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R Code used to produce results

01 July, 2020

Contents

Preliminaries

Packages

Load in the required packages and set baseline plotting parameters. Non-CRAN packages show source repositories.

```r
library(tidyverse)
library(finalfit)
library(phsmethods) # remotes::install_github("Health-SocialCare-Scotland/phsmethods")
library(broom)
library(here)
library(janitor)
library(socviz)
library(glue)
library(ComplexUpset) # remotes::install_github("krassowski/complex-upset")
library(kableExtra)
library(extrafont)

#Helper function to provide opposite of %in%
`%nin%` <- negate(`%in%`)


#Base plotting options
theme_set(theme_minimal(base_family = "Helvetica 45 Light", base_size = 16) +
            theme(panel.grid.minor = element_blank(),
                  axis.title.y = element_text(margin = margin(0, 20, 0, 0)),
                  axis.title.x = element_text(margin = margin(20, 0, 0, 0)))))
```

Import and clean data

The original data is provided as a SPSS `.sav` file. This can be loaded in but requires some cleaning. Code below is commented to identify what is being done on each command.

```r
# Create new object called "spice"
spice <-
  # read in from project data folder
  haven::read_sav(here("data/MM_LIVING_WELL_FINAL_DATASET_APRIL_2011.sav")) %>%
  #Use janitor package to convert variable names to snake_case
  clean_names() %>%
  #Drop unneeded variables
  select(-practice_id:-date_registered, -age_group:-age65,
         -carstairs_depcat:-qof_two_or_more, -filter) %>%
  #Reorder variables so that Mental health variables listed first
  select(unique_patient_id:carstairs_decile, ckd, dementia, mental_alcohol,
         mental_psycho, learning_disability, anorexia, depression, schiz_bipolar,
         anxiety, everything()) %>%
  #Drop those under the age of 25
  filter(age >= 25) %>%
  #Now count a) all morbidities, b)mental health morbs, c)physical health morbs
  #Easy to do by row counting relevant columns. These counts *exclude* CKD
  #And so are a count of CKD co-morbidity
  mutate(all_morbidities_count = rowSums(.[7:45]),
```

```
         mental_morbidities_count = rowSums(.[7:14]),
         physical_morbidities_count = rowSums(.[15:45]),
         all_morbidities = factor(all_morbidities_count),
         #Now create a factor version of each of the counts and specify labels
         all_morbidities = fct_collapse(all_morbidities,
                                        `0` = "0",
                                        `1-3` = c("1", "2", "3"),
                                        `4-6` = c("4", "5", "6"),
                                        other_level = ">=7"),
         physical_morbidities = factor(physical_morbidities_count),
         physical_morbidities = fct_collapse(physical_morbidities,
                                        `0` = "0",
                                        `1-3` = c("1", "2", "3"),
                                        `4-6` = c("4", "5", "6"),
                                        other_level = ">=7"),
         mental_morbidities = factor(mental_morbidities_count),
         mental_morbidities = fct_collapse(mental_morbidities,
                                        `0` = "0",
                                        `1-3` = c("1", "2", "3"),
                                        other_level = ">=4"),
         #Coerce sex variable to a factor and label
         sex = factor(sex, levels = c("0","1"),
                      labels = c("Female", "Male")),
         #Calculate age groups using phsmethods package and age_group()function
         age_group = age_group(age, from = 25, to = 85, by = 10),
         #Explicitly specify the factor levels for accuracy
         age_group = factor(age_group,
                            levels = c("25-34", "35-44", "45-54", "55-64",
                                       "65-74", "75-84", "85+")),
         #Factorise deprivation deciles
         carstairs_decile = factor(carstairs_decile),
         carstairs_decile = fct_inseq(carstairs_decile),
         #Important that main outcome variable is levelled as "failure" and
         #then "success" as per glm() models used later
         ckd = factor(ckd, levels = c(0, 1),
                      labels = c("No CKD", "CKD"))) %>%
  #All 39 other disease variables are now factorised
  mutate_at(vars(dementia:pain), ~factor(., levels = c("1", "0"),
                                 labels = c("Yes", "No"))) %>%
  #rearrange variable order again
  select(unique_patient_id, sex, age, age_group, carstairs_score:ckd, all_morbidities,
         all_morbidities_count, physical_morbidities, physical_morbidities_count,
         mental_morbidities, mental_morbidities_count, everything())
```

Descriptive stats

The `finalfit` package provides a simple way of printing a basic "Table 1" using the `summary_factorlist()` function. This won't be the final table 1 but used as the foundation. Additional cleaning added in order to allow this table to be joined to other results later.

```
#Create vector of all variable names
spice_names <- names(spice)
#Define dependent variable
dependent <- "ckd"
#Define explanatory variables by subsetting the spice_names vector to
#exclude the ID and CKD #variables
explanatory <- c(spice_names[spice_names %nin% c("unique_patient_id", "ckd")])

#Create the table
tab_1 <-
  spice %>%
  summary_factorlist(dependent, explanatory, add_col_totals = TRUE,
                     include_col_totals_percent = TRUE) %>%
  #Coerce back to tidy object
  as_tibble() %>%
  #Drop negative levels for diseases
  filter(levels %nin% "No") %>%
  #Repeat label names in each group - this will enable joining to other tables later
  mutate(label = na_if(label, ""),
         label = zoo::na.locf(label))
```

Models

Logistic regression models are used with presence of CKD (Yes/No) as the outcome variable. We fit unadjusted models for all variables of interest (age group, sex, deprivation decile, morbidity groups, and presence of each of the other 39 diseases in the dataset), and models adjusted for age (continuous), sex, and deprivation score (continuous).

A total of 92 models are fitted. Adjusted models for Age, Sex, and deprivation are adjusted only for the two other demographic groups e.g. Sex is adjusted for age and deprivation.

In order to complete this efficiently and collate results tidily, a data frame containing each of the independent variable names is initialised. . .

```
model_tab <-
  tibble(label = spice_names[spice_names %nin% c("unique_patient_id", "ckd")])
```

Two functions are now defined, one for fitting a univariate logistic regression model with the argument x used to denote the independent variable. The second is a helper function to save typing repetition when extracting model results.

```
model_uni <- function(x){
  glm(as.formula(paste("ckd ~",x)), family = binomial, data = spice)
}


mm_tidy <- function(df, mod_type = tidy_mod_multi){
  mod_type <- enquo(mod_type)

  df %>%
    #drop unneeded columns from model output
```

```
    select(label, !!mod_type) %>%
    #unnest the model results
    unnest(!!mod_type) %>%
    #calculate odds-ratio and 95% CIs
    mutate(or = exp(estimate),
           conf_low = exp(estimate - (1.96*std.error)),
           conf_hi = exp(estimate + (1.96*std.error))) %>%
    #tidy column order
    select(label, levels = term, or, conf_low, conf_hi, everything()) %>%
    #round to 2 significant figures
    round_df(dig = 2) -> x


  return(x)


}
```

Sex

The first models are fitted with sex as independent variable. As the adjusted model cannot include sex a separate adjusted model function is created for sex. Both models are then run with sex as independent variable and model objects appended as list columns to `model_tab`. The previously defined `mm_tidy()` function is then used to extract model results. Finally, the unadjusted and adjusted models results are joined together.

```
#Define adjusted model for sex
sex_model_multi <- function(x){
  glm(as.formula(paste("ckd ~",x,"+ age + carstairs_score")),
      family = binomial, data = spice)
}


#fit unadjusted and adjusted models, then extract results with broom::tidy()
#all results stored in new list columns
model_tab %>%
  filter(label %in% "sex") %>%
  mutate(model_uni = map(label, ~model_uni(.x)),
         model_multi = map(label, ~sex_model_multi(.x)),
         tidy_mod_uni = map(model_uni, tidy),
         tidy_mod_multi = map(model_multi, tidy)) -> sex_mod


#run the previously defined function to extract results and calculate
#ORs with CIs from adjusted model
sex_mod %>%
  mm_tidy() %>%
  #drop the reference level
  filter(levels %in% "sexMale") %>%
  #tidy labels and add prefix to indicated these are adjusted results
  mutate(levels = str_replace(levels,"sex", "")) %>%
  rename_at(vars(or:p.value), ~paste0("adj_", .)) -> sex_mod_multi


#repeat above but for the unadjusted model
sex_mod %>%
  mm_tidy(., mod_type = tidy_mod_uni) %>%
```

```
  filter(levels %in% "sexMale") %>%
  mutate(levels = str_replace(levels,"sex", "")) %>%
  rename_at(vars(or:p.value), ~paste0("unadj_", .)) -> sex_mod_uni

#Join adjusted and unadjusted results together
sex_mod_all <- left_join(sex_mod_uni, sex_mod_multi)

#Drop intermediary objects from memory
rm(list = c("sex_mod", "sex_mod_multi", "sex_mod_uni"))
```

