

Introduction to R for SAS programmers

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Table of contents

About	4
Further material	4
I datatype & structure	6
1 datatype and structure	7
1.1 Storing outputs	7
1.2 Loading data into R	8
1.3 R Packages	9
1.4 Installing R packages	9
1.5 Using R packages, functions from an R package, and accessing help pages . . .	10
1.6 Data types	10
1.7 Date formats	11
1.8 Structures	12
2 datatype_structure_exercise	14
3 Exercise 2	15
II dplyr	16
4 dplyr	17
4.1 dplyr	19
4.2 Datawrangling	19
4.2.1 select	19
4.2.2 filter	115
4.2.3 arrange	131
5 dplyr exercises	145
5.1 Data wrangling with dplyr	145

III	mutate	148
6	mutate	149
7	mutate() Exercises	157
7.1	Exercise 1	157
7.2	Exercise 2	158
IV	summarize	160
8	Summarizing Data	161
9	Summarizing Data Exercises	164
9.1	Exercise 1	164
9.2	Exercise 2	165
9.3	Exercise 3	165
V	tidyr	166
10	tidyr	167
10.0.1	Some Context	167
10.0.2	Setup	168
10.1	Relational Data (Joins)	170
11	tidyr exercises	173
11.1	Pivoting with tidyr	173
11.2	Joining using dplyr	176

About

On this page you find the materials for the workshop *Introduction to R for SAS programmers*. The workshop provides an RStudio cloud workspace, so you don't need to have R and RStudio locally installed.

If you want to participate in this workshop using your local machine, you need to download the data first. Executing the following chunk in R on your machine will create and populate a data folder in your current working directory. If you work on the RStudio cloud instance provided by us via link, you do not need to run this chunk.

```
# set paths and data names
path <- "https://github.com/pharmaverse/intro-to-r-for-sas-programmers-workshop/blob/main/"
local.path <- ("data")
files <- c("adsl.RData", "adsl.csv", "adsl.sas7bdat", "adsl_1.RData", "adsl_2.RData", "ae.")
urls <- file.path(path, files)
dest <- file.path(local.path, files)

# create data folder in wd
if (!file.exists(local.path)) {
  dir.create(local.path)
}

# download files
download.file(urls, destfile = dest)
```

Further material

You can't get enough? [Here is a resource to help transitioning from SAS to R.](#)

SAS <-> R :: CHEAT SHEET

Introduction

This guide aims to familiarise SAS users with R.
R examples make use of tidyverse collection of packages.

Install tidyverse:
Attach tidyverse packages for use: `install.packages("tidyverse")`
`library(tidyverse)`

R data here in 'data frames', and occasionally vectors (via `c()`)
Other R structures (lists, matrices...) are not explored here.

Keyboard shortcuts: `<-` Alt + - `%>%` Ctrl + Shift + m

Datasets; drop, keep & rename variables

```
data new_data;
set old_data;
run;

data new_data (keep=id);
set old_data (drop=job_title);
run;

data new_data (drop= temp);
set old_data;
run;

data new_data;
set old_data;
rename old_name = new_name;
run;
```

Note order differs

Conditional filtering

```
data new_data;
set old_data;
if Sex = "M";
run;

data new_data;
set old_data;
if year in (2010,2011,2012);
run;

data new_data;
set old_data;
by id;
if first.id;
run;

data new_data;
set old_data;
if dob > "25APR1990"d;
run;
```

Could use slice(n()) for last

New variables, conditional editing

```
data new_data;
set old_data;
total_income = wages + benefits;
run;

data new_data;
set old_data;
if hours > 30 then full_time = "Y";
else full_time = "N";
run;

data new_data;
set old_data;
if temp > 20 then weather = "Warm";
else if temp > 10 then weather = "Mild";
else weather = "Cold";
run;
```

Counting and Summarising

```
proc freq data = old_data;
table job_type;
run;

proc freq data = old_data;
table job_type*region;
run;

proc summary data = old_data nway;
class job_type region;
output out = new_data;
sum(salary) = total_salaries;
run;
```

Equivalent without nway not trivially produced

Lots of summary functions in both languages
Swap summarise() for mutate() to add summary data to original data

Combining datasets

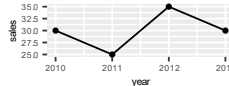
```
data new_data;
set data_1 data_2;
run;

data new_data;
merge data_1 (in=in_1) data_2;
by id;
if in_1;
run;
```

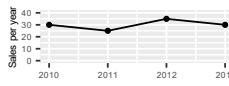
C.f. full_join(), right_join(), inner_join()

Some plotting in R


```
ggplot(my_data, aes(year, sales)) +
geom_point() + geom_line()
```



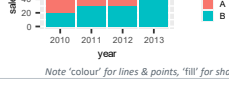
```
ggplot(my_data, aes(year, sales)) +
geom_point() + geom_line() + ylim(0, 40) +
labs(x = "", y = "Sales per year")
```



```
ggplot(my_data, aes(year, sales, colour = dept)) +
geom_point() + geom_line()
```

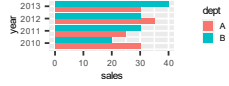


```
ggplot(my_data, aes(year, sales, fill = dept)) +
geom_col()
```



Note 'colour' for lines & points, 'fill' for shapes

```
ggplot(my_data, aes(year, sales, fill = dept)) +
geom_col(position = "dodge") + coord_flip()
```



C.f. position = "fill" for 100% stacked bars/cols

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Figure 1: Cheatsheet for the transition from SAS to R and vice versa.

Part I

datatype & structure

1 datatype and structure

Sadchla Mascary

R can be used as a calculator following the order of operations using the basic arithmetic operators, although, the arithmetic equal sign (=) in the equivalent of ==.

```
# simple calculations  
3*2
```

```
[1] 6
```

```
(59 + 73 + 2) / 3
```

```
[1] 44.66667
```

```
# complex calculations  
pi/8
```

```
[1] 0.3926991
```

1.1 Storing outputs

An object can be created to assign the value of your operation to a specific variable name, which can be reused later in the R session. Using the `object_name <- value` naming convention, you can assign (<-) the value `((59 + 73 + 2) / 3)` to an `object_name` `simple_cal` to look like `simple_cal <- (59 + 73 + 2) / 3` to store the evaluation of that calculation.

```
x <- 1:10
```

```
y <- 2*x

simple_cal <- (59 + 73 + 2) / 3
```

1.2 Loading data into R

Depending on the formats for the files containing your data, we can use different base R functions to read and load data into memory

R has two native data formats, **Rdata** (sometimes call Rda) and **RDS**.

Rdata can be selected R objects or a workspace, and **RDS** are single R object. R has base functions available to read the two native data formats, and some delimited files.

```
# saving rdata
save(x, file = "data/intro_1.RData")
# Save multiple objects
save(x, y, file = "data/intro_2.RData")

# Saving the entire workspake
save.image(file="intro_program")

# We can follow the syntax for saving single Rdata object to save Rds files
# saveRDS(object, file = "my_data.rds")

# loading Rdata or Rda files
load(file = "data/intro_program.RData")

# loading RDS
# We can follow the syntax for read Rdata object to sread Rds files using the readRDS()

# Comma delimited
adsl_CSV <- read.csv("data/adsl.csv", header = TRUE)

# Save CSV
adsl_csv_save <- write.csv(adsl_CSV, "data/save_data/adsl.csv", row.names=TRUE)

adsl_TAB_save <- write.table(
```



```

adsl_CSV,
"data/save_data/adsl.txt",
append = FALSE,
sep = "\t",
dec = ".",
row.names = TRUE,
col.names = TRUE
)

# Tab-delimited
adsl_TAB <- read.table("data/save_data/adsl.txt", header = TRUE, sep = "\t")

```

1.3 R Packages

R packages are a collection of reusable functions, compiled codes, documentation, sample data and tests. Some formats of data require the use of an R package in order to load that data into memory. Shareable R packages are typically stored in a repository such as the Comprehensive R Archive Network (CRAN), Bioconductor, and GitHub.

1.4 Installing R packages

```

# From CRAN
#install.packages("insert_package_name")
# {haven} is used to import or export foreign statistical format files (SPSS, Stata, SAS)
install.packages("haven")

# {readxl}
install.packages("readxl")

# From Github
remotes::install_github("pharmaverse/admiral", ref = "devel")

```

1.5 Using R packages, functions from an R package, and accessing help pages

Since R packages are a collection of functions, you can choose to load the entire package within R memory or just the needed function from that package. Usually, the order you choose to load your package does not make a difference, unless you are loading two or more packages that has functions with the same name. If you are loading two or more packages with common function name, then the package loaded last will hide that function in the earlier packages, so in that case is important to note the order you choose to load the packages.

```
# Read file using ::
adsl_sas1 <- haven::read_sas("data/adsl.sas7bdat")

# read file using library call
library(haven)
adsl_sas2 <- read_sas("data/adsl.sas7bdat")

# Reading Excel xls|xlsx files
# read_excel reads both xls|xlsx files but read_xls and read_xlsx can also be used to read

# if NA are represented by another something other than blank then you can specified the N
# within the read_excel() function
```

1.6 Data types

R has different types of **Datatype**

* Integer * numeric * Character * Logical * complex * raw

But we will focus on the top 4.

```
set.seed(1234)

type_int <- (1:5)
type_num <- rnorm(5)
type_char <- "USUBJID"
type_logl_1 <- TRUE
type_logl_2 <- FALSE
```

```
class(type_int)
```

```
[1] "integer"
```

```
class(type_num)
```

```
[1] "numeric"
```

```
class(type_logl_1)
```

```
[1] "logical"
```

```
class(type_logl_2)
```

```
[1] "logical"
```

```
class(type_char)
```

```
[1] "character"
```

1.7 Date formats

There are base R functions that can be used to format a date object similar to the Date9 formatted date variable from SAS. In addition, there are R packages available, such as {lubridate}, for more complex date/date time formatted objects.

```
# using adsl_sas1 RFSTDTC  
class(adsl_sas1$RFSTDTC)
```

```
[1] "character"
```

```
# Convert the date from that adsl_sas1 into a date variable
adsl_sas1$RFSTDTC <- as.Date(adsl_sas1$RFSTDTC)
class(adsl_sas1$RFSTDTC)
```

```
[1] "Date"
```

```
date9 <- lubridate::as_date(18757)
lubridate::mdy(adsl_sas1$RFSTDTC)
```

Warning: All formats failed to parse. No formats found.

```
[1] NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA
[26] NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA
[51] NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA
[76] NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA
[101] NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA
[126] NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA
[151] NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA
[176] NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA
[201] NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA
[226] NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA
[251] NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA
[276] NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA
[301] NA NA NA NA NA NA
```

1.8 Structures

Data structures are dimensional ways of organizing the data. There are different data structures in R, let's focus on **vectors** and **dataframe**

Vectors are 1 dimensional collection of data that can contain one or more element of the same data type

```
vect_1 <- 2
vect_2 <- c(2, "USUBJID")

class(vect_1)
```

```
[1] "numeric"
```

```
class(vect_2)
```

```
[1] "character"
```

```
# Saving vectors from a dataset to a specific variable
usubjid <- adsl_sas1$USUBJID
subjid <- adsl_sas1[, 3]
```

