positive correlations with mortality i.e. mortality is low when the intake amounts are low, and mortality is high when intake amounts are high. Data Exploration plots as given below also show these positive relations.

Food subgroups such as Alcoholic Beverages (-0.79), Added Sugars/Sugars and Sweets (-0.64), Whole Grains (-0.61), and 'Nuts, Seeds, and Soy Products' (-0.55) show the most negative correlations with CKD mortality. Data exploration also shows negative correlations as shown in the charts below. These outcomes are also consistent with current knowledge except for Sugars. Prevalence of Stage 3 CKD is lower in Alcohol Drinkers than non-drinkers [2, 49], Nuts being Phosphorus rich and Whole Grains being Potassium rich are detrimental to CKD patients and can cause higher mortality when taken in higher quantities.

Mortality Study with Non-aggregated Data

For experiments (Set 7) where mortality rates based on ages were used for each NHANES survey row (i.e. not aggregated), the following food subgroups show more positive correlations than others: Fats, Eggs, Other vegetables, Non-alcoholic beverages, White potatoes and Puerto Rican starchy vegetables, Tomatoes and tomato mixtures, Oils, Deep-yellow vegetables respectively. In the study, the following subgroups showed more negative correlations than others: Grain mixtures, Frozen plate meals, Soups, Crackers and Salty snacks from grain products, Milks and milk drinks, Sandwiches with Meat, Poultry, and fish, Poultry. Although the correlation numbers in this study are very low, the positive and negative correlations are consistent with current knowledge [48, 49, 50, 51, 52, 53, 54, 55, 56, 57].

Food Groups, Food Nutrients, and Albumin to Creatinine Ratio (ACR) Association

The experiments (Set 3, 4, and 5) using PCA and Regression showed negligible correlation between ACR and food groups and subgroups intake. However, some food groups and/or nutrients such as Dairy, and 'Sugars, Sweets, and Beverages' have higher and positive though negligible (0.02) effect than the others where Fruits (-0.01) showed negative

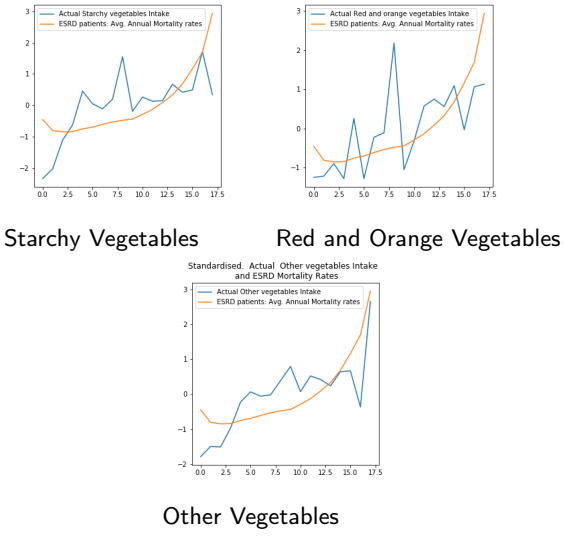

Figure 4: Food Subgroups and Mortality - Positive Correlations

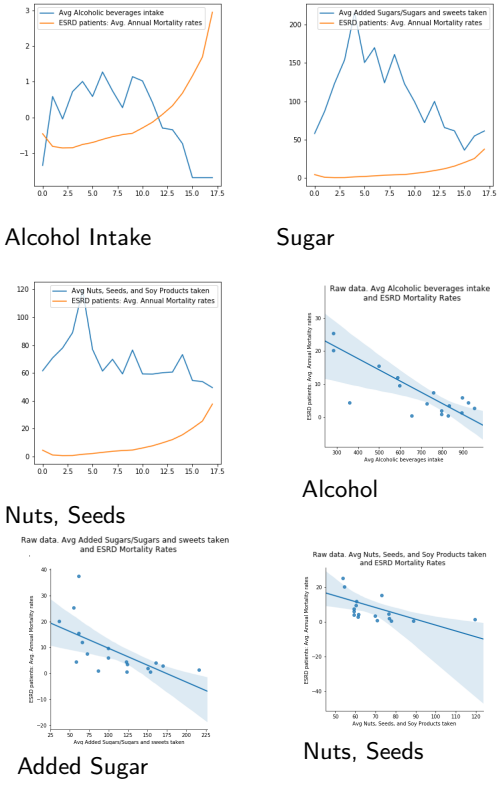

Figure 5: Food Subgroups and Mortality - Negative Correlations

effect. For nutrients, Polyunsaturated fatty acids (-0.02), and Iron (-0.02) have negative correlations where Choline (0.02) showed better positive correlation than others. Findings for Choline matches with medical knowledge [48]. As the correlations are not significant further analysis can be done on the data especially for food groups and nutrients that are found important (using PCA) in the data as provided below: Dairy, Fats, oils, and salad dressings', Fruits, Grains, Pro-

tein, Sugars, sweets, and beverages', Vegetables, Avg energy kcal, avg protein gm, avg carbohydrate gm, avg total fat gm, avg total saturated fatty acids gm, avg total monounsaturated fatty acids gm, avg total polyunsaturated fatty acids gm, avg lutein zeaxanthin mcg, avg thiamin vitamin B1 mg, avg riboflavin Vitamin B2 mg, avg Niacin mg, avg Calcium mg, avg Phosphorus mg, avg Magnesium mg, avg Iron mg, avg Zinc mg, avg Copper mg, avg Sodium mg, avg Potassium mg, avg Selenium mcg, Hexadecenoic gm, Octadecenoic gm

4.2. Food Subgroups and Albumin to Creatinine Ratio (ACR) Association

The experiments showed 'Milk desserts, Sauces, Gravies' (0.22), and Alcoholic Beverages (0.087) have more positive correlations with ACR than the other food subgroups i.e. taking more of these food subgroups results higher ACR values. Research by Uehara et al. [55] also shows that excessive Alcohol consumption can cause Proteinuria/Albuminuria (high ACR). Nettleton et al. [56] found that high fat dairy can be linked to high ACR values where low-fat dairy is not strongly linked to high ACR values. However, the correlation as this research found is very low. Low values might still explain a correlation where ACR values might depend on other factors in together than only these food subgroups. Fruits and juicy baby foods show negative correlation (-0.04) though not significant i.e. taking high amount does not increase ACR values that matched with current knowledge [57].