Age

The above process for Sex is now repeated for Age groups. An important point here is that the reference group is changed to be 45-54 which includes the mean and median ages for all the observations in the data.

```
#Change reference group to 45-54
spice %<>%
  mutate(age_group = fct_relevel(age_group, "45-54"))

#Define function for adjusted model for age group
age_model_multi <- function(x){
  glm(as.formula(paste("ckd ~ ",x,"+ sex + carstairs_score")),
      family = binomial,  data = spice)
}

#Fit models and tidy
model_tab %>%
  filter(label %in% "age_group") %>%
  mutate(model_uni = map(label, ~model_uni(.x)),
         model_multi = map(label, ~age_model_multi(.x)),
         tidy_mod_uni = map(model_uni, tidy),
         tidy_mod_multi = map(model_multi, tidy)) -> age_mod

#Extract and tidy adjusted model results
age_mod %>%
  mm_tidy() %>%
  filter(levels %nin% c("(Intercept)", "sexMale", "carstairs_score")) %>%
  mutate(levels = str_replace(levels, "age_group", "")) %>%
  rename_at(vars(or:p.value), ~paste0("adj_", .)) -> age_mod_multi

#Extract and tidy unadjusted results
age_mod %>%
  mm_tidy(., tidy_mod_uni) %>%
  filter(levels %nin% c("(Intercept)", "sexMale", "carstairs_score")) %>%
  mutate(levels = str_replace(levels, "age_group", "")) %>%
  rename_at(vars(or:p.value), ~paste0("unadj_", .)) -> age_mod_uni

#Join age group models together
age_mod_all <- left_join(age_mod_uni, age_mod_multi)

#Drop intermediary objects
rm(list = c("age_mod", "age_mod_multi", "age_mod_uni"))
```

Deprivation

The final bespoke set of models is for deprivation adjusting for sex and age.

```r
#Define adjusted model for deprivation
dep_model_multi <- function(x){
  glm(as.formula(paste("ckd ~",x,"+ sex + age")),
      family = binomial,
      data = spice)
}

#Fit and tidy models
model_tab %>%
  filter(label %in% "carstairs_decile") %>%
  mutate(model_uni = map(label, ~model_uni(.x)),
         model_multi = map(label, ~dep_model_multi(.x)),
         tidy_mod_uni = map(model_uni, tidy),
         tidy_mod_multi = map(model_multi, tidy)) -> dep_mod

#Extract and tidy adjusted model results
dep_mod %>%
  mm_tidy  %>%
  filter(levels %nin% c("(Intercept)", "sexMale", "sexFemale", "age")) %>%
  mutate(levels = str_replace(levels, "carstairs_decile", "")) %>%
  rename_at(vars(or:p.value), ~paste0("adj_", .)) -> dep_mod_multi

#Extract and tidy unadjusted model results
dep_mod %>%
  mm_tidy(., tidy_mod_uni) %>%
  filter(levels %nin% c("(Intercept)", "sexMale", "sexFemale", "age")) %>%
  mutate(levels = str_replace(levels, "carstairs_decile", "")) %>%
  rename_at(vars(or:p.value), ~paste0("unadj_", .)) -> dep_mod_uni

#Join deprivation model results together
dep_mod_all <- left_join(dep_mod_uni, dep_mod_multi)

#Drop intermediary objects from memory
rm(list = c("dep_mod", "dep_mod_multi", "dep_mod_uni"))
#results not printed
```

All other models

The remaining 84 models can be run with one chunk of code as the adjusted model is the same for each variable of interest: all co-morbidity grouped count, all physical co-morbidity grouped count, all mental health co-morbidity grouped count, and each of the other 39 diseases.

```r
#Define function for adjusted model
model_multi <- function(x){
  glm(as.formula(paste("ckd ~",x,"+ age + sex + carstairs_score")),
      family = binomial, data = spice)
}
```

```r
#Relevel all of the disease variables so "No" is reference
spice %<>%
  mutate_at(vars(dementia:pain), ~fct_relevel(.x, "No"))

#Fit and tidy the models
model_tab %>%
  filter(label %nin% c("unique_patient_id",  "age", "age_group", "sex",
                       "carstairs_score", "carstairs_decile", "ckd")) %>%
  mutate(model_uni = map(label, ~model_uni(.x)),
         model_multi = map(label, ~model_multi(.x)),
         tidy_mod_uni = map(model_uni, tidy),
         tidy_mod_multi = map(model_multi, tidy)) -> other_mod

#Extract and tidy adjusted model results
other_mod %>%
  mm_tidy() %>%
  filter(levels %nin% c("(Intercept)", "sexMale", "carstairs_score", "age")) %>%
  mutate(levels = str_replace(levels,"all_morbidities", ""),
         levels = str_replace(levels, "physical_morbidities", ""),
         levels = str_replace(levels, "mental_morbidities", ""),
         levels = str_replace(levels, "Yes", "")) %>%
  rename_at(vars(or:p.value), ~paste0("adj_", .)) -> other_mod_multi

#Extract and tidy unadjusted model results
other_mod %>%
  mm_tidy(., tidy_mod_uni) %>%
  filter(levels %nin% c("(Intercept)", "sexMale", "carstairs_score", "age")) %>%
  mutate(levels = str_replace(levels,"all_morbidities", ""),
         levels = str_replace(levels, "physical_morbidities", ""),
         levels = str_replace(levels, "mental_morbidities", ""),
         levels = str_replace(levels, "Yes", "")) %>%
  rename_at(vars(or:p.value), ~paste0("unadj_", .)) -> other_mod_uni

#Join and tidy adjusted and unadjusted results
other_mod_all <- left_join(other_mod_uni, other_mod_multi) %>%
  mutate(levels = case_when(
    levels %in% c("1-3", "4-6", ">=7", ">=4") ~ levels,
    TRUE ~ "Yes"
  ))

#remove intermediary objects
rm(list = c("other_mod", "other_mod_multi", "other_mod_uni"))
```