Dataframe is similar to SAS data sets and are 2 dimensional collection of vectors. Dataframe can store vectors of different types but must be of the same length

```
df <- data.frame(
  age = c(65, 20, 37, 19, 45),
  seq = (1:5),
  type_log1 = c(TRUE, FALSE, TRUE, TRUE, FALSE),
  usubjid = c("001-940-9785", "002-950-9726", "003-940-9767", "004-940-9795", "005-940-9734")
)

# str() provides the data structure for each object in the dataframe
str(df)
```

```
'data.frame':  5 obs. of  4 variables:
 $ age      : num  65 20 37 19 45
 $ seq      : int   1 2 3 4 5
 $ type_log1: logi  TRUE FALSE TRUE TRUE FALSE
 $ usubjid  : chr   "001-940-9785" "002-950-9726" "003-940-9767" "004-940-9795" ...
```

```
# In addition to the data structure per variable, also get some descriptive statistics
summary(df)
```

age		seq		type_log1		usubjid	
Min.	:19.0	Min.	:1	Mode	:logical	Length	:5
1st Qu.	:20.0	1st Qu.	:2	FALSE	:2	Class	:character
Median	:37.0	Median	:3	TRUE	:3	Mode	:character
Mean	:37.2	Mean	:3				
3rd Qu.	:45.0	3rd Qu.	:4				
Max.	:65.0	Max.	:5				

2 datatype_structure_exercise

Install and load the following packages

```
{tidyverse} {admiral} {dplyr} {tidyr} {admiral.test}
```

```
#installing the packages
install.packages(c("tidyverse", "admiral", "dplyr", "tidyr"))

library(tidyverse)
library(admiral)
library(admiral.test)
library(dplyr)
library(tidyr)
```

3 Exercise 2

Import `adsl.sas7bdat` as `adsl`

```
adsl <- haven::read_sas("data/adsl.sas7bdat")
```

Part II

dplyr

4 dplyr

Stefan Thoma

```
# remotes::install_github("https://github.com/pharmaverse/admiral")
# library(admiral)
library(tidyverse)
```

```
-- Attaching packages ----- tidyverse 1.3.2 --
v ggplot2 3.3.6      v purrr   0.3.5
v tibble  3.1.8      v dplyr   1.0.10
v tidyr   1.2.1      v stringr 1.4.1
v readr   2.1.3      v forcats 0.5.2
-- Conflicts ----- tidyverse_conflicts() --
x dplyr::filter() masks stats::filter()
x dplyr::lag()    masks stats::lag()
```

Read data

```
adsl <- read.csv("data/adsl.csv", header = TRUE)
```

We can have a look at the data using many different commands / functions, e.g. the `head()` function which gives us the first six observations:

```
head(adsl)
```

	STUDYID	USUBJID	SUBJID	RFSTDTC	RFENDTC	RFXSTDTC	RFXENDTC
1	CDISCPIL0T01	01-701-1015	1015	2014-01-02	2014-07-02	2014-01-02	2014-07-02
2	CDISCPIL0T01	01-701-1023	1023	2012-08-05	2012-09-02	2012-08-05	2012-09-01
3	CDISCPIL0T01	01-701-1028	1028	2013-07-19	2014-01-14	2013-07-19	2014-01-14
4	CDISCPIL0T01	01-701-1033	1033	2014-03-18	2014-04-14	2014-03-18	2014-03-31
5	CDISCPIL0T01	01-701-1034	1034	2014-07-01	2014-12-30	2014-07-01	2014-12-30
6	CDISCPIL0T01	01-701-1047	1047	2013-02-12	2013-03-29	2013-02-12	2013-03-09

	RFICDTC	RFPENDTC	DTHDTC	DTHFL	SITEID	AGE	AGEU	SEX	RACE	
1	NA	2014-07-02T11:45	<NA>	<NA>	701	63	YEARS	F	WHITE	
2	NA	2013-02-18	<NA>	<NA>	701	64	YEARS	M	WHITE	
3	NA	2014-01-14T11:10	<NA>	<NA>	701	71	YEARS	M	WHITE	
4	NA	2014-09-15	<NA>	<NA>	701	74	YEARS	M	WHITE	
5	NA	2014-12-30T09:50	<NA>	<NA>	701	77	YEARS	F	WHITE	
6	NA	2013-07-28	<NA>	<NA>	701	85	YEARS	F	WHITE	
	ETHNIC	ARMCD						ARM	ACTARMCD	
1	HISPANIC OR LATINO	Pbo						Placebo	Pbo	
2	HISPANIC OR LATINO	Pbo						Placebo	Pbo	
3	NOT HISPANIC OR LATINO	Xan_Hi	Xanomeline	High Dose				Xan_Hi		
4	NOT HISPANIC OR LATINO	Xan_Lo	Xanomeline	Low Dose				Xan_Lo		
5	NOT HISPANIC OR LATINO	Xan_Hi	Xanomeline	High Dose				Xan_Hi		
6	NOT HISPANIC OR LATINO	Pbo						Placebo	Pbo	
	ACTARM	COUNTRY		DMDTC	DMDY				TRT01P	
1	Placebo	USA		2013-12-26	-7				Placebo	
2	Placebo	USA		2012-07-22	-14				Placebo	
3	Xanomeline High Dose	USA		2013-07-11	-8	Xanomeline	High Dose			
4	Xanomeline Low Dose	USA		2014-03-10	-8	Xanomeline	Low Dose			
5	Xanomeline High Dose	USA		2014-06-24	-7	Xanomeline	High Dose			
6	Placebo	USA		2013-01-22	-21				Placebo	
	TRT01A			TRTSDTM	TRTSTMF				TRTEDTM	
1	Placebo	2014-01-02T00:00:00Z			H	2014-07-02T23:59:59Z				
2	Placebo	2012-08-05T00:00:00Z			H	2012-09-01T23:59:59Z				
3	Xanomeline High Dose	2013-07-19T00:00:00Z			H	2014-01-14T23:59:59Z				
4	Xanomeline Low Dose	2014-03-18T00:00:00Z			H	2014-03-31T23:59:59Z				
5	Xanomeline High Dose	2014-07-01T00:00:00Z			H	2014-12-30T23:59:59Z				
6	Placebo	2013-02-12T00:00:00Z			H	2013-03-09T23:59:59Z				
	TRTETMF	TRTSDT	TRTEDT	TRTDURD	SCRFTD		EOSDT		EOSSTT	
1	H	2014-01-02	2014-07-02	182	<NA>	2014-07-02		COMPLETED		
2	H	2012-08-05	2012-09-01	28	<NA>	2012-09-02		DISCONTINUED		
3	H	2013-07-19	2014-01-14	180	<NA>	2014-01-14		COMPLETED		
4	H	2014-03-18	2014-03-31	14	<NA>	2014-04-14		DISCONTINUED		
5	H	2014-07-01	2014-12-30	183	<NA>	2014-12-30		COMPLETED		
6	H	2013-02-12	2013-03-09	26	<NA>	2013-03-29		DISCONTINUED		
	FRVDT	RANDDT	DTHDT	DTHADY	LDDTHELD		LSTALVDT	AGEGR1	SAFFL	RACEGR1
1	<NA>	2014-01-02	<NA>	NA	NA	2014-07-02	18-64	Y	White	
2	2013-02-18	2012-08-05	<NA>	NA	NA	2012-09-02	18-64	Y	White	
3	<NA>	2013-07-19	<NA>	NA	NA	2014-01-14	>=65	Y	White	
4	2014-09-15	2014-03-18	<NA>	NA	NA	2014-04-14	>=65	Y	White	
5	<NA>	2014-07-01	<NA>	NA	NA	2014-12-30	>=65	Y	White	
6	2013-07-28	2013-02-12	<NA>	NA	NA	2013-04-07	>=65	Y	White	
	REGION1	LDDTHGR1	DTH30FL	DTHA30FL	DTHB30FL					

1	NA	<NA>	<NA>	NA	<NA>
2	NA	<NA>	<NA>	NA	<NA>
3	NA	<NA>	<NA>	NA	<NA>
4	NA	<NA>	<NA>	NA	<NA>
5	NA	<NA>	<NA>	NA	<NA>
6	NA	<NA>	<NA>	NA	<NA>

4.1 dplyr

`dplyr` is a package which is part of the tidyverse. `dplyr` helps us handle data. In R, we generally work with data-sets. With `dplyr` we can easily select variables, filter specific rows, sort data-sets based on variable values and much more.

`dplyr` is not strictly needed for any of that, everything can be done in base R. However, `dplyr` provides a framework to write readable code and a pipeline to work efficiently.

4.2 Datawrangling

There are various functions within `dplyr` for datawrangling which follow a consistent structure. The first input of the most used `dplyr` functions is the data-frame. Then follow arguments specifying the behaviour of the function. Compared to the base r syntax we do not have to write column / variable names in quotation marks; `dplyr` syntax lets us refer to columns within a data-frame without the need to always reference the dataframe of origin.

4.2.1 select

The `select` function lets us select all variables mentioned in the arguments (and drops all other variables). Alternatively, we can selectively drop variables if we place a minus (-) in front of the variable name.

We can first have a look at all variable names of the data-frame:

```
names(adsl)
```

```
[1] "STUDYID" "USUBJID" "SUBJID" "RFSTDTC" "RFENDTC" "RFXSTDTC"
[7] "RFXENDTC" "RFICDTC" "RFPENDTC" "DTHDTC" "DTHFL" "SITEID"
[13] "AGE" "AGEU" "SEX" "RACE" "ETHNIC" "ARMCD"
[19] "ARM" "ACTARMCD" "ACTARM" "COUNTRY" "DMDTC" "DMDY"
[25] "TRT01P" "TRT01A" "TRTSDTM" "TRTSTMF" "TRTEDTM" "TRTETMF"
[31] "TRTSDT" "TRTEDT" "TRTDURD" "SCRFDI" "EOSDT" "EOSSTT"
```

```

[37] "FRVDT"      "RANDDT"      "DTHDT"      "DTHADY"      "LDDTHELD" "LSTALVDT"
[43] "AGEGR1"     "SAFFL"       "RACEGR1"    "REGION1"     "LDDTHGR1" "DTH3OFL"
[49] "DTHA3OFL"   "DTHB3OFL"

```

And then select the desired variables:

```

# dplyr::select
select(.data = adsl,
      STUDYID,
      USUBJID,
      ARM,
      AGE,
      SEX,
      RACE)