4.3. Relation with Shift Recommendation

Recommended Shift: Include more vegetables from all subgroups where with few exceptions, the U.S. population does not meet intake recommendations for any of the vegetable subgroups.
Our Study: This study found moderate positive correlations with mortality for CKD patients. Hence, more vegetables intake is from all vegetable subgroups is not highly recommended for CKD patients. As this study also finds that food subgroups such as Other Vegetables, Red and Orange Vegetables, and Starchy vegetables are positively correlated with mortality; hence, limiting these subcategories with moderate intake of overall vegetables can be beneficial to CKD patients.

Recommended Shift: Increase fruit (whole fruit) intake for all individuals. Also, take fruits as snacks, salads, and side-dishes.
Our Study: This study finds Fruits has negative correlations with CKD mortality. Hence, more fruits intake will be beneficial to CKD patients. Shift recommendation is in align with our study.

Recommended Shift: Half of all grains should be whole grain.
Our Study: This study found strong negative correlation of Grains with CKD mortality i.e. more Grain intake showed low mortality rates. Hence, like shift recommendations, CKD patients will benefit by taking recommended amount of Grains. However, this Grain intake includes both whole and refined grain intake. This study also found that Whole grain has moderate negative correlation with mortality i.e. Refined grain contributed to the overall strong correlation. Hence, refined grain-based products can be seen to contribute in negative correlation. Whole grains having rich in Potassium are not highly recommended for CKD patients (I have to check for what level of CKD). CKD patients might get benefit with a mix of whole and refined grain based products where finding the ideal ratio will need further research.

Recommended Shift: Increase dairy intake in fat-free form.
Our study: This study did not find any strong correlation between dairy products and mortality. However, this study found positive correlation of Urine ACR with dairy products i.e. Urine ACR is high when dairy products are taken more.

However, the recommended Shift i.e. Increase dairy intake in fat-free form consistent with the recommendation done to CKD patients.

Recommended Shift: Increase seafood intake where Teen boys and adult men are recommended to reduce protein intake (instead increase/replace that with vegetables)
Our study: This study did not find any strong correlation between protein and mortality.

However, CKD patients based on stages of CKD are recommended to take moderate amount of Protein. The recommended shift i.e. Reduce protein intake for Teen Boys and Adult Men will help CKD patients for that age groups along with others.

Recommended Shift: Increase Oil intake and reduce solid fat intake. Use Oils rather than solid fats.
Our Study: This study did not see any strong correlation in this regard for CKD patients

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Recommended Shift: Reduce added sugars to less than 10% of calories intake per day.
Our Study: This study found negative correlation between CKD mortality and Added Sugars i.e. Less sugar intake is related to high mortality. This is contradictory to current knowledge and goes against shift recommendation. However, investigation is required on our data and finding to see what were included in the sugar category.

Recommended Shift: Reduce saturated fat intake to 10% of calories per day. Shift to take more polyunsaturated and monounsaturated fats than saturated fats.
Our study: Polyunsaturated fatty acids have negative correlation with CKD mortality i.e. CKD patients will benefit by taking more Polyunsaturated fatty acids. Hence, recommended shift will benefit CKD patients.

Recommended Shift: Reduce Sodium Intake.
Our Study: This study did not find any correlation between Sodium and CKD Mortality (I have to verify to what extent sodium is included or not in the study).

5. Conclusions

Chronic Kidney Disease (CKD) leading to End Stage Renal Disease (ESRD) is very prevalent today; treatment facilities for dialysis, and donors for organ transplantation are limited. Consequently, many patients die waiting for proper treatment (recent news on USA, Bloomberg). Majority of the studies focused on drugs to control CKD progression where some studies focused on diets, Nutrients, and Food Items. Controlling CKD using changes to dietary patterns can be beneficial to both the patients and the economy. Hence, this study focused on the effect of dietary patterns on CKD mortality as well as on a CKD measure named Albumin to Creatinine Ratio (ACR). PCA and Regression are used to study the association between ACR and CKD mortality/survival. Additionally, regression models are trained to predict ACR values from dietary patterns. Grains, Other Vegetables showed positive correlations with Mortality whereas Alcohol, Sugar, and Nuts showed negative correlations. ACR values were not found strongly correlated with dietary patterns. Overall, the results of this research matched the findings of other studies and current knowledge with few exceptions. Machine Learning approaches showed that ACR values could be predicted in the test dataset with high accuracy; the best performing approach was 10 Fold Cross Validation for Polynomial Regression (95%).

6. Bibliography

A. My Appendix

CRediT authorship contribution statement

Sayed Ahmed: .... **Youcef Derbal:** ....

Author biography with author photo. Author biography.

Author biography with author photo. Author biography. Author biography. Author biography. Author biography. Author biography. Author biography. Author biography. Author biography. Author biography. Author biography. Author biography. Author biography.