Join Descriptive and Model Tables

Here the results of the models are combined with base table created above in the Descriptive statistics section. Odds ratio and associated results are added to rows for each variable with some tidying of labels. New variables are created that paste together results of OR with CIs for easier printing in final tables. P-values are only included in they are >0.05.

```r
final_tab <-
  #Combine model result tables
  bind_rows(sex_mod_all, age_mod_all, dep_mod_all, other_mod_all) %>%
  #Join to base table
  left_join(tab_1, ., by = c("label", "levels")) %>%
  #coerce non-sig p-value to NA
  mutate(unadj_p.value = if_else(unadj_p.value < 0.05, NA_real_, unadj_p.value),
         #Coerce p value column to character
         unadj_p.value = as.character(unadj_p.value),
         #Conditionally add label if p>0.05
         unadj_p.value = if_else(!is.na(unadj_p.value),
                                 paste0("p = ", unadj_p.value), unadj_p.value),
         #repeat for adjusted model p values
         adj_p.value = if_else(adj_p.value < 0.05, NA_real_, adj_p.value),
         adj_p.value = as.character(adj_p.value),
         adj_p.value = if_else(!is.na(adj_p.value), paste0("p = ", adj_p.value),
                               adj_p.value),
         #Create result label column for unadjusted models
         unadj_label =
           glue("{unadj_or} ({unadj_conf_low} to {unadj_conf_hi}) {unadj_p.value}",
                .na = ""),
         #tidy blank space
         unadj_label = str_replace(unadj_label, "\\( to \\)", ""),
         #Repeat for unadjusted model
         adj_label =
           glue("{adj_or} ({adj_conf_low} to {adj_conf_hi}) {adj_p.value}", .na = ""),
         adj_label = str_replace(adj_label, "\\( to \\)", ""),
         #Change main lables to title case
         label = snakecase::to_any_case(label, "title"),
         #Fix those that fall through the net!
         label = str_replace(label, "Chd", "Coronary Heart Disease"),
         label = str_replace(label, "Pvd", "Peripheral Vascular Disease"),
         label = str_replace(label, "Tia Stroke",
                             "Stroke and Transient Ischaemic Attack"),
         label = str_replace(label, "Crohns", "Inflammatory Bowel Disease"),
         label = str_replace(label, "Pain", "Painful Condition"),
         label = str_replace(label, "Schiz Bipolar",
                             "Scizophrenia and Associated Conditions"),
         label = str_replace(label, "Liver Disease", "Chronic Liver Disease"),
         label = str_replace(label, "Psor Ecz", "Psoriasis or Eczema"),
         label = str_replace(label, "Bronchitis",
                             "Chronic Obstructive Pulmonary Disease"),
         label = str_replace(label, "Any Cancer Last 5 Yrs",
                             "New Diagnosis of Cancer in last 5 Years"),
         label = str_replace(label, "Prostate", "Prostate Disorders"),
         label = str_replace(label, "Anxiety", "Anxiety and associated conditions"),
         label = str_replace(label, "Diverticular", "Diverticular Disease of Intestine"),
         label = str_replace(label, "Dyspepsia", "Dyspepsia"),
         label = str_replace(label, "Anorexia", "Anorexia or Bulimia"),
         label = str_replace(label, "Active Asthma", "Asthma"),
         label = str_replace(label, "Blindness", "Blindness and Low Vision"),
         label = str_replace(label, "Mental Psycho",
                             "Other Psychoactive Substance Misuse"),
```

```
        label = str_replace(label, "Ibs", "Irritable Bowel Disease"),
        label = str_replace(label, "Laxatives Constipation", "Constipation"),
        label = str_replace(label, "Sinusitis", "Chronic Sinusitis"),
        label = str_replace(label, "Mental Alcohol", "Alcohol Problems"),
        label = str_replace(label, "Ms", "Muliple Sclerosis"),
        label = str_replace(label, "Parkinsons", "Parkinson's disease"),
        label = str_replace(label, "Rheu Arthritis", "Rheumatological Conditions"),
        label = str_replace(label, "Atrial Fib", "Atrial Fibrillation")) %>%
  #Reorder columns
  select(label, levels, `No CKD`, CKD, unadj_label, adj_label, unadj_or:unadj_conf_hi,
         unadj_p.value, adj_or:adj_conf_hi, adj_p.value, everything())

#Remove disease rows and reorder by adjusted OR
final_tab %>%
  filter(levels == "Yes") %>%
  arrange(-adj_or) -> ordered_morbs
#Drop diseases from main tab then rejoin with ordered rows
final_tab %<>%
  filter(levels != "Yes") %>%
  bind_rows(., ordered_morbs)
```

Outputs

Table 1

```
final_tab %>%
  filter(label %in% c("Total n", "Sex", "Age", "Age Group", "Carstairs Decile")) %>%
  select(label, levels, `No CKD`, CKD, unadj_label, adj_label) %>%
  rename(Variable = label,
         Value = levels,
         `Unadjusted OR (95% CI)` = unadj_label,
         `Adjusted OR (95% CI)` = adj_label) %>%
  kable(., booktabs = TRUE) %>%
  kable_styling(latex_options = c("striped", "scale_down"),
                stripe_index = c(1, 4, 12:21))
```

Variable	Value	No CKD	CKD	Unadjusted OR (95% CI)	Adjusted OR (95% CI)
Total n		1240807 (97.4)	33567 (2.6)		
Sex	Female	630127 (50.8)	21342 (63.6)		
Sex	Male	610680 (49.2)	12225 (36.4)	0.59 (0.58 to 0.6)	0.81 (0.79 to 0.83)
Age	Mean (SD)	50.6 (16.2)	74.9 (10.9)		
Age Group	25-34	229477 (18.5)	117 (0.3)	0.12 (0.1 to 0.15)	0.12 (0.1 to 0.15)
Age Group	35-44	278929 (22.5)	420 (1.3)	0.36 (0.32 to 0.4)	0.36 (0.32 to 0.4)
Age Group	45-54	253110 (20.4)	1054 (3.1)		
Age Group	55-64	216168 (17.4)	3536 (10.5)	3.93 (3.67 to 4.21)	3.94 (3.68 to 4.22)
Age Group	65-74	146356 (11.8)	9136 (27.2)	14.99 (14.06 to 15.98)	14.86 (13.94 to 15.85)
Age Group	75-84	86223 (6.9)	13238 (39.4)	36.87 (34.61 to 39.28)	36.12 (33.9 to 38.47)
Age Group	85+	30544 (2.5)	6066 (18.1)	47.69 (44.62 to 50.97)	45.67 (42.72 to 48.81)
Carstairs Decile	1	116316 (9.4)	3032 (9.0)		
Carstairs Decile	2	123215 (9.9)	3470 (10.3)	1.08 (1.03 to 1.14)	1.16 (1.1 to 1.22)
Carstairs Decile	3	120684 (9.7)	3197 (9.5)	1.02 (0.97 to 1.07) p = 0.53	0.94 (0.89 to 0.99)
Carstairs Decile	4	147848 (11.9)	4048 (12.1)	1.05 (1 to 1.1)	1.04 (0.99 to 1.1) p = 0.09
Carstairs Decile	5	142850 (11.5)	3816 (11.4)	1.02 (0.98 to 1.08) p = 0.32	1.05 (1 to 1.1) p = 0.06
Carstairs Decile	6	140072 (11.3)	3213 (9.6)	0.88 (0.84 to 0.93)	0.93 (0.88 to 0.98)
Carstairs Decile	7	130990 (10.6)	3436 (10.2)	1.01 (0.96 to 1.06) p = 0.8	1.12 (1.07 to 1.18)
Carstairs Decile	8	104384 (8.4)	3086 (9.2)	1.13 (1.08 to 1.19)	1.25 (1.18 to 1.32)
Carstairs Decile	9	113568 (9.2)	3453 (10.3)	1.17 (1.11 to 1.23)	1.26 (1.2 to 1.33)
Carstairs Decile	10	100880 (8.1)	2816 (8.4)	1.07 (1.02 to 1.13)	1.39 (1.32 to 1.47)

Figure 1

Adjusted odds-ratios from table 1 are visualised here.

```
final_tab %>%
  filter(label %in% c("Sex", "Age Group",
                      "Carstairs Decile")) %>%
  filter(levels != "Female") %>%
  mutate(levels = factor(levels,
                      levels = c("Male", "25-34", "35-44", "45-54", "55-64", "65-74",
                                 "75-84", "85+", "1", "2", "3", "4", "5", "6", "7",
                                 "8", "9", "10"),
                      labels = c("Male (ref Female)", "Age Group: 25-34", "35-44",
                                 "45-54 (ref)", "55-64", "65-74", "75-84", "85+",
                                 "Deprivation Decile 1 (ref)", "2", "3", "4", "5",
                                 "6", "7", "8", "9", "10 - most deprived"))) %>%
  ggplot(aes(fct_rev(levels), adj_or)) +
  geom_hline(yintercept = 1) +
  geom_point() +
  geom_errorbar(aes(ymin = adj_conf_low, ymax = adj_conf_hi)) +
  scale_y_log10(breaks = scales::log_breaks(n = 6)) +
  theme(legend.position = "top",
        text = element_text(size = 16),
        axis.text.y = element_text(margin = margin(t = 50, b = 50))) +
  coord_flip() +
  labs(y = "Odds Ratio with 95% CI\n(log scale)",
       x = "",
       title = "Odds ratios for demographics in relation to CKD status",
       subtitle = "Adjusted for age and/or sex and/or deprivation",
       colour = "Morbidity type",
```

```
      caption = "CKD group = 33,567\nNon-CKD group = 1,240,807") -> fig_1
fig_1
```