```

	STUDYID	USUBJID	ARM	AGE	SEX
1	CDISCPIL0T01	01-701-1015	Placebo	63	F
2	CDISCPIL0T01	01-701-1023	Placebo	64	M
3	CDISCPIL0T01	01-701-1028	Xanomeline High Dose	71	M
4	CDISCPIL0T01	01-701-1033	Xanomeline Low Dose	74	M
5	CDISCPIL0T01	01-701-1034	Xanomeline High Dose	77	F
6	CDISCPIL0T01	01-701-1047	Placebo	85	F
7	CDISCPIL0T01	01-701-1057	Screen Failure	59	F
8	CDISCPIL0T01	01-701-1097	Xanomeline Low Dose	68	M
9	CDISCPIL0T01	01-701-1111	Xanomeline Low Dose	81	F
10	CDISCPIL0T01	01-701-1115	Xanomeline Low Dose	84	M
11	CDISCPIL0T01	01-701-1118	Placebo	52	M
12	CDISCPIL0T01	01-701-1130	Placebo	84	M
13	CDISCPIL0T01	01-701-1133	Xanomeline High Dose	81	F
14	CDISCPIL0T01	01-701-1145	Screen Failure	57	F
15	CDISCPIL0T01	01-701-1146	Xanomeline High Dose	75	F
16	CDISCPIL0T01	01-701-1148	Xanomeline High Dose	57	M
17	CDISCPIL0T01	01-701-1153	Placebo	79	F
18	CDISCPIL0T01	01-701-1162	Screen Failure	82	F
19	CDISCPIL0T01	01-701-1176	Screen Failure	62	F
20	CDISCPIL0T01	01-701-1180	Xanomeline High Dose	56	M
21	CDISCPIL0T01	01-701-1181	Xanomeline High Dose	79	F
22	CDISCPIL0T01	01-701-1188	Xanomeline Low Dose	71	M
23	CDISCPIL0T01	01-701-1192	Xanomeline Low Dose	80	F
24	CDISCPIL0T01	01-701-1203	Placebo	81	F
25	CDISCPIL0T01	01-701-1211	Xanomeline Low Dose	76	F
26	CDISCPIL0T01	01-701-1234	Placebo	69	M

27	CDISCPILLOT01	01-701-1239	Xanomeline High Dose	56	M
28	CDISCPILLOT01	01-701-1240	Screen Failure	57	F
29	CDISCPILLOT01	01-701-1275	Xanomeline High Dose	61	M
30	CDISCPILLOT01	01-701-1287	Xanomeline High Dose	56	F
31	CDISCPILLOT01	01-701-1294	Xanomeline Low Dose	67	M
32	CDISCPILLOT01	01-701-1302	Xanomeline High Dose	61	M
33	CDISCPILLOT01	01-701-1307	Screen Failure	80	F
34	CDISCPILLOT01	01-701-1317	Xanomeline Low Dose	68	M
35	CDISCPILLOT01	01-701-1324	Xanomeline Low Dose	79	M
36	CDISCPILLOT01	01-701-1341	Xanomeline Low Dose	51	M
37	CDISCPILLOT01	01-701-1345	Placebo	63	F
38	CDISCPILLOT01	01-701-1356	Screen Failure	54	F
39	CDISCPILLOT01	01-701-1360	Xanomeline High Dose	67	M
40	CDISCPILLOT01	01-701-1363	Placebo	81	F
41	CDISCPILLOT01	01-701-1369	Screen Failure	74	M
42	CDISCPILLOT01	01-701-1383	Xanomeline High Dose	72	F
43	CDISCPILLOT01	01-701-1386	Screen Failure	71	M
44	CDISCPILLOT01	01-701-1387	Placebo	87	F
45	CDISCPILLOT01	01-701-1392	Placebo	78	M
46	CDISCPILLOT01	01-701-1411	Screen Failure	76	M
47	CDISCPILLOT01	01-701-1415	Placebo	85	M
48	CDISCPILLOT01	01-701-1429	Xanomeline Low Dose	84	F
49	CDISCPILLOT01	01-701-1440	Placebo	70	M
50	CDISCPILLOT01	01-701-1442	Xanomeline Low Dose	57	F
51	CDISCPILLOT01	01-701-1444	Xanomeline High Dose	63	M
52	CDISCPILLOT01	01-702-1082	Xanomeline Low Dose	84	F
53	CDISCPILLOT01	01-703-1042	Placebo	64	M
54	CDISCPILLOT01	01-703-1076	Xanomeline High Dose	69	M
55	CDISCPILLOT01	01-703-1086	Xanomeline Low Dose	71	M
56	CDISCPILLOT01	01-703-1096	Placebo	81	F
57	CDISCPILLOT01	01-703-1100	Placebo	84	F
58	CDISCPILLOT01	01-703-1119	Xanomeline Low Dose	81	F
59	CDISCPILLOT01	01-703-1175	Placebo	75	M
60	CDISCPILLOT01	01-703-1182	Xanomeline Low Dose	84	M
61	CDISCPILLOT01	01-703-1197	Xanomeline Low Dose	76	F
62	CDISCPILLOT01	01-703-1210	Placebo	72	F
63	CDISCPILLOT01	01-703-1258	Xanomeline High Dose	78	F
64	CDISCPILLOT01	01-703-1279	Xanomeline Low Dose	72	F
65	CDISCPILLOT01	01-703-1295	Xanomeline High Dose	88	F
66	CDISCPILLOT01	01-703-1299	Placebo	81	F
67	CDISCPILLOT01	01-703-1335	Xanomeline High Dose	67	F
68	CDISCPILLOT01	01-703-1379	Xanomeline Low Dose	81	F
69	CDISCPILLOT01	01-703-1396	Screen Failure	84	M

70	CDISCPILLOT01	01-703-1403	Xanomeline High Dose	67	M
71	CDISCPILLOT01	01-703-1439	Xanomeline High Dose	76	F
72	CDISCPILLOT01	01-704-1008	Xanomeline High Dose	76	F
73	CDISCPILLOT01	01-704-1009	Xanomeline Low Dose	83	M
74	CDISCPILLOT01	01-704-1010	Placebo	80	M
75	CDISCPILLOT01	01-704-1017	Xanomeline High Dose	77	M
76	CDISCPILLOT01	01-704-1025	Xanomeline Low Dose	81	F
77	CDISCPILLOT01	01-704-1065	Xanomeline High Dose	75	M
78	CDISCPILLOT01	01-704-1074	Xanomeline High Dose	80	F
79	CDISCPILLOT01	01-704-1093	Xanomeline High Dose	79	M
80	CDISCPILLOT01	01-704-1114	Xanomeline Low Dose	77	M
81	CDISCPILLOT01	01-704-1120	Xanomeline Low Dose	71	F
82	CDISCPILLOT01	01-704-1127	Placebo	84	F
83	CDISCPILLOT01	01-704-1135	Xanomeline Low Dose	74	F
84	CDISCPILLOT01	01-704-1164	Placebo	67	F
85	CDISCPILLOT01	01-704-1218	Xanomeline Low Dose	81	F
86	CDISCPILLOT01	01-704-1233	Placebo	87	F
87	CDISCPILLOT01	01-704-1241	Xanomeline High Dose	86	M
88	CDISCPILLOT01	01-704-1260	Placebo	71	F
89	CDISCPILLOT01	01-704-1266	Xanomeline High Dose	82	M
90	CDISCPILLOT01	01-704-1323	Xanomeline Low Dose	68	F
91	CDISCPILLOT01	01-704-1325	Xanomeline Low Dose	81	M
92	CDISCPILLOT01	01-704-1332	Xanomeline High Dose	80	M
93	CDISCPILLOT01	01-704-1351	Placebo	70	M
94	CDISCPILLOT01	01-704-1388	Placebo	81	M
95	CDISCPILLOT01	01-704-1435	Placebo	74	M
96	CDISCPILLOT01	01-704-1445	Placebo	75	M
97	CDISCPILLOT01	01-705-1011	Screen Failure	75	F
98	CDISCPILLOT01	01-705-1018	Placebo	69	F
99	CDISCPILLOT01	01-705-1031	Xanomeline Low Dose	56	F
100	CDISCPILLOT01	01-705-1058	Screen Failure	89	M
101	CDISCPILLOT01	01-705-1059	Placebo	66	F
102	CDISCPILLOT01	01-705-1112	Screen Failure	78	M
103	CDISCPILLOT01	01-705-1186	Placebo	84	F
104	CDISCPILLOT01	01-705-1199	Xanomeline Low Dose	87	M
105	CDISCPILLOT01	01-705-1243	Screen Failure	70	F
106	CDISCPILLOT01	01-705-1280	Xanomeline High Dose	56	F
107	CDISCPILLOT01	01-705-1281	Xanomeline High Dose	73	F
108	CDISCPILLOT01	01-705-1282	Placebo	70	F
109	CDISCPILLOT01	01-705-1292	Xanomeline Low Dose	60	F
110	CDISCPILLOT01	01-705-1303	Xanomeline High Dose	72	M
111	CDISCPILLOT01	01-705-1310	Xanomeline High Dose	74	F
112	CDISCPILLOT01	01-705-1349	Placebo	86	F

113	CDISCPIL0T01	01-705-1377	Xanomeline High Dose	63	F
114	CDISCPIL0T01	01-705-1382	Xanomeline High Dose	82	M
115	CDISCPIL0T01	01-705-1393	Xanomeline Low Dose	84	F
116	CDISCPIL0T01	01-705-1421	Screen Failure	87	M
117	CDISCPIL0T01	01-705-1431	Xanomeline Low Dose	68	F
118	CDISCPIL0T01	01-706-1041	Placebo	64	F
119	CDISCPIL0T01	01-706-1049	Xanomeline High Dose	60	F
120	CDISCPIL0T01	01-706-1384	Xanomeline Low Dose	74	F
121	CDISCPIL0T01	01-707-1037	Xanomeline Low Dose	72	F
122	CDISCPIL0T01	01-707-1206	Placebo	65	M
123	CDISCPIL0T01	01-707-1276	Screen Failure	72	F
124	CDISCPIL0T01	01-707-1430	Screen Failure	81	F
125	CDISCPIL0T01	01-707-1434	Screen Failure	76	F
126	CDISCPIL0T01	01-708-1013	Screen Failure	80	M
127	CDISCPIL0T01	01-708-1019	Xanomeline Low Dose	68	M
128	CDISCPIL0T01	01-708-1032	Xanomeline Low Dose	62	M
129	CDISCPIL0T01	01-708-1054	Screen Failure	73	F
130	CDISCPIL0T01	01-708-1067	Screen Failure	88	M
131	CDISCPIL0T01	01-708-1084	Xanomeline Low Dose	73	F
132	CDISCPIL0T01	01-708-1087	Placebo	74	F
133	CDISCPIL0T01	01-708-1104	Screen Failure	78	F
134	CDISCPIL0T01	01-708-1158	Placebo	81	F
135	CDISCPIL0T01	01-708-1171	Placebo	77	F
136	CDISCPIL0T01	01-708-1178	Xanomeline High Dose	77	F
137	CDISCPIL0T01	01-708-1184	Screen Failure	70	F
138	CDISCPIL0T01	01-708-1213	Xanomeline High Dose	76	F
139	CDISCPIL0T01	01-708-1216	Xanomeline High Dose	78	M
140	CDISCPIL0T01	01-708-1236	Xanomeline High Dose	86	F
141	CDISCPIL0T01	01-708-1242	Screen Failure	80	M
142	CDISCPIL0T01	01-708-1253	Placebo	61	M
143	CDISCPIL0T01	01-708-1272	Xanomeline Low Dose	82	M
144	CDISCPIL0T01	01-708-1286	Placebo	80	F
145	CDISCPIL0T01	01-708-1296	Placebo	57	M
146	CDISCPIL0T01	01-708-1297	Xanomeline Low Dose	61	M
147	CDISCPIL0T01	01-708-1316	Placebo	74	F
148	CDISCPIL0T01	01-708-1336	Xanomeline High Dose	73	M
149	CDISCPIL0T01	01-708-1342	Placebo	59	F
150	CDISCPIL0T01	01-708-1347	Xanomeline High Dose	61	F
151	CDISCPIL0T01	01-708-1348	Xanomeline Low Dose	79	F
152	CDISCPIL0T01	01-708-1352	Screen Failure	87	F
153	CDISCPIL0T01	01-708-1353	Xanomeline Low Dose	87	F
154	CDISCPIL0T01	01-708-1372	Xanomeline High Dose	84	M
155	CDISCPIL0T01	01-708-1378	Placebo	67	M

156	CDISCPIL0T01	01-708-1406	Xanomeline High Dose	71	F
157	CDISCPIL0T01	01-708-1428	Xanomeline Low Dose	84	F
158	CDISCPIL0T01	01-709-1001	Placebo	76	F
159	CDISCPIL0T01	01-709-1007	Xanomeline Low Dose	54	F
160	CDISCPIL0T01	01-709-1020	Xanomeline Low Dose	72	F
161	CDISCPIL0T01	01-709-1029	Xanomeline High Dose	82	M
162	CDISCPIL0T01	01-709-1081	Xanomeline Low Dose	86	F
163	CDISCPIL0T01	01-709-1088	Placebo	69	M
164	CDISCPIL0T01	01-709-1099	Xanomeline High Dose	79	F
165	CDISCPIL0T01	01-709-1102	Xanomeline Low Dose	71	F
166	CDISCPIL0T01	01-709-1168	Xanomeline High Dose	72	F
167	CDISCPIL0T01	01-709-1217	Xanomeline Low Dose	77	M
168	CDISCPIL0T01	01-709-1224	Screen Failure	84	M
169	CDISCPIL0T01	01-709-1237	Screen Failure	88	F
170	CDISCPIL0T01	01-709-1238	Xanomeline High Dose	69	M
171	CDISCPIL0T01	01-709-1259	Placebo	82	M
172	CDISCPIL0T01	01-709-1285	Xanomeline Low Dose	87	M
173	CDISCPIL0T01	01-709-1301	Placebo	62	F
174	CDISCPIL0T01	01-709-1306	Placebo	60	F
175	CDISCPIL0T01	01-709-1309	Xanomeline High Dose	65	M
176	CDISCPIL0T01	01-709-1312	Placebo	68	F
177	CDISCPIL0T01	01-709-1326	Xanomeline Low Dose	75	F
178	CDISCPIL0T01	01-709-1329	Xanomeline High Dose	70	M
179	CDISCPIL0T01	01-709-1339	Placebo	81	M
180	CDISCPIL0T01	01-709-1424	Xanomeline High Dose	77	M
181	CDISCPIL0T01	01-710-1002	Xanomeline Low Dose	88	M
182	CDISCPIL0T01	01-710-1006	Xanomeline High Dose	77	M
183	CDISCPIL0T01	01-710-1021	Xanomeline High Dose	79	M
184	CDISCPIL0T01	01-710-1027	Placebo	83	M
185	CDISCPIL0T01	01-710-1045	Xanomeline Low Dose	83	F
186	CDISCPIL0T01	01-710-1053	Xanomeline Low Dose	84	F
187	CDISCPIL0T01	01-710-1060	Placebo	82	M
188	CDISCPIL0T01	01-710-1070	Xanomeline High Dose	85	F
189	CDISCPIL0T01	01-710-1077	Placebo	76	F
190	CDISCPIL0T01	01-710-1078	Placebo	81	F
191	CDISCPIL0T01	01-710-1083	Placebo	89	F
192	CDISCPIL0T01	01-710-1129	Screen Failure	69	F
193	CDISCPIL0T01	01-710-1137	Xanomeline High Dose	79	F
194	CDISCPIL0T01	01-710-1142	Xanomeline High Dose	76	F
195	CDISCPIL0T01	01-710-1149	Screen Failure	79	F
196	CDISCPIL0T01	01-710-1154	Xanomeline Low Dose	84	M
197	CDISCPIL0T01	01-710-1166	Xanomeline Low Dose	81	F
198	CDISCPIL0T01	01-710-1183	Placebo	80	F

199	CDISCPIL0T01	01-710-1187	Xanomeline High Dose	78	F
200	CDISCPIL0T01	01-710-1235	Xanomeline Low Dose	56	F
201	CDISCPIL0T01	01-710-1249	Xanomeline High Dose	79	M
202	CDISCPIL0T01	01-710-1257	Screen Failure	85	F
203	CDISCPIL0T01	01-710-1264	Placebo	78	M
204	CDISCPIL0T01	01-710-1270	Xanomeline Low Dose	83	F
205	CDISCPIL0T01	01-710-1271	Placebo	86	F
206	CDISCPIL0T01	01-710-1278	Xanomeline High Dose	81	M
207	CDISCPIL0T01	01-710-1300	Xanomeline Low Dose	78	F
208	CDISCPIL0T01	01-710-1314	Placebo	78	F
209	CDISCPIL0T01	01-710-1315	Placebo	83	F
210	CDISCPIL0T01	01-710-1337	Screen Failure	73	M
211	CDISCPIL0T01	01-710-1354	Xanomeline High Dose	73	M
212	CDISCPIL0T01	01-710-1358	Xanomeline Low Dose	82	M
213	CDISCPIL0T01	01-710-1368	Placebo	88	F
214	CDISCPIL0T01	01-710-1376	Screen Failure	89	F
215	CDISCPIL0T01	01-710-1380	Screen Failure	80	F
216	CDISCPIL0T01	01-710-1385	Xanomeline Low Dose	77	M
217	CDISCPIL0T01	01-710-1408	Xanomeline High Dose	80	M
218	CDISCPIL0T01	01-710-1443	Screen Failure	88	F
219	CDISCPIL0T01	01-711-1012	Xanomeline High Dose	67	F
220	CDISCPIL0T01	01-711-1022	Screen Failure	86	F
221	CDISCPIL0T01	01-711-1036	Placebo	70	M
222	CDISCPIL0T01	01-711-1143	Xanomeline Low Dose	76	F
223	CDISCPIL0T01	01-711-1163	Screen Failure	74	F
224	CDISCPIL0T01	01-711-1173	Screen Failure	62	M
225	CDISCPIL0T01	01-711-1226	Screen Failure	74	F
226	CDISCPIL0T01	01-711-1251	Screen Failure	82	M
227	CDISCPIL0T01	01-711-1283	Screen Failure	75	F
228	CDISCPIL0T01	01-711-1284	Screen Failure	77	F
229	CDISCPIL0T01	01-711-1290	Screen Failure	61	F
230	CDISCPIL0T01	01-711-1433	Xanomeline High Dose	84	F
231	CDISCPIL0T01	01-713-1043	Xanomeline Low Dose	78	F
232	CDISCPIL0T01	01-713-1073	Xanomeline Low Dose	74	F
233	CDISCPIL0T01	01-713-1106	Xanomeline High Dose	74	M
234	CDISCPIL0T01	01-713-1141	Xanomeline High Dose	79	M
235	CDISCPIL0T01	01-713-1179	Placebo	64	F
236	CDISCPIL0T01	01-713-1209	Xanomeline High Dose	77	F
237	CDISCPIL0T01	01-713-1256	Placebo	71	M
238	CDISCPIL0T01	01-713-1269	Placebo	73	M
239	CDISCPIL0T01	01-713-1448	Xanomeline Low Dose	71	F
240	CDISCPIL0T01	01-714-1035	Placebo	88	F
241	CDISCPIL0T01	01-714-1068	Xanomeline Low Dose	79	F

242	CDISCPIL0T01	01-714-1195	Xanomeline Low Dose	75	M
243	CDISCPIL0T01	01-714-1288	Xanomeline High Dose	77	M
244	CDISCPIL0T01	01-714-1375	Placebo	78	F
245	CDISCPIL0T01	01-714-1425	Xanomeline High Dose	81	M
246	CDISCPIL0T01	01-715-1085	Xanomeline Low Dose	77	F
247	CDISCPIL0T01	01-715-1107	Xanomeline Low Dose	65	M
248	CDISCPIL0T01	01-715-1134	Screen Failure	50	F
249	CDISCPIL0T01	01-715-1155	Placebo	59	F
250	CDISCPIL0T01	01-715-1207	Placebo	78	F
251	CDISCPIL0T01	01-715-1225	Screen Failure	77	F
252	CDISCPIL0T01	01-715-1319	Xanomeline High Dose	65	M
253	CDISCPIL0T01	01-715-1321	Xanomeline High Dose	75	F
254	CDISCPIL0T01	01-715-1333	Screen Failure	75	F
255	CDISCPIL0T01	01-715-1397	Placebo	76	F
256	CDISCPIL0T01	01-715-1405	Xanomeline Low Dose	69	M
257	CDISCPIL0T01	01-715-1407	Screen Failure	73	F
258	CDISCPIL0T01	01-716-1003	Screen Failure	79	M
259	CDISCPIL0T01	01-716-1024	Placebo	87	F
260	CDISCPIL0T01	01-716-1026	Placebo	73	F
261	CDISCPIL0T01	01-716-1030	Xanomeline High Dose	83	F
262	CDISCPIL0T01	01-716-1044	Placebo	74	M
263	CDISCPIL0T01	01-716-1061	Screen Failure	81	M
264	CDISCPIL0T01	01-716-1063	Xanomeline Low Dose	80	M
265	CDISCPIL0T01	01-716-1071	Xanomeline High Dose	78	F
266	CDISCPIL0T01	01-716-1094	Xanomeline Low Dose	82	M
267	CDISCPIL0T01	01-716-1103	Xanomeline Low Dose	79	M
268	CDISCPIL0T01	01-716-1108	Placebo	86	F
269	CDISCPIL0T01	01-716-1151	Xanomeline Low Dose	83	F
270	CDISCPIL0T01	01-716-1157	Xanomeline Low Dose	85	M
271	CDISCPIL0T01	01-716-1160	Placebo	83	F
272	CDISCPIL0T01	01-716-1167	Xanomeline Low Dose	68	M
273	CDISCPIL0T01	01-716-1177	Placebo	72	M
274	CDISCPIL0T01	01-716-1189	Xanomeline High Dose	81	M
275	CDISCPIL0T01	01-716-1229	Xanomeline High Dose	73	F
276	CDISCPIL0T01	01-716-1244	Screen Failure	72	F
277	CDISCPIL0T01	01-716-1298	Xanomeline Low Dose	76	F
278	CDISCPIL0T01	01-716-1305	Screen Failure	73	F
279	CDISCPIL0T01	01-716-1308	Placebo	76	F
280	CDISCPIL0T01	01-716-1311	Xanomeline Low Dose	78	M
281	CDISCPIL0T01	01-716-1331	Screen Failure	59	F
282	CDISCPIL0T01	01-716-1364	Xanomeline High Dose	84	F
283	CDISCPIL0T01	01-716-1373	Xanomeline High Dose	74	M
284	CDISCPIL0T01	01-716-1418	Xanomeline High Dose	80	F