Odds ratios for demographics in relation to CKD status
Adjusted for age and/or sex and/or deprivation
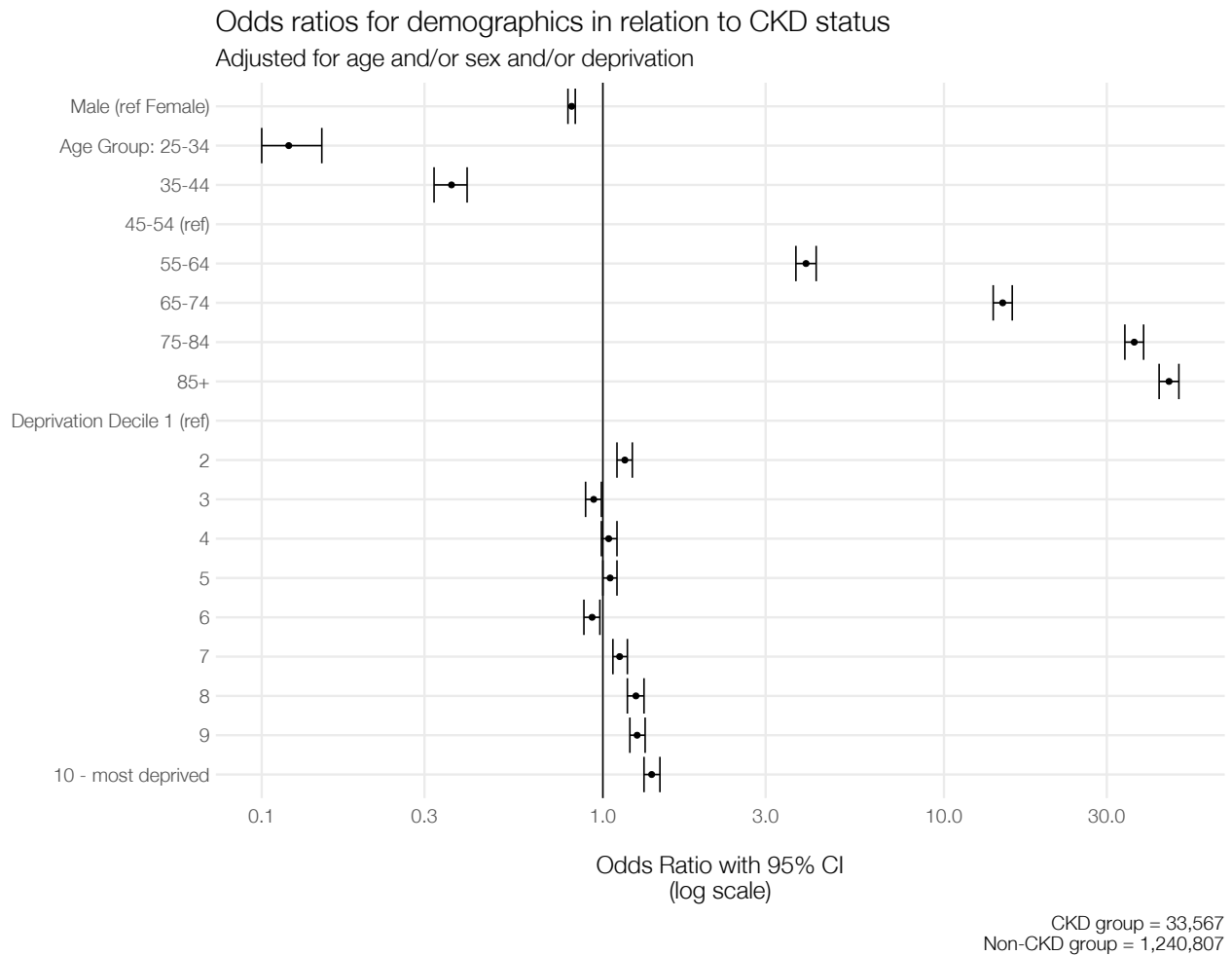
Table 2

Results of models for grouped disease counts.

```
final_tab %>%
  filter(label %in% c("All Morbidities Count", "All Morbidities",
                      "Physical Morbidities Count", "Physical Morbidities",
                      "Mental Morbidities Count", "Mental Morbidities")) %>%
  select(label, levels, `No CKD`, CKD, unadj_label, adj_label) %>%
  rename(Variable = label,
         Value = levels,
         `Unadjusted OR (95% CI)` = unadj_label,
         `Adjusted OR (95% CI)` = adj_label) %>%
  kable(., booktabs = TRUE) %>%
  kable_styling(latex_options = c("striped", "scale_down"),
                stripe_index = c(5, 10, 14))
```

Variable	Value	No CKD	CKD	Unadjusted OR (95% CI)	Adjusted OR (95% CI)
All Morbidities	0	598194 (48.2)	614 (1.8)		
All Morbidities	1-3	527778 (42.5)	16025 (47.7)	29.58 (27.29 to 32.07)	11.19 (10.32 to 12.15)
All Morbidities	4-6	99779 (8.0)	13000 (38.7)	126.93 (117.03 to 137.67)	24.87 (22.88 to 27.02)
All Morbidities	>=7	15056 (1.2)	3928 (11.7)	254.18 (233.1 to 277.16)	38.94 (35.61 to 42.58)
All Morbidities Count	Mean (SD)	1.2 (1.6)	3.8 (2.2)		
Physical Morbidities	0	669088 (53.9)	801 (2.4)		
Physical Morbidities	1-3	496265 (40.0)	18486 (55.1)	31.12 (28.99 to 33.4)	10.84 (10.09 to 11.65)
Physical Morbidities	4-6	69280 (5.6)	12070 (36.0)	145.53 (135.43 to 156.38)	26.08 (24.21 to 28.09)
Physical Morbidities	>=7	6174 (0.5)	2210 (6.6)	299 (274.74 to 325.41)	44.7 (40.94 to 48.81)
Physical Morbidities Count	Mean (SD)	0.9 (1.4)	3.4 (1.9)		
Mental Morbidities	0	1022283 (82.4)	22980 (68.5)		
Mental Morbidities	1-3	216618 (17.5)	10480 (31.2)	2.15 (2.1 to 2.2)	1.29 (1.25 to 1.32)
Mental Morbidities	>=4	1906 (0.2)	107 (0.3)	2.5 (2.05 to 3.04)	1.37 (1.11 to 1.69)
Mental Morbidities Count	Mean (SD)	0.2 (0.6)	0.4 (0.8)		

Table S1

```
final_tab %>%
  filter(label %nin% c("Total n", "Sex", "Age", "Age Group", "Carstairs Decile",
                       "All Morbidities", "Physical Morbidities", "Mental Morbidities",
                       "Carstairs Score", "Physical Morbidities Count",
                       "Mental Morbidities Count", "All Morbidities Count")) %>%
  select(label, `No CKD`, CKD, unadj_label, adj_label) %>%
  rename(Variable = label,
         `Unadjusted OR (95% CI)` = unadj_label,
         `Adjusted OR (95% CI)` = adj_label) %>%
  kable(., booktabs = TRUE) %>%
  kable_styling(latex_options = "striped") %>%
  landscape()
```