285	CDISCPILLOT01	01-716-1441	Placebo	85	M
286	CDISCPILLOT01	01-716-1447	Xanomeline High Dose	72	F
287	CDISCPILLOT01	01-717-1004	Xanomeline Low Dose	80	F
288	CDISCPILLOT01	01-717-1109	Xanomeline High Dose	84	M
289	CDISCPILLOT01	01-717-1174	Xanomeline High Dose	73	M
290	CDISCPILLOT01	01-717-1201	Placebo	85	F
291	CDISCPILLOT01	01-717-1344	Placebo	64	F
292	CDISCPILLOT01	01-717-1357	Xanomeline High Dose	77	M
293	CDISCPILLOT01	01-717-1446	Xanomeline Low Dose	75	F
294	CDISCPILLOT01	01-718-1066	Xanomeline Low Dose	79	F
295	CDISCPILLOT01	01-718-1079	Xanomeline Low Dose	67	F
296	CDISCPILLOT01	01-718-1101	Xanomeline High Dose	82	M
297	CDISCPILLOT01	01-718-1139	Placebo	77	M
298	CDISCPILLOT01	01-718-1150	Placebo	73	F
299	CDISCPILLOT01	01-718-1170	Xanomeline Low Dose	80	F
300	CDISCPILLOT01	01-718-1172	Placebo	74	M
301	CDISCPILLOT01	01-718-1250	Xanomeline Low Dose	82	F
302	CDISCPILLOT01	01-718-1254	Xanomeline Low Dose	78	M
303	CDISCPILLOT01	01-718-1328	Xanomeline High Dose	86	M
304	CDISCPILLOT01	01-718-1355	Placebo	79	M
305	CDISCPILLOT01	01-718-1371	Xanomeline High Dose	69	F
306	CDISCPILLOT01	01-718-1427	Xanomeline High Dose	74	F

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133	ASIAN
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221	BLACK OR AFRICAN AMERICAN
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223	BLACK OR AFRICAN AMERICAN
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227	BLACK OR AFRICAN AMERICAN
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232	BLACK OR AFRICAN AMERICAN
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296	BLACK OR AFRICAN AMERICAN
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301	WHITE
302	WHITE
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304	WHITE
305	WHITE
306	BLACK OR AFRICAN AMERICAN

We end up with a new data-frame including only the selected variables. Note here that we do not save the resulting data-frame at the moment.

There are also some helper functions to use within the `select` function of `dplyr`. `starts_with()` `ends_with()` `num_range()`. They allow us to select multiple columns sharing a naming structure. `num_range()` let's us select consecutively numbered columns, e.g.: `num_range("example", 1:4)` would select the columns named: `example1`, `example2`, `example3`, `example4`.

We can try out `starts_with()`:

```
select(adsl,
      USUBJID,
      starts_with("trt"))
```

	USUBJID	TRT01P	TRT01A	TRTSDTM
1	01-701-1015	Placebo	Placebo	2014-01-02T00:00:00Z
2	01-701-1023	Placebo	Placebo	2012-08-05T00:00:00Z
3	01-701-1028	Xanomeline High Dose	Xanomeline High Dose	2013-07-19T00:00:00Z
4	01-701-1033	Xanomeline Low Dose	Xanomeline Low Dose	2014-03-18T00:00:00Z
5	01-701-1034	Xanomeline High Dose	Xanomeline High Dose	2014-07-01T00:00:00Z
6	01-701-1047	Placebo	Placebo	2013-02-12T00:00:00Z
7	01-701-1057	Screen Failure	Screen Failure	<NA>
8	01-701-1097	Xanomeline Low Dose	Xanomeline Low Dose	2014-01-01T00:00:00Z
9	01-701-1111	Xanomeline Low Dose	Xanomeline Low Dose	2012-09-07T00:00:00Z
10	01-701-1115	Xanomeline Low Dose	Xanomeline Low Dose	2012-11-30T00:00:00Z
11	01-701-1118	Placebo	Placebo	2014-03-12T00:00:00Z
12	01-701-1130	Placebo	Placebo	2014-02-15T00:00:00Z
13	01-701-1133	Xanomeline High Dose	Xanomeline High Dose	2012-10-28T00:00:00Z
14	01-701-1145	Screen Failure	Screen Failure	<NA>
15	01-701-1146	Xanomeline High Dose	Xanomeline High Dose	2013-05-20T00:00:00Z
16	01-701-1148	Xanomeline High Dose	Xanomeline High Dose	2013-08-23T00:00:00Z
17	01-701-1153	Placebo	Placebo	2013-09-23T00:00:00Z
18	01-701-1162	Screen Failure	Screen Failure	<NA>
19	01-701-1176	Screen Failure	Screen Failure	<NA>
20	01-701-1180	Xanomeline High Dose	Xanomeline High Dose	2013-02-12T00:00:00Z
21	01-701-1181	Xanomeline High Dose	Xanomeline Low Dose	2013-12-05T00:00:00Z
22	01-701-1188	Xanomeline Low Dose	Xanomeline Low Dose	2013-02-15T00:00:00Z
23	01-701-1192	Xanomeline Low Dose	Xanomeline Low Dose	2012-07-22T00:00:00Z
24	01-701-1203	Placebo	Placebo	2013-02-02T00:00:00Z
25	01-701-1211	Xanomeline Low Dose	Xanomeline Low Dose	2012-11-15T00:00:00Z
26	01-701-1234	Placebo	Placebo	2013-03-30T00:00:00Z
27	01-701-1239	Xanomeline High Dose	Xanomeline High Dose	2014-01-11T00:00:00Z
28	01-701-1240	Screen Failure	Screen Failure	<NA>
29	01-701-1275	Xanomeline High Dose	Xanomeline High Dose	2014-02-07T00:00:00Z
30	01-701-1287	Xanomeline High Dose	Xanomeline High Dose	2014-01-25T00:00:00Z
31	01-701-1294	Xanomeline Low Dose	Xanomeline Low Dose	2013-03-24T00:00:00Z
32	01-701-1302	Xanomeline High Dose	Xanomeline High Dose	2013-08-29T00:00:00Z
33	01-701-1307	Screen Failure	Screen Failure	<NA>
34	01-701-1317	Xanomeline Low Dose	Xanomeline Low Dose	2014-05-22T00:00:00Z
35	01-701-1324	Xanomeline Low Dose	Xanomeline Low Dose	2012-10-02T00:00:00Z
36	01-701-1341	Xanomeline Low Dose	Xanomeline Low Dose	2013-01-05T00:00:00Z
37	01-701-1345	Placebo	Placebo	2013-10-08T00:00:00Z
38	01-701-1356	Screen Failure	Screen Failure	<NA>
39	01-701-1360	Xanomeline High Dose	Xanomeline Low Dose	2013-07-31T00:00:00Z
40	01-701-1363	Placebo	Placebo	2013-05-30T00:00:00Z
41	01-701-1369	Screen Failure	Screen Failure	<NA>
42	01-701-1383	Xanomeline High Dose	Xanomeline High Dose	2013-02-04T00:00:00Z

43	01-701-1386	Screen Failure	Screen Failure	<NA>
44	01-701-1387	Placebo	Placebo	2014-03-12T00:00:00Z
45	01-701-1392	Placebo	Placebo	2012-10-28T00:00:00Z
46	01-701-1411	Screen Failure	Screen Failure	<NA>
47	01-701-1415	Placebo	Placebo	2013-09-23T00:00:00Z
48	01-701-1429	Xanomeline Low Dose	Xanomeline Low Dose	2013-03-19T00:00:00Z
49	01-701-1440	Placebo	Placebo	2013-08-08T00:00:00Z
50	01-701-1442	Xanomeline Low Dose	Xanomeline Low Dose	2013-10-26T00:00:00Z
51	01-701-1444	Xanomeline High Dose	Xanomeline High Dose	2013-01-05T00:00:00Z
52	01-702-1082	Xanomeline Low Dose	Xanomeline Low Dose	2013-07-26T00:00:00Z
53	01-703-1042	Placebo	Placebo	2013-03-02T00:00:00Z
54	01-703-1076	Xanomeline High Dose	Xanomeline High Dose	2013-10-25T00:00:00Z
55	01-703-1086	Xanomeline Low Dose	Xanomeline Low Dose	2012-09-02T00:00:00Z
56	01-703-1096	Placebo	Placebo	2013-01-25T00:00:00Z
57	01-703-1100	Placebo	Placebo	2013-03-13T00:00:00Z
58	01-703-1119	Xanomeline Low Dose	Xanomeline Low Dose	2013-02-20T00:00:00Z
59	01-703-1175	Placebo	Placebo	2013-12-20T00:00:00Z
60	01-703-1182	Xanomeline Low Dose	Xanomeline Low Dose	2013-10-17T00:00:00Z
61	01-703-1197	Xanomeline Low Dose	Xanomeline Low Dose	2013-06-16T00:00:00Z
62	01-703-1210	Placebo	Placebo	2013-03-16T00:00:00Z
63	01-703-1258	Xanomeline High Dose	Xanomeline High Dose	2012-07-20T00:00:00Z
64	01-703-1279	Xanomeline Low Dose	Xanomeline Low Dose	2013-05-13T00:00:00Z
65	01-703-1295	Xanomeline High Dose	Xanomeline High Dose	2013-11-21T00:00:00Z
66	01-703-1299	Placebo	Placebo	2012-09-12T00:00:00Z
67	01-703-1335	Xanomeline High Dose	Xanomeline High Dose	2014-03-17T00:00:00Z
68	01-703-1379	Xanomeline Low Dose	Xanomeline Low Dose	2013-09-22T00:00:00Z
69	01-703-1396	Screen Failure	Screen Failure	<NA>
70	01-703-1403	Xanomeline High Dose	Xanomeline Low Dose	2012-12-12T00:00:00Z
71	01-703-1439	Xanomeline High Dose	Xanomeline High Dose	2014-03-12T00:00:00Z
72	01-704-1008	Xanomeline High Dose	Xanomeline High Dose	2013-01-13T00:00:00Z
73	01-704-1009	Xanomeline Low Dose	Xanomeline Low Dose	2013-08-27T00:00:00Z
74	01-704-1010	Placebo	Placebo	2014-02-21T00:00:00Z
75	01-704-1017	Xanomeline High Dose	Xanomeline High Dose	2013-10-06T00:00:00Z
76	01-704-1025	Xanomeline Low Dose	Xanomeline Low Dose	2013-09-27T00:00:00Z
77	01-704-1065	Xanomeline High Dose	Xanomeline High Dose	2013-10-24T00:00:00Z
78	01-704-1074	Xanomeline High Dose	Xanomeline High Dose	2014-01-22T00:00:00Z
79	01-704-1093	Xanomeline High Dose	Xanomeline High Dose	2013-03-15T00:00:00Z
80	01-704-1114	Xanomeline Low Dose	Xanomeline Low Dose	2013-01-23T00:00:00Z
81	01-704-1120	Xanomeline Low Dose	Xanomeline Low Dose	2013-12-02T00:00:00Z
82	01-704-1127	Placebo	Placebo	2013-10-02T00:00:00Z
83	01-704-1135	Xanomeline Low Dose	Xanomeline Low Dose	2013-10-31T00:00:00Z
84	01-704-1164	Placebo	Placebo	2012-09-19T00:00:00Z
85	01-704-1218	Xanomeline Low Dose	Xanomeline Low Dose	2012-11-19T00:00:00Z

86	01-704-1233	Placebo	Placebo	2013-03-21T00:00:00Z
87	01-704-1241	Xanomeline High Dose	Xanomeline High Dose	2013-08-25T00:00:00Z
88	01-704-1260	Placebo	Placebo	2012-08-30T00:00:00Z
89	01-704-1266	Xanomeline High Dose	Xanomeline High Dose	2013-10-13T00:00:00Z
90	01-704-1323	Xanomeline Low Dose	Xanomeline Low Dose	2013-07-08T00:00:00Z
91	01-704-1325	Xanomeline Low Dose	Xanomeline Low Dose	2014-04-23T00:00:00Z
92	01-704-1332	Xanomeline High Dose	Xanomeline High Dose	2013-12-09T00:00:00Z
93	01-704-1351	Placebo	Placebo	2013-10-12T00:00:00Z
94	01-704-1388	Placebo	Placebo	2012-12-07T00:00:00Z
95	01-704-1435	Placebo	Placebo	2012-11-17T00:00:00Z
96	01-704-1445	Placebo	Placebo	2014-05-11T00:00:00Z
97	01-705-1011	Screen Failure	Screen Failure	<NA>
98	01-705-1018	Placebo	Placebo	2013-07-05T00:00:00Z
99	01-705-1031	Xanomeline Low Dose	Xanomeline Low Dose	2013-11-27T00:00:00Z
100	01-705-1058	Screen Failure	Screen Failure	<NA>
101	01-705-1059	Placebo	Placebo	2013-08-05T00:00:00Z
102	01-705-1112	Screen Failure	Screen Failure	<NA>
103	01-705-1186	Placebo	Placebo	2014-01-08T00:00:00Z
104	01-705-1199	Xanomeline Low Dose	Xanomeline Low Dose	2013-09-16T00:00:00Z
105	01-705-1243	Screen Failure	Screen Failure	<NA>
106	01-705-1280	Xanomeline High Dose	Xanomeline High Dose	2014-01-17T00:00:00Z
107	01-705-1281	Xanomeline High Dose	Xanomeline High Dose	2013-11-28T00:00:00Z
108	01-705-1282	Placebo	Placebo	2012-12-26T00:00:00Z
109	01-705-1292	Xanomeline Low Dose	Xanomeline Low Dose	2013-10-14T00:00:00Z
110	01-705-1303	Xanomeline High Dose	Xanomeline High Dose	2013-12-16T00:00:00Z
111	01-705-1310	Xanomeline High Dose	Xanomeline High Dose	2013-11-02T00:00:00Z
112	01-705-1349	Placebo	Placebo	2013-03-10T00:00:00Z
113	01-705-1377	Xanomeline High Dose	Xanomeline High Dose	2014-01-04T00:00:00Z
114	01-705-1382	Xanomeline High Dose	Xanomeline Low Dose	2013-05-13T00:00:00Z
115	01-705-1393	Xanomeline Low Dose	Xanomeline Low Dose	2012-09-07T00:00:00Z
116	01-705-1421	Screen Failure	Screen Failure	<NA>
117	01-705-1431	Xanomeline Low Dose	Xanomeline Low Dose	2013-06-23T00:00:00Z
118	01-706-1041	Placebo	Placebo	2013-12-31T00:00:00Z
119	01-706-1049	Xanomeline High Dose	Xanomeline High Dose	2013-05-14T00:00:00Z
120	01-706-1384	Xanomeline Low Dose	Xanomeline Low Dose	2012-09-15T00:00:00Z
121	01-707-1037	Xanomeline Low Dose	Xanomeline Low Dose	2013-12-20T00:00:00Z
122	01-707-1206	Placebo	Placebo	2013-10-28T00:00:00Z
123	01-707-1276	Screen Failure	Screen Failure	<NA>
124	01-707-1430	Screen Failure	Screen Failure	<NA>
125	01-707-1434	Screen Failure	Screen Failure	<NA>
126	01-708-1013	Screen Failure	Screen Failure	<NA>
127	01-708-1019	Xanomeline Low Dose	Xanomeline Low Dose	2013-12-20T00:00:00Z
128	01-708-1032	Xanomeline Low Dose	Xanomeline Low Dose	2013-02-09T00:00:00Z

129	01-708-1054	Screen Failure	Screen Failure	<NA>
130	01-708-1067	Screen Failure	Screen Failure	<NA>
131	01-708-1084	Xanomeline Low Dose	Xanomeline Low Dose	2013-05-09T00:00:00Z
132	01-708-1087	Placebo	Placebo	2012-10-22T00:00:00Z
133	01-708-1104	Screen Failure	Screen Failure	<NA>
134	01-708-1158	Placebo	Placebo	2014-02-08T00:00:00Z
135	01-708-1171	Placebo	Placebo	2012-12-06T00:00:00Z
136	01-708-1178	Xanomeline High Dose	Xanomeline High Dose	2013-12-29T00:00:00Z
137	01-708-1184	Screen Failure	Screen Failure	<NA>
138	01-708-1213	Xanomeline High Dose	Xanomeline Low Dose	2013-02-09T00:00:00Z
139	01-708-1216	Xanomeline High Dose	Xanomeline High Dose	2012-10-24T00:00:00Z
140	01-708-1236	Xanomeline High Dose	Xanomeline Low Dose	2013-09-21T00:00:00Z
141	01-708-1242	Screen Failure	Screen Failure	<NA>
142	01-708-1253	Placebo	Placebo	2013-05-07T00:00:00Z
143	01-708-1272	Xanomeline Low Dose	Xanomeline Low Dose	2013-02-06T00:00:00Z
144	01-708-1286	Placebo	Placebo	2013-09-10T00:00:00Z
145	01-708-1296	Placebo	Placebo	2013-06-14T00:00:00Z
146	01-708-1297	Xanomeline Low Dose	Xanomeline Low Dose	2013-01-25T00:00:00Z
147	01-708-1316	Placebo	Placebo	2013-08-23T00:00:00Z
148	01-708-1336	Xanomeline High Dose	Xanomeline High Dose	2012-12-07T00:00:00Z
149	01-708-1342	Placebo	Placebo	2012-12-29T00:00:00Z
150	01-708-1347	Xanomeline High Dose	Xanomeline High Dose	2013-04-20T00:00:00Z
151	01-708-1348	Xanomeline Low Dose	Xanomeline Low Dose	2013-08-05T00:00:00Z
152	01-708-1352	Screen Failure	Screen Failure	<NA>
153	01-708-1353	Xanomeline Low Dose	Xanomeline Low Dose	2013-07-04T00:00:00Z
154	01-708-1372	Xanomeline High Dose	Xanomeline Low Dose	2013-04-12T00:00:00Z
155	01-708-1378	Placebo	Placebo	2013-09-03T00:00:00Z
156	01-708-1406	Xanomeline High Dose	Xanomeline High Dose	2013-12-26T00:00:00Z
157	01-708-1428	Xanomeline Low Dose	Xanomeline Low Dose	2013-11-09T00:00:00Z
158	01-709-1001	Placebo	Placebo	2013-10-08T00:00:00Z
159	01-709-1007	Xanomeline Low Dose	Xanomeline Low Dose	2012-07-31T00:00:00Z
160	01-709-1020	Xanomeline Low Dose	Xanomeline Low Dose	2012-12-01T00:00:00Z
161	01-709-1029	Xanomeline High Dose	Xanomeline High Dose	2012-12-25T00:00:00Z
162	01-709-1081	Xanomeline Low Dose	Xanomeline Low Dose	2014-01-18T00:00:00Z
163	01-709-1088	Placebo	Placebo	2014-04-12T00:00:00Z
164	01-709-1099	Xanomeline High Dose	Xanomeline High Dose	2013-10-25T00:00:00Z
165	01-709-1102	Xanomeline Low Dose	Xanomeline Low Dose	2013-01-15T00:00:00Z
166	01-709-1168	Xanomeline High Dose	Xanomeline High Dose	2013-08-02T00:00:00Z
167	01-709-1217	Xanomeline Low Dose	Xanomeline Low Dose	2013-03-04T00:00:00Z
168	01-709-1224	Screen Failure	Screen Failure	<NA>
169	01-709-1237	Screen Failure	Screen Failure	<NA>
170	01-709-1238	Xanomeline High Dose	Xanomeline High Dose	2013-05-15T00:00:00Z
171	01-709-1259	Placebo	Placebo	2013-01-26T00:00:00Z

172	01-709-1285	Xanomeline Low Dose	Xanomeline Low Dose	2013-03-24T00:00:00Z
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174	01-709-1306	Placebo	Placebo	2014-02-03T00:00:00Z
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191		WHITE NOT HISPANIC OR LATINO	Pbo
192	BLACK OR AFRICAN AMERICAN	NOT HISPANIC OR LATINO	Scrnfail
193	BLACK OR AFRICAN AMERICAN	NOT HISPANIC OR LATINO	Xan_Hi
194		WHITE NOT HISPANIC OR LATINO	Xan_Hi
195		WHITE NOT HISPANIC OR LATINO	Scrnfail
196		WHITE HISPANIC OR LATINO	Xan_Lo
197		WHITE NOT HISPANIC OR LATINO	Xan_Lo
198		WHITE NOT HISPANIC OR LATINO	Pbo
199		WHITE NOT HISPANIC OR LATINO	Xan_Hi
200		WHITE HISPANIC OR LATINO	Xan_Lo
201		WHITE NOT HISPANIC OR LATINO	Xan_Hi
202		WHITE NOT HISPANIC OR LATINO	Scrnfail
203		WHITE NOT HISPANIC OR LATINO	Pbo