Variable	No CKD	CKD	Unadjusted OR (95% CI)	Adjusted OR (95% CI)
Hypertension	210474 (17.0)	23887 (71.2)	12.08 (11.79 to 12.37)	3.99 (3.89 to 4.09)
Heart Failure	14528 (1.2)	4363 (13.0)	12.61 (12.17 to 13.07)	3.45 (3.32 to 3.59)
Diabetes	65006 (5.2)	8833 (26.3)	6.46 (6.3 to 6.63)	3.4 (3.31 to 3.49)
Coronary Heart Disease	69990 (5.6)	11571 (34.5)	8.8 (8.59 to 9.01)	2.74 (2.67 to 2.81)
Peripheral Vascular Disease	20063 (1.6)	2883 (8.6)	5.72 (5.49 to 5.95)	2.25 (2.16 to 2.35)
Rheumatological Conditions	51699 (4.2)	5661 (16.9)	4.67 (4.53 to 4.81)	2.2 (2.13 to 2.27)
Atrial Fibrillation	19945 (1.6)	4049 (12.1)	8.4 (8.1 to 8.7)	2.02 (1.94 to 2.1)
Stroke and Transient Ischaemic Attack	31354 (2.5)	5169 (15.4)	7.02 (6.8 to 7.25)	1.9 (1.83 to 1.96)
Inflammatory Bowel Disease	8947 (0.7)	480 (1.4)	2 (1.82 to 2.19)	1.78 (1.61 to 1.96)
Painful Condition	116667 (9.4)	8521 (25.4)	3.28 (3.2 to 3.36)	1.75 (1.7 to 1.8)
Thyroid Disorders	65632 (5.3)	5635 (16.8)	3.61 (3.51 to 3.72)	1.72 (1.67 to 1.78)
Scizophrenia and Associated Conditions	11664 (0.9)	498 (1.5)	1.59 (1.45 to 1.74)	1.53 (1.39 to 1.69)
Chronic Liver Disease	2510 (0.2)	104 (0.3)	1.53 (1.26 to 1.87)	1.53 (1.25 to 1.87)
Psoriasis or Eczema	9233 (0.7)	450 (1.3)	1.81 (1.65 to 1.99)	1.5 (1.35 to 1.66)
Depression	132317 (10.7)	5950 (17.7)	1.8 (1.75 to 1.86)	1.48 (1.43 to 1.52)
Viral Hepatitis	1126 (0.1)	12 (0.0)	0.39 (0.22 to 0.69)	1.48 (0.82 to 2.66) p = 0.19
Learning Disability	4346 (0.4)	94 (0.3)	0.8 (0.65 to 0.98)	1.46 (1.18 to 1.8)
Chronic Obstructive Pulmonary Disease	48120 (3.9)	3846 (11.5)	3.21 (3.1 to 3.32)	1.37 (1.32 to 1.42)
New Diagnosis of Cancer in last 5 Years	39716 (3.2)	3359 (10.0)	3.36 (3.24 to 3.49)	1.36 (1.3 to 1.41)
Prostate Disorders	14009 (1.1)	1223 (3.6)	3.31 (3.12 to 3.51)	1.36 (1.27 to 1.45)
Anxiety and associated conditions	50423 (4.1)	3734 (11.1)	2.95 (2.85 to 3.06)	1.34 (1.29 to 1.39)
Diverticular Disease of Intestine	30254 (2.4)	3591 (10.7)	4.79 (4.62 to 4.97)	1.34 (1.29 to 1.39)
Migraine	8814 (0.7)	205 (0.6)	0.86 (0.75 to 0.99)	1.34 (1.16 to 1.54)
Dyspepsia	74077 (6.0)	4598 (13.7)	2.5 (2.42 to 2.58)	1.31 (1.27 to 1.36)
Anorexia or Bulimia	4698 (0.4)	107 (0.3)	0.84 (0.69 to 1.02) p = 0.08	1.29 (1.05 to 1.59)
Asthma	73886 (6.0)	2422 (7.2)	1.23 (1.18 to 1.28)	1.24 (1.19 to 1.3)
Blindness and Low Vision	7061 (0.6)	992 (3.0)	5.32 (4.97 to 5.69)	1.24 (1.15 to 1.33)
Other Psychoactive Substance Misuse	38109 (3.1)	2459 (7.3)	2.49 (2.39 to 2.6)	1.19 (1.14 to 1.25)
Irritable Bowel Disease	48995 (3.9)	1523 (4.5)	1.16 (1.1 to 1.22)	1.18 (1.12 to 1.25)
Constipation	32112 (2.6)	4014 (12.0)	5.11 (4.94 to 5.29)	1.18 (1.13 to 1.22)
Bronchiectasis	2601 (0.2)	181 (0.5)	2.58 (2.22 to 3)	1.13 (0.96 to 1.32) p = 0.13
Hearing Loss	48383 (3.9)	3662 (10.9)	3.02 (2.91 to 3.13)	1.08 (1.04 to 1.12)
Chronic Sinusitis	8706 (0.7)	246 (0.7)	1.04 (0.92 to 1.19) p = 0.5	1.07 (0.94 to 1.22) p = 0.33
Glaucoma	14381 (1.2)	1529 (4.6)	4.07 (3.86 to 4.3)	1.05 (0.99 to 1.11) p = 0.09
Epilepsy	11238 (0.9)	325 (1.0)	1.07 (0.96 to 1.2) p = 0.23	1.02 (0.91 to 1.15) p = 0.73
Alcohol Problems	39764 (3.2)	844 (2.5)	0.78 (0.73 to 0.83)	0.97 (0.9 to 1.04) p = 0.4
Muliple Sclerosis	3761 (0.3)	67 (0.2)	0.66 (0.52 to 0.84)	0.81 (0.63 to 1.03) p = 0.09
Parkinson's disease	2517 (0.2)	226 (0.7)	3.33 (2.91 to 3.82)	0.77 (0.67 to 0.89)
Dementia	10339 (0.8)	1346 (4.0)	4.97 (4.69 to 5.27)	0.68 (0.64 to 0.72)

Figure 2

There are 39 diseases, difficult to show in a table so visualisation is better. Some tidying required first to include the percentage of those with CKD who had each disease in the label.

```
mh_conditions <- c("Schizophrenia and Associated Conditions", "Depression",
                                    "Learning Disability",
                                    "Anxiety and associated conditions",
                                    "Anorexia or Bulimia",
                                    "Other Psychoactive Substance Misuse",
                                    "Alcohol Problems", "Dementia")


final_tab %>%
  filter(label %nin% c("Total n", "Sex", "Age", "Age Group", "Carstairs Decile",
                       "All Morbidities", "Physical Morbidities", "Mental Morbidities",
                       "Carstairs Score", "Physical Morbidities Count",
                       "Mental Morbidities Count", "All Morbidities Count")) %>%
  mutate(morb_type = if_else(label %in% mh_conditions,
                             "Mental Health", "Physical Health")) %>%
  select(label, CKD, morb_type, unadj_or, unadj_conf_low, unadj_conf_hi, adj_or,
         adj_conf_low, adj_conf_hi) %>%
  separate(CKD, into = c(NA, "pct", sep = " ")) %>%
  unite(pct, c(pct, ` `), sep = ".") %>%
  mutate(pct = if_else(label == "Viral Hepatitis", "<0.1", pct),
         pct = glue("({pct}%)")) %>%
  unite(label, c(label, pct), sep = " ") %>%
  ggplot(aes(reorder(label, adj_or), adj_or, colour = morb_type)) +
  geom_hline(yintercept = 1) +
  geom_point(size = 2.5) +
  geom_errorbar(aes(ymin = adj_conf_low, ymax = adj_conf_hi)) +
  scale_y_log10(breaks = scales::pretty_breaks()) +
  scale_colour_grey(start = 0.8, end = 0.4) +
  theme(legend.position = "top",
        text = element_text(size = 16),
        axis.text.y = element_text(margin = margin(t = 50, b = 50))) +
  coord_flip() +
  labs(y = "Odds Ratio with 95% CI\n(log scale)",
       x = "",
       title = "Odds ratios for morbidities in relation to CKD status",
       subtitle = "Adjusted for age, sex, and deprivation\nLabels show % indiviudals with CKD who also
       colour = "") -> fig_2
```

Odds ratios for morbidities in relation to CKD status

Adjusted for age, sex, and deprivation
Labels show % indiviudals with CKD who also have condition