204		WHITE NOT HISPANIC OR LATINO	Xan_Lo
205		WHITE NOT HISPANIC OR LATINO	Pbo
206		WHITE NOT HISPANIC OR LATINO	Xan_Hi
207		WHITE NOT HISPANIC OR LATINO	Xan_Lo
208		WHITE NOT HISPANIC OR LATINO	Pbo
209		WHITE NOT HISPANIC OR LATINO	Pbo
210		WHITE NOT HISPANIC OR LATINO	Scrnfail
211		WHITE NOT HISPANIC OR LATINO	Xan_Hi
212		WHITE NOT HISPANIC OR LATINO	Xan_Lo
213		WHITE NOT HISPANIC OR LATINO	Pbo
214		WHITE NOT HISPANIC OR LATINO	Scrnfail
215		WHITE NOT HISPANIC OR LATINO	Scrnfail
216		WHITE NOT HISPANIC OR LATINO	Xan_Lo
217		WHITE NOT HISPANIC OR LATINO	Xan_Hi
218		WHITE NOT HISPANIC OR LATINO	Scrnfail
219		WHITE NOT HISPANIC OR LATINO	Xan_Hi
220		WHITE NOT HISPANIC OR LATINO	Scrnfail
221	BLACK OR AFRICAN AMERICAN	NOT HISPANIC OR LATINO	Pbo
222		WHITE NOT HISPANIC OR LATINO	Xan_Lo
223	BLACK OR AFRICAN AMERICAN	NOT HISPANIC OR LATINO	Scrnfail
224		WHITE NOT HISPANIC OR LATINO	Scrnfail
225		WHITE NOT HISPANIC OR LATINO	Scrnfail
226		WHITE NOT HISPANIC OR LATINO	Scrnfail
227	BLACK OR AFRICAN AMERICAN	NOT HISPANIC OR LATINO	Scrnfail
228		WHITE NOT HISPANIC OR LATINO	Scrnfail
229		WHITE NOT HISPANIC OR LATINO	Scrnfail
230		WHITE NOT HISPANIC OR LATINO	Xan_Hi
231		WHITE NOT HISPANIC OR LATINO	Xan_Lo
232	BLACK OR AFRICAN AMERICAN	NOT HISPANIC OR LATINO	Xan_Lo
233		WHITE NOT HISPANIC OR LATINO	Xan_Hi
234		WHITE NOT HISPANIC OR LATINO	Xan_Hi
235		WHITE NOT HISPANIC OR LATINO	Pbo
236		WHITE NOT HISPANIC OR LATINO	Xan_Hi
237		WHITE NOT HISPANIC OR LATINO	Pbo
238		WHITE NOT HISPANIC OR LATINO	Pbo
239		WHITE NOT HISPANIC OR LATINO	Xan_Lo
240		WHITE NOT HISPANIC OR LATINO	Pbo
241		WHITE NOT HISPANIC OR LATINO	Xan_Lo
242		WHITE NOT HISPANIC OR LATINO	Xan_Lo
243	BLACK OR AFRICAN AMERICAN	NOT HISPANIC OR LATINO	Xan_Hi
244		WHITE NOT HISPANIC OR LATINO	Pbo
245		WHITE NOT HISPANIC OR LATINO	Xan_Hi
246		WHITE NOT HISPANIC OR LATINO	Xan_Lo

247	WHITE NOT HISPANIC OR LATINO	Xan_Lo
248	WHITE NOT HISPANIC OR LATINO	Scrnfail
249	WHITE NOT HISPANIC OR LATINO	Pbo
250	WHITE NOT HISPANIC OR LATINO	Pbo
251	WHITE NOT HISPANIC OR LATINO	Scrnfail
252	WHITE NOT HISPANIC OR LATINO	Xan_Hi
253	WHITE NOT HISPANIC OR LATINO	Xan_Hi
254	WHITE NOT HISPANIC OR LATINO	Scrnfail
255	WHITE NOT HISPANIC OR LATINO	Pbo
256	WHITE NOT HISPANIC OR LATINO	Xan_Lo
257	WHITE NOT HISPANIC OR LATINO	Scrnfail
258	WHITE HISPANIC OR LATINO	Scrnfail
259	WHITE NOT HISPANIC OR LATINO	Pbo
260	WHITE NOT HISPANIC OR LATINO	Pbo
261	WHITE NOT HISPANIC OR LATINO	Xan_Hi
262	WHITE NOT HISPANIC OR LATINO	Pbo
263	WHITE NOT HISPANIC OR LATINO	Scrnfail
264	WHITE NOT HISPANIC OR LATINO	Xan_Lo
265	WHITE NOT HISPANIC OR LATINO	Xan_Hi
266	WHITE NOT HISPANIC OR LATINO	Xan_Lo
267	WHITE NOT HISPANIC OR LATINO	Xan_Lo
268	WHITE NOT HISPANIC OR LATINO	Pbo
269	WHITE NOT HISPANIC OR LATINO	Xan_Lo
270	WHITE NOT HISPANIC OR LATINO	Xan_Lo
271	WHITE NOT HISPANIC OR LATINO	Pbo
272	WHITE NOT HISPANIC OR LATINO	Xan_Lo
273	WHITE NOT HISPANIC OR LATINO	Pbo
274	WHITE NOT HISPANIC OR LATINO	Xan_Hi
275	WHITE NOT HISPANIC OR LATINO	Xan_Hi
276	WHITE NOT HISPANIC OR LATINO	Scrnfail
277	WHITE NOT HISPANIC OR LATINO	Xan_Lo
278	WHITE NOT HISPANIC OR LATINO	Scrnfail
279	WHITE NOT HISPANIC OR LATINO	Pbo
280	WHITE NOT HISPANIC OR LATINO	Xan_Lo
281	WHITE NOT HISPANIC OR LATINO	Scrnfail
282	WHITE NOT HISPANIC OR LATINO	Xan_Hi
283	WHITE NOT HISPANIC OR LATINO	Xan_Hi
284	WHITE NOT HISPANIC OR LATINO	Xan_Hi
285	WHITE NOT HISPANIC OR LATINO	Pbo
286	WHITE NOT HISPANIC OR LATINO	Xan_Hi
287	WHITE NOT HISPANIC OR LATINO	Xan_Lo
288	WHITE NOT HISPANIC OR LATINO	Xan_Hi
289	WHITE NOT HISPANIC OR LATINO	Xan_Hi

290		WHITE NOT HISPANIC OR LATINO	Pbo
291		WHITE NOT HISPANIC OR LATINO	Pbo
292		WHITE NOT HISPANIC OR LATINO	Xan_Hi
293		WHITE NOT HISPANIC OR LATINO	Xan_Lo
294		WHITE NOT HISPANIC OR LATINO	Xan_Lo
295		WHITE NOT HISPANIC OR LATINO	Xan_Lo
296	BLACK OR AFRICAN AMERICAN NOT HISPANIC OR LATINO		Xan_Hi
297		WHITE NOT HISPANIC OR LATINO	Pbo
298		WHITE NOT HISPANIC OR LATINO	Pbo
299		WHITE NOT HISPANIC OR LATINO	Xan_Lo
300		WHITE NOT HISPANIC OR LATINO	Pbo
301		WHITE HISPANIC OR LATINO	Xan_Lo
302		WHITE HISPANIC OR LATINO	Xan_Lo
303		WHITE NOT HISPANIC OR LATINO	Xan_Hi
304		WHITE NOT HISPANIC OR LATINO	Pbo
305		WHITE NOT HISPANIC OR LATINO	Xan_Hi
306	BLACK OR AFRICAN AMERICAN NOT HISPANIC OR LATINO		Xan_Hi

	ARM	ACTARMCD		ACTARM	COUNTRY	DMDTC	DMDY
1	Placebo	Pbo		Placebo	USA	2013-12-26	-7
2	Placebo	Pbo		Placebo	USA	2012-07-22	-14
3	Xanomeline High Dose	Xan_Hi	Xanomeline High Dose		USA	2013-07-11	-8
4	Xanomeline Low Dose	Xan_Lo	Xanomeline Low Dose		USA	2014-03-10	-8
5	Xanomeline High Dose	Xan_Hi	Xanomeline High Dose		USA	2014-06-24	-7
6	Placebo	Pbo		Placebo	USA	2013-01-22	-21
7	Screen Failure	Scrnfail		Screen Failure	USA	2013-12-20	NA
8	Xanomeline Low Dose	Xan_Lo	Xanomeline Low Dose		USA	2013-12-23	-9
9	Xanomeline Low Dose	Xan_Lo	Xanomeline Low Dose		USA	2012-08-25	-13
10	Xanomeline Low Dose	Xan_Lo	Xanomeline Low Dose		USA	2012-11-23	-7
11	Placebo	Pbo		Placebo	USA	2014-02-27	-13
12	Placebo	Pbo		Placebo	USA	2014-02-09	-6
13	Xanomeline High Dose	Xan_Hi	Xanomeline High Dose		USA	2012-10-23	-5
14	Screen Failure	Scrnfail		Screen Failure	USA	2013-09-05	NA
15	Xanomeline High Dose	Xan_Hi	Xanomeline High Dose		USA	2013-05-07	-13
16	Xanomeline High Dose	Xan_Hi	Xanomeline High Dose		USA	2013-08-14	-9
17	Placebo	Pbo		Placebo	USA	2013-09-06	-17
18	Screen Failure	Scrnfail		Screen Failure	USA	2013-04-18	NA
19	Screen Failure	Scrnfail		Screen Failure	USA	2012-09-30	NA
20	Xanomeline High Dose	Xan_Hi	Xanomeline High Dose		USA	2013-01-28	-15
21	Xanomeline High Dose	Xan_Lo	Xanomeline Low Dose		USA	2013-11-26	-9
22	Xanomeline Low Dose	Xan_Lo	Xanomeline Low Dose		USA	2013-02-03	-12
23	Xanomeline Low Dose	Xan_Lo	Xanomeline Low Dose		USA	2012-07-08	-14
24	Placebo	Pbo		Placebo	USA	2013-01-25	-8
25	Xanomeline Low Dose	Xan_Lo	Xanomeline Low Dose		USA	2012-10-30	-16

26	Placebo	Pbo	Placebo	USA	2013-03-20	-10
27	Xanomeline High Dose	Xan_Hi	Xanomeline High Dose	USA	2013-12-28	-14
28	Screen Failure	Scrnfail	Screen Failure	USA	2013-09-22	NA
29	Xanomeline High Dose	Xan_Hi	Xanomeline High Dose	USA	2014-01-25	-13
30	Xanomeline High Dose	Xan_Hi	Xanomeline High Dose	USA	2014-01-17	-8
31	Xanomeline Low Dose	Xan_Lo	Xanomeline Low Dose	USA	2013-03-17	-7
32	Xanomeline High Dose	Xan_Hi	Xanomeline High Dose	USA	2013-08-20	-9
33	Screen Failure	Scrnfail	Screen Failure	USA	2013-12-08	NA
34	Xanomeline Low Dose	Xan_Lo	Xanomeline Low Dose	USA	2014-05-10	-12
35	Xanomeline Low Dose	Xan_Lo	Xanomeline Low Dose	USA	2012-09-16	-16
36	Xanomeline Low Dose	Xan_Lo	Xanomeline Low Dose	USA	2012-12-22	-14
37	Placebo	Pbo	Placebo	USA	2013-10-01	-7
38	Screen Failure	Scrnfail	Screen Failure	USA	2014-04-01	NA
39	Xanomeline High Dose	Xan_Lo	Xanomeline Low Dose	USA	2013-07-24	-7
40	Placebo	Pbo	Placebo	USA	2013-05-20	-10
41	Screen Failure	Scrnfail	Screen Failure	USA	2013-09-18	NA
42	Xanomeline High Dose	Xan_Hi	Xanomeline High Dose	USA	2013-01-22	-13
43	Screen Failure	Scrnfail	Screen Failure	USA	2013-12-28	NA
44	Placebo	Pbo	Placebo	USA	2014-02-23	-17
45	Placebo	Pbo	Placebo	USA	2012-10-17	-11
46	Screen Failure	Scrnfail	Screen Failure	USA	2012-11-14	NA
47	Placebo	Pbo	Placebo	USA	2013-09-15	-8
48	Xanomeline Low Dose	Xan_Lo	Xanomeline Low Dose	USA	2013-02-25	-22
49	Placebo	Pbo	Placebo	USA	2013-07-24	-15
50	Xanomeline Low Dose	Xan_Lo	Xanomeline Low Dose	USA	2013-10-17	-9
51	Xanomeline High Dose	Xan_Hi	Xanomeline High Dose	USA	2012-12-31	-5
52	Xanomeline Low Dose	Xan_Lo	Xanomeline Low Dose	USA	2013-07-03	-23
53	Placebo	Pbo	Placebo	USA	2013-02-23	-7
54	Xanomeline High Dose	Xan_Hi	Xanomeline High Dose	USA	2013-10-17	-8
55	Xanomeline Low Dose	Xan_Lo	Xanomeline Low Dose	USA	2012-08-22	-11
56	Placebo	Pbo	Placebo	USA	2012-12-19	-37
57	Placebo	Pbo	Placebo	USA	2013-02-28	-13
58	Xanomeline Low Dose	Xan_Lo	Xanomeline Low Dose	USA	2013-02-02	-18
59	Placebo	Pbo	Placebo	USA	2013-12-13	-7
60	Xanomeline Low Dose	Xan_Lo	Xanomeline Low Dose	USA	2013-10-08	-9
61	Xanomeline Low Dose	Xan_Lo	Xanomeline Low Dose	USA	2013-06-01	-15
62	Placebo	Pbo	Placebo	USA	2013-03-08	-8
63	Xanomeline High Dose	Xan_Hi	Xanomeline High Dose	USA	2012-07-10	-10
64	Xanomeline Low Dose	Xan_Lo	Xanomeline Low Dose	USA	2013-04-27	-16
65	Xanomeline High Dose	Xan_Hi	Xanomeline High Dose	USA	2013-10-24	-28
66	Placebo	Pbo	Placebo	USA	2012-09-07	-5
67	Xanomeline High Dose	Xan_Hi	Xanomeline High Dose	USA	2014-02-28	-17
68	Xanomeline Low Dose	Xan_Lo	Xanomeline Low Dose	USA	2013-09-12	-10