● Mental Health ● Physical Health

Hypertension (71.2%)
Heart Failure (13.0%)
Diabetes (26.3%)
Coronary Heart Disease (34.5%)
Peripheral Vascular Disease (8.6%)
Rheumatological Conditions (16.9%)
Atrial Fibrillation (12.1%)
Stroke and Transient Ischaemic Attack (15.4%)
Inflammatory Bowel Disease (1.4%)
Painful Condition (25.4%)
Thyroid Disorders (16.8%)
Scizophrenia and Associated Conditions (1.5%)
Chronic Liver Disease (0.3%)
Psoriasis or Eczema (1.3%)
Viral Hepatitis (<0.1%)
Depression (17.7%)
Learning Disability (0.3%)
Chronic Obstructive Pulmonary Disease (11.5%)
Prostate Disorders (3.6%)
New Diagnosis of Cancer in last 5 Years (10.0%)
Migraine (0.6%)
Diverticular Disease of Intestine (10.7%)
Anxiety and associated conditions (11.1%)
Dyspepsia (13.7%)
Anorexia or Bulimia (0.3%)
Blindness and Low Vision (3.0%)
Asthma (7.2%)
Other Psychoactive Substance Misuse (7.3%)
Irritable Bowel Disease (4.5%)
Constipation (12.0%)
Bronchiectasis (0.5%)
Hearing Loss (10.9%)
Chronic Sinusitis (0.7%)
Glaucoma (4.6%)
Epilepsy (1.0%)
Alcohol Problems (2.5%)
Muliple Sclerosis (0.2%)
Parkinson's disease (0.7%)
Dementia (4.0%)
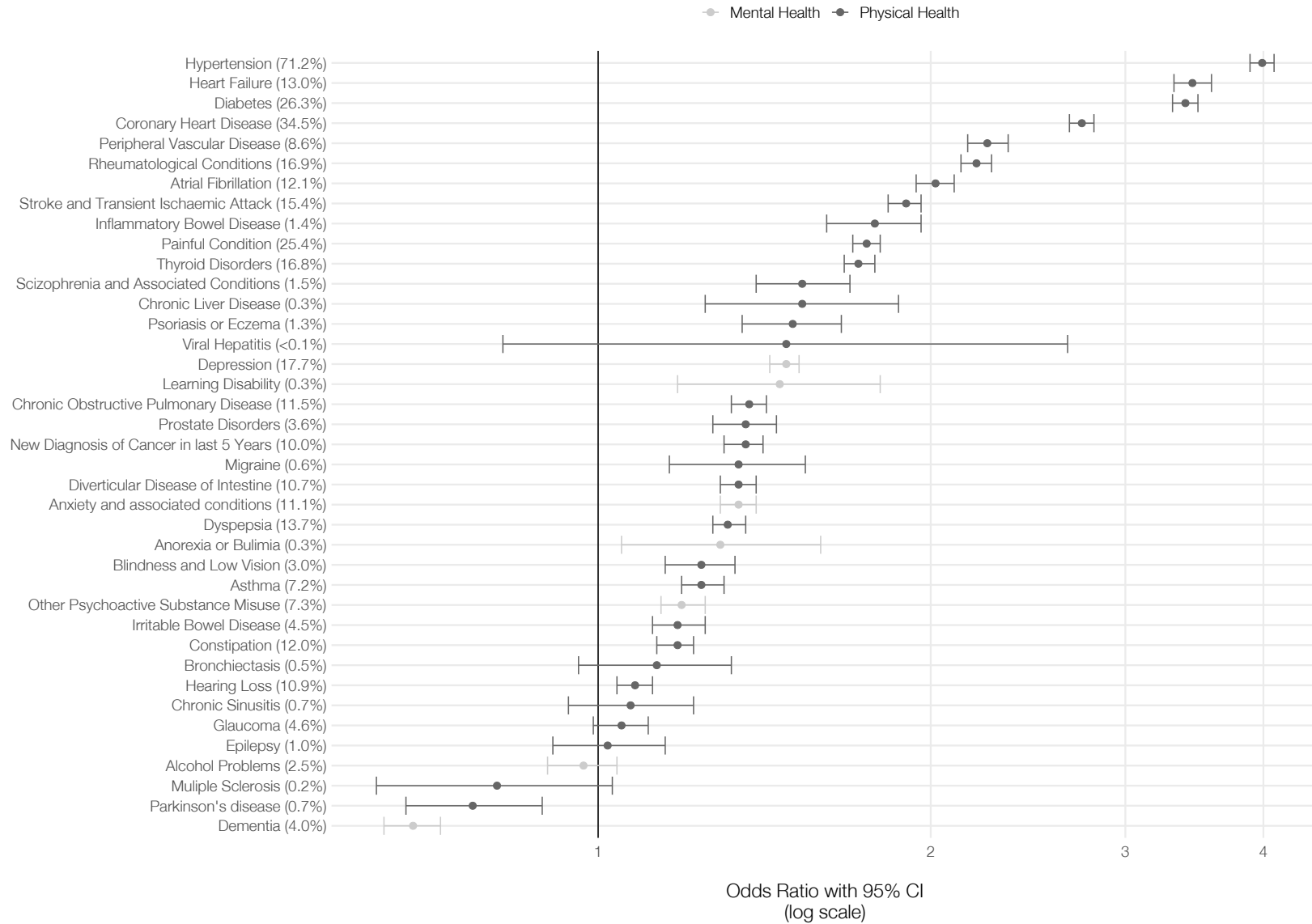
Odds Ratio with 95% CI
(log scale)

Figure 3

One way to show how morbidities cluster with CKD is via an upset plot as shown here. As we are going back to the original dataframe for plotting purposes, the variable names need tidied again.

```r
#Tidy up disease names in original `spice` dataframe

colnames(spice)[14:52] <- snakecase::to_any_case(colnames(spice)[14:52],
                                                  case = "title") %>%
  str_replace(., "Chd", "Coronary Heart Disease") %>%
  str_replace(., "Pvd", "Peripheral Vascular Disease") %>%
  str_replace(., "Tia Stroke", "Stroke and Transient Ischaemic Attack") %>%
  str_replace(., "Crohns", "Infalmmatory Bowel Disease") %>%
  str_replace(., "Pain", "Painful Condition") %>%
  str_replace(., "Schiz Bipolar", "Scizophrenia and Associated Conditions") %>%
  str_replace(., "Liver Disease", "Chronic Liver Disease") %>%
  str_replace(., "Psor Ecz", "Psoriasis or Eczema") %>%
  str_replace(., "Bronchitis", "Chronic Obstructive Pulmonary Disease") %>%
  str_replace(., "Any Cancer Last 5 Yrs", "New Diagnosis of Cancer in last 5 Years") %>%
  str_replace(., "Prostate", "Prostate Disorders") %>%
  str_replace(., "Anxiety", "Anxiety and associated conditions") %>%
  str_replace(., "Diverticular", "Diverticular Disease of Intestine") %>%
  str_replace(., "Dyspepsia", "Dyspepsia") %>%
  str_replace(., "Anorexia", "Anorexia or Bulimia") %>%
  str_replace(., "Active Asthma", "Asthma") %>%
  str_replace(., "Blindness", "Blindness and Low Vision") %>%
  str_replace(., "Mental Psycho", "Other Psychoactive Substance Misuse") %>%
  str_replace(., "Ibs", "Irritable Bowel Disease") %>%
  str_replace(., "Laxatives Constipation", "Constipation") %>%
  str_replace(., "Sinusitis", "Chronic Sinusitis") %>%
  str_replace(., "Mental Alcohol", "Alcohol Problems") %>%
  str_replace(., "Ms", "Muliple Sclerosis") %>%
  str_replace(., "Parkinsons", "Parkinson's disease") %>%
  str_replace(., "Rheu Arthritis", "Rheumatological Conditions") %>%
  str_replace(., "Atrial Fib", "Atrial Fibrillation")

morbs <- colnames(spice)[14:52]

spice %>%
  filter(ckd == "CKD") %>%
  mutate_at(vars(Dementia:`Painful Condition`),
            function(x) if_else(x == "Yes", 1, 0)) -> ckd_upset

#Upset plot
fig_3 <- upset(ckd_upset, morbs, name = "Morbidities",
               base_annotations = list(
                 "Intersection size" = intersection_size(
                   text_aes = aes(
                     label = paste0(round(intersection_size/33567 * 100, 1), "%")),
                   text = list(size = 4.5, vjust = -0.5, hjust = -0.05, angle = 60))),
               width_ratio = 0.1,
               height_ratio = 1,
               min_size = 75,
```

```
            stripes = c("gray60", "gray80"),
            themes = upset_modify_themes(
              list(
                "overall_sizes" = theme(axis.text.x = element_text(angle = 90)),
                "intersections_matrix" = theme(text = element_text(size = 16))
              )
            )) +
  labs(title = "Frequency of CKD comorbidity groups",
       subtitle = "Limited to groups with frequency >= 75",
       x = "",
       caption = "n = 33,567 with CKD\nMost frequent 32 combinations shown\nTotal combinations = 13,891
  scale_fill_grey()
```
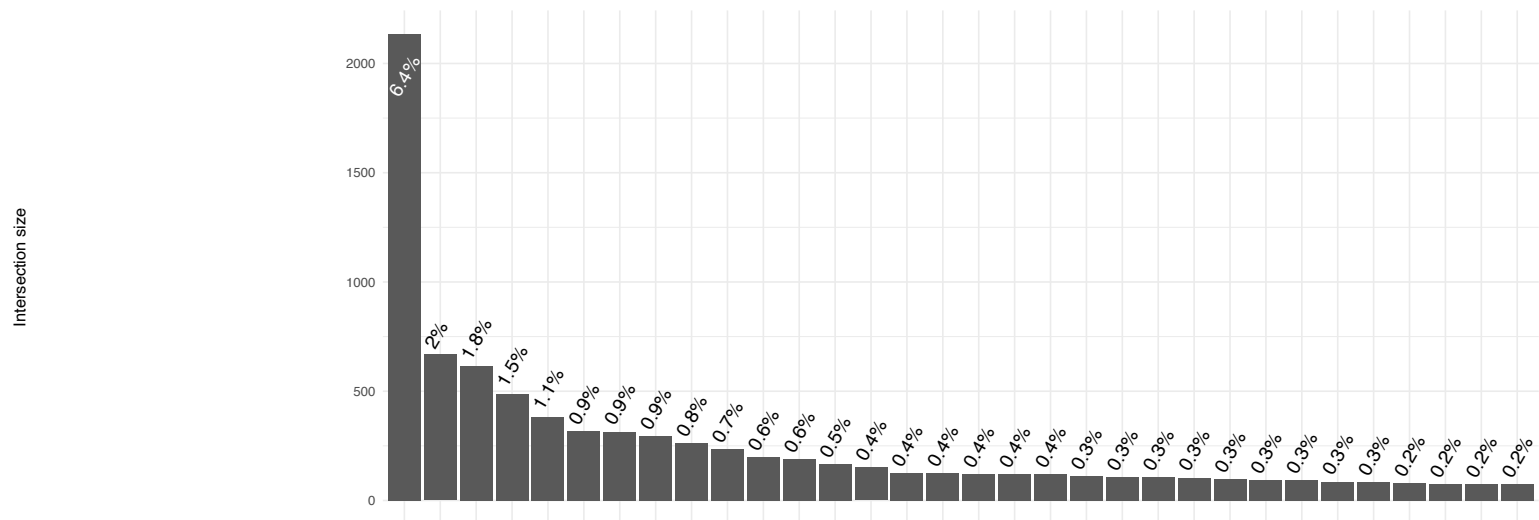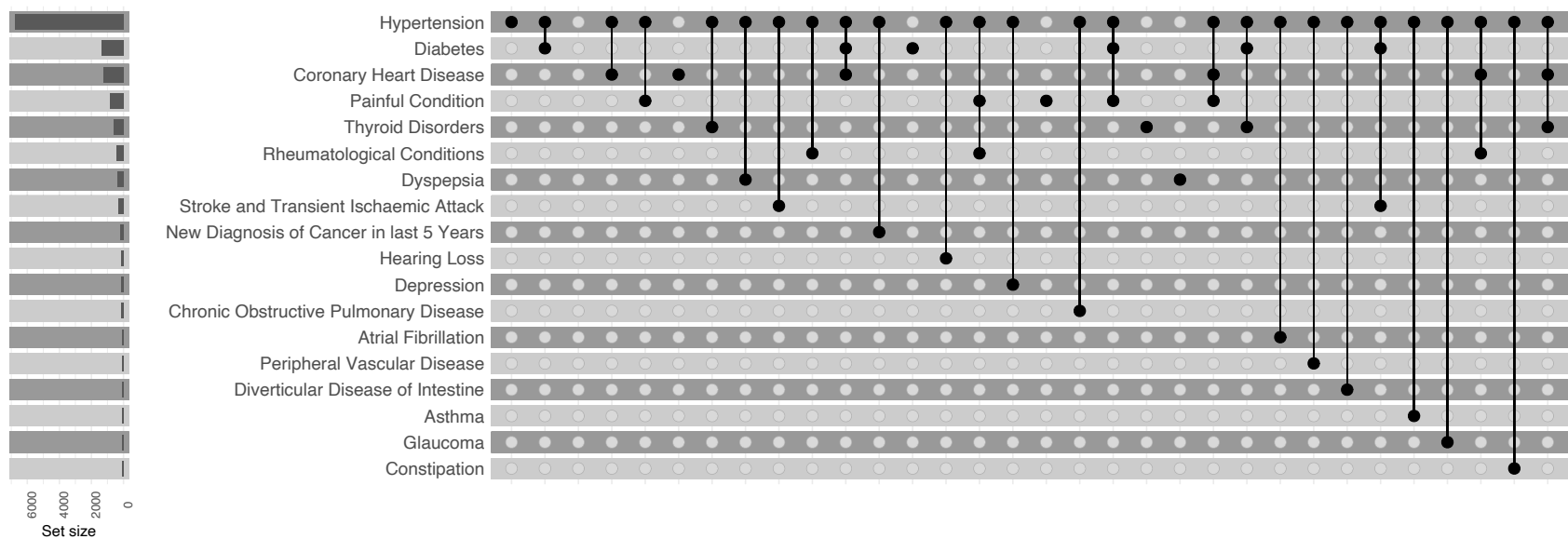
```
## [1] "Converting non-logical columns to binary: Dementia, Alcohol Problems, Other Psychoactive Substa
## [1] "Dropping 21 empty groups"
```

Frequency of CKD comorbidity groups
Limited to groups with frequency >= 75

Intersection size

6.4%
2%
1.8%
1.5%
1.1%
0.9% 0.9% 0.9% 0.8% 0.7% 0.6% 0.6% 0.5% 0.4% 0.4% 0.4% 0.4% 0.4% 0.4% 0.3% 0.3% 0.3% 0.3% 0.3% 0.3% 0.3% 0.3% 0.3% 0.2% 0.2% 0.2% 0.2%

Hypertension
Diabetes
Coronary Heart Disease
Painful Condition
Thyroid Disorders
Rheumatological Conditions
Dyspepsia
Stroke and Transient Ischaemic Attack
New Diagnosis of Cancer in last 5 Years
Hearing Loss
Depression
Chronic Obstructive Pulmonary Disease
Atrial Fibrillation
Peripheral Vascular Disease
Diverticular Disease of Intestine
Asthma
Glaucoma
Constipation

Set size

n = 33,567 with CKD
Most frequent 32 combinations shown
Total combinations = 13,891

Count combinations

Here we count the unique combinations of diseases that co-occur with CKD.

```
spice %>%
  filter(ckd == "CKD") %>%
  select(unique_patient_id, age, age_group, sex, carstairs_decile,
         Dementia:`Painful Condition`) %>%
  pivot_longer(cols = Dementia:`Painful Condition`,
               names_to = "diseases", values_to = "present") %>%
  group_by(unique_patient_id) %>%
  filter(present == "Yes") %>%
  select(-present) %>%
  mutate(comb = paste0(sort(diseases), collapse = "-"),
         comb = sort(comb)) %>%
  nest(diseases = diseases) %>%
  ungroup -> ckd_morb

ckd_morb %>%
  summarise(n_combinations = n_distinct(comb)) %>%
  kable(.)
```

n_combinations
13890

Table 3

Now count the number of times these combinations occur. This is just a tabular form of the previous plot with a % score added. It is good practice not to divulge individual-level data below 5 observations in any table so these observations are lumped together. They make up nearly half of all the people with CKD. That is, almost half the people with CKD have a combination of conditions that they share with only 3 other people. The top 50 rows are shown here, this will be truncated to include only the top 33 (those shown in figure 3).

```
fct_count(fct_lump_min(ckd_morb$comb, min = 5)) %>%
  mutate(pct = round(n/sum(n) * 100,1),
         f = str_replace_all(f, "-", " & "),
         f = str_replace(f, "Other",
                         "Combinations shared with fewer than 5 other people")) %>%
  add_row(f = "No comorbidity", n = 614L, pct = 1.8) %>%
  slice_min(order_by = -n, n = 50) %>%
  kable(., booktabs = TRUE, longtable = TRUE) %>%
  kable_styling(latex_options = "striped")
```

f	n	pct
Combinations shared with fewer than 5 other people	16038	48.7
Hypertension	2136	6.5
Diabetes & Hypertension	668	2.0
No comorbidity	614	1.8
Coronary Heart Disease & Hypertension	489	1.5
Hypertension & Painful Condition	384	1.2
Coronary Heart Disease	316	1.0
Hypertension & Thyroid Disorders	315	1.0
Dyspepsia & Hypertension	295	0.9

Hypertension & Stroke and Transient Ischaemic Attack	262	0.8
Hypertension & Rheumatological Conditions	235	0.7
Coronary Heart Disease & Diabetes & Hypertension	199	0.6
Hypertension & New Diagnosis of Cancer in last 5 Years	189	0.6
Diabetes	166	0.5
Hearing Loss & Hypertension	151	0.5
Hypertension & Painful Condition & Rheumatological Conditions	126	0.4
Depression & Hypertension	125	0.4
Painful Condition	120	0.4
Chronic Obstructive Pulmonary Disease & Hypertension	119	0.4
Diabetes & Hypertension & Painful Condition	119	0.4
Thyroid Disorders	111	0.3
Dyspepsia	107	0.3
Coronary Heart Disease & Hypertension & Painful Condition	106	0.3
Diabetes & Hypertension & Thyroid Disorders	105	0.3
Atrial Fibrillation & Hypertension	98	0.3
Hypertension & Peripheral Vascular Disease	94	0.3
Diverticular Disease of Intestine & Hypertension	92	0.3
Diabetes & Hypertension & Stroke and Transient Ischaemic Attack	86	0.3
Asthma & Hypertension	85	0.3
Glaucoma & Hypertension	79	0.2
Coronary Heart Disease & Hypertension & Rheumatological Conditions	76	0.2
Constipation & Hypertension	75	0.2
Coronary Heart Disease & Hypertension & Thyroid Disorders	75	0.2
Coronary Heart Disease & Heart Failure	74	0.2
Coronary Heart Disease & Heart Failure & Hypertension	72	0.2
Coronary Heart Disease & Hypertension & Stroke and Transient Ischaemic Attack	72	0.2
Dyspepsia & Hypertension & Rheumatological Conditions	72	0.2
Diabetes & Hypertension & Rheumatological Conditions	71	0.2
Coronary Heart Disease & Diabetes	70	0.2
Heart Failure & Hypertension	69	0.2
Depression & Hypertension & Painful Condition	68	0.2
Hypertension & Painful Condition & Thyroid Disorders	68	0.2
Coronary Heart Disease & Painful Condition	66	0.2
New Diagnosis of Cancer in last 5 Years	62	0.2
Atrial Fibrillation & Coronary Heart Disease & Hypertension	58	0.2
Diabetes & Dyspepsia & Hypertension	57	0.2
Rheumatological Conditions	57	0.2
Coronary Heart Disease & Diabetes & Hypertension & Painful Condition	55	0.2
Hypertension & Prostate Disorders	55	0.2
Dyspepsia & Hypertension & Thyroid Disorders	54	0.2

Session Information

```
pander::pander(sessionInfo(), locale = FALSE)
```

R version 4.0.0 (2020-04-24)

Platform: x86_64-apple-darwin17.0 (64-bit)

attached base packages: *stats*, *graphics*, *grDevices*, *utils*, *datasets*, *methods* and *base*

other attached packages: *extrafont(v.0.17)*, *kableExtra(v.1.1.0)*, *ComplexUpset(v.0.5.9)*, *glue(v.1.4.1)*, *socviz(v.1.1)*, *janitor(v.2.0.1)*, *here(v.0.1)*, *broom(v.0.5.6)*, *phsmethods(v.0.2.0)*, *finalfit(v.1.0.1)*, *forcats(v.0.5.0)*, *stringr(v.1.4.0)*, *dplyr(v.1.0.0)*, *purrr(v.0.3.4)*, *readr(v.1.3.1)*, *tidyr(v.1.1.0)*, *tibble(v.3.0.1)*, *ggplot2(v.3.3.1)* and *tidyverse(v.1.3.0)*

loaded via a namespace (and not attached): *httr(v.1.4.1)*, *jsonlite(v.1.6.1)*, *viridisLite(v.0.3.0)*, *splines(v.4.0.0)*, *modelr(v.0.1.8)*, *assertthat(v.0.2.1)*, *pander(v.0.6.3)*, *blob(v.1.2.1)*, *cellranger(v.1.1.0)*, *yaml(v.2.2.1)*, *Rttf2pt1(v.1.3.8)*, *pillar(v.1.4.4)*, *backports(v.1.1.8)*, *lattice(v.0.20-41)*, *extrafontdb(v.1.0)*, *digest(v.0.6.25)*, *rvest(v.0.3.5)*, *snakecase(v.0.11.0)*, *colorspace(v.1.4-1)*, *htmltools(v.0.4.0)*, *Matrix(v.1.2-18)*, *pkgconfig(v.2.0.3)*, *feather(v.0.3.5)*, *haven(v.2.3.1)*, *patchwork(v.1.0.0)*, *scales(v.1.1.1)*, *webshot(v.0.5.2)*, *farver(v.2.0.3)*, *generics(v.0.0.2)*, *ellipsis(v.0.3.1)*, *withr(v.2.2.0)*, *cli(v.2.0.2)*, *survival(v.3.1-12)*, *magrittr(v.1.5)*, *crayon(v.1.3.4)*, *readxl(v.1.3.1)*, *evaluate(v.0.14)*, *mice(v.3.9.0)*, *fs(v.1.4.1)*, *fansi(v.0.4.1)*, *nlme(v.3.1-148)*, *xml2(v.1.3.2)*, *tools(v.4.0.0)*, *hms(v.0.5.3)*, *lifecycle(v.0.2.0)*, *munsell(v.0.5.0)*, *reprex(v.0.3.0)*, *compiler(v.4.0.0)*, *rlang(v.0.4.6)*, *grid(v.4.0.0)*, *rstudioapi(v.0.11)*, *labeling(v.0.3)*, *rmarkdown(v.2.2)*, *boot(v.1.3-25)*, *gtable(v.0.3.0)*, *DBI(v.1.1.0)*, *R6(v.2.4.1)*, *zoo(v.1.8-8)*, *lubridate(v.1.7.8)*, *knitr(v.1.28)*, *rprojroot(v.1.3-2)*, *stringi(v.1.4.6)*, *Rcpp(v.1.0.4.6)*, *vctrs(v.0.3.1)*, *dbplyr(v.1.4.4)*, *tidyselect(v.1.1.0)* and *xfun(v.0.14)*