69	Screen Failure	Scrnfail	Screen Failure	USA	2014-02-09	NA
70	Xanomeline High Dose	Xan_Lo	Xanomeline Low Dose	USA	2012-12-05	-7
71	Xanomeline High Dose	Xan_Hi	Xanomeline High Dose	USA	2014-03-04	-8
72	Xanomeline High Dose	Xan_Hi	Xanomeline High Dose	USA	2013-01-06	-7
73	Xanomeline Low Dose	Xan_Lo	Xanomeline Low Dose	USA	2013-08-20	-7
74	Placebo	Pbo	Placebo	USA	2014-02-08	-13
75	Xanomeline High Dose	Xan_Hi	Xanomeline High Dose	USA	2013-09-20	-16
76	Xanomeline Low Dose	Xan_Lo	Xanomeline Low Dose	USA	2013-09-18	-9
77	Xanomeline High Dose	Xan_Hi	Xanomeline High Dose	USA	2013-10-17	-7
78	Xanomeline High Dose	Xan_Hi	Xanomeline High Dose	USA	2014-01-19	-3
79	Xanomeline High Dose	Xan_Hi	Xanomeline High Dose	USA	2013-02-22	-21
80	Xanomeline Low Dose	Xan_Lo	Xanomeline Low Dose	USA	2013-01-09	-14
81	Xanomeline Low Dose	Xan_Lo	Xanomeline Low Dose	USA	2013-11-18	-14
82	Placebo	Pbo	Placebo	USA	2013-09-16	-16
83	Xanomeline Low Dose	Xan_Lo	Xanomeline Low Dose	USA	2013-10-23	-8
84	Placebo	Pbo	Placebo	USA	2012-09-11	-8
85	Xanomeline Low Dose	Xan_Lo	Xanomeline Low Dose	USA	2012-11-11	-8
86	Placebo	Pbo	Placebo	USA	2013-03-08	-13
87	Xanomeline High Dose	Xan_Hi	Xanomeline High Dose	USA	2013-08-14	-11
88	Placebo	Pbo	Placebo	USA	2012-08-23	-7
89	Xanomeline High Dose	Xan_Hi	Xanomeline High Dose	USA	2013-10-05	-8
90	Xanomeline Low Dose	Xan_Lo	Xanomeline Low Dose	USA	2013-06-13	-25
91	Xanomeline Low Dose	Xan_Lo	Xanomeline Low Dose	USA	2014-04-16	-7
92	Xanomeline High Dose	Xan_Hi	Xanomeline High Dose	USA	2013-11-24	-15
93	Placebo	Pbo	Placebo	USA	2013-09-26	-16
94	Placebo	Pbo	Placebo	USA	2012-11-28	-9
95	Placebo	Pbo	Placebo	USA	2012-11-01	-16
96	Placebo	Pbo	Placebo	USA	2014-05-01	-10
97	Screen Failure	Scrnfail	Screen Failure	USA	2013-09-01	NA
98	Placebo	Pbo	Placebo	USA	2013-06-30	-5
99	Xanomeline Low Dose	Xan_Lo	Xanomeline Low Dose	USA	2013-11-17	-10
100	Screen Failure	Scrnfail	Screen Failure	USA	2013-12-02	NA
101	Placebo	Pbo	Placebo	USA	2013-08-02	-3
102	Screen Failure	Scrnfail	Screen Failure	USA	2014-02-23	NA
103	Placebo	Pbo	Placebo	USA	2014-01-03	-5
104	Xanomeline Low Dose	Xan_Lo	Xanomeline Low Dose	USA	2013-09-11	-5
105	Screen Failure	Scrnfail	Screen Failure	USA	2013-02-26	NA
106	Xanomeline High Dose	Xan_Hi	Xanomeline High Dose	USA	2014-01-11	-6
107	Xanomeline High Dose	Xan_Hi	Xanomeline High Dose	USA	2013-11-26	-2
108	Placebo	Pbo	Placebo	USA	2012-12-23	-3
109	Xanomeline Low Dose	Xan_Lo	Xanomeline Low Dose	USA	2013-10-11	-3
110	Xanomeline High Dose	Xan_Hi	Xanomeline High Dose	USA	2013-12-10	-6
111	Xanomeline High Dose	Xan_Hi	Xanomeline High Dose	USA	2013-10-26	-7

112	Placebo	Pbo	Placebo	USA	2013-02-24	-14
113	Xanomeline High Dose	Xan_Hi	Xanomeline High Dose	USA	2013-12-29	-6
114	Xanomeline High Dose	Xan_Lo	Xanomeline Low Dose	USA	2013-05-09	-4
115	Xanomeline Low Dose	Xan_Lo	Xanomeline Low Dose	USA	2012-09-02	-5
116	Screen Failure	Scrnfail	Screen Failure	USA	2013-01-14	NA
117	Xanomeline Low Dose	Xan_Lo	Xanomeline Low Dose	USA	2013-06-16	-7
118	Placebo	Pbo	Placebo	USA	2013-12-21	-10
119	Xanomeline High Dose	Xan_Hi	Xanomeline High Dose	USA	2013-04-30	-14
120	Xanomeline Low Dose	Xan_Lo	Xanomeline Low Dose	USA	2012-08-25	-21
121	Xanomeline Low Dose	Xan_Lo	Xanomeline Low Dose	USA	2013-12-12	-8
122	Placebo	Pbo	Placebo	USA	2013-10-20	-8
123	Screen Failure	Scrnfail	Screen Failure	USA	2012-10-12	NA
124	Screen Failure	Scrnfail	Screen Failure	USA	2014-02-14	NA
125	Screen Failure	Scrnfail	Screen Failure	USA	2013-07-25	NA
126	Screen Failure	Scrnfail	Screen Failure	USA	2012-10-13	NA
127	Xanomeline Low Dose	Xan_Lo	Xanomeline Low Dose	USA	2013-12-10	-10
128	Xanomeline Low Dose	Xan_Lo	Xanomeline Low Dose	USA	2013-02-02	-7
129	Screen Failure	Scrnfail	Screen Failure	USA	2014-02-14	NA
130	Screen Failure	Scrnfail	Screen Failure	USA	2013-02-07	NA
131	Xanomeline Low Dose	Xan_Lo	Xanomeline Low Dose	USA	2013-05-01	-8
132	Placebo	Pbo	Placebo	USA	2012-10-06	-16
133	Screen Failure	Scrnfail	Screen Failure	USA	2014-01-23	NA
134	Placebo	Pbo	Placebo	USA	2014-02-01	-7
135	Placebo	Pbo	Placebo	USA	2012-11-25	-11
136	Xanomeline High Dose	Xan_Hi	Xanomeline High Dose	USA	2013-12-13	-16
137	Screen Failure	Scrnfail	Screen Failure	USA	2013-01-14	NA
138	Xanomeline High Dose	Xan_Lo	Xanomeline Low Dose	USA	2013-02-01	-8
139	Xanomeline High Dose	Xan_Hi	Xanomeline High Dose	USA	2012-10-14	-10
140	Xanomeline High Dose	Xan_Lo	Xanomeline Low Dose	USA	2013-09-08	-13
141	Screen Failure	Scrnfail	Screen Failure	USA	2012-08-13	NA
142	Placebo	Pbo	Placebo	USA	2013-04-26	-11
143	Xanomeline Low Dose	Xan_Lo	Xanomeline Low Dose	USA	2013-01-22	-15
144	Placebo	Pbo	Placebo	USA	2013-08-25	-16
145	Placebo	Pbo	Placebo	USA	2013-06-07	-7
146	Xanomeline Low Dose	Xan_Lo	Xanomeline Low Dose	USA	2013-01-15	-10
147	Placebo	Pbo	Placebo	USA	2013-08-15	-8
148	Xanomeline High Dose	Xan_Hi	Xanomeline High Dose	USA	2012-11-21	-16
149	Placebo	Pbo	Placebo	USA	2012-12-21	-8
150	Xanomeline High Dose	Xan_Hi	Xanomeline High Dose	USA	2013-04-11	-9
151	Xanomeline Low Dose	Xan_Lo	Xanomeline Low Dose	USA	2013-07-28	-8
152	Screen Failure	Scrnfail	Screen Failure	USA	2013-09-16	NA
153	Xanomeline Low Dose	Xan_Lo	Xanomeline Low Dose	USA	2013-06-17	-17
154	Xanomeline High Dose	Xan_Lo	Xanomeline Low Dose	USA	2013-04-03	-9

155	Placebo	Pbo	Placebo	USA	2013-08-24	-10
156	Xanomeline High Dose	Xan_Hi	Xanomeline High Dose	USA	2013-12-06	-20
157	Xanomeline Low Dose	Xan_Lo	Xanomeline Low Dose	USA	2013-11-02	-7
158	Placebo	Pbo	Placebo	USA	2013-09-20	-18
159	Xanomeline Low Dose	Xan_Lo	Xanomeline Low Dose	USA	2012-07-21	-10
160	Xanomeline Low Dose	Xan_Lo	Xanomeline Low Dose	USA	2012-11-22	-9
161	Xanomeline High Dose	Xan_Hi	Xanomeline High Dose	USA	2012-12-10	-15
162	Xanomeline Low Dose	Xan_Lo	Xanomeline Low Dose	USA	2014-01-09	-9
163	Placebo	Pbo	Placebo	USA	2014-03-30	-13
164	Xanomeline High Dose	Xan_Hi	Xanomeline High Dose	USA	2013-10-14	-11
165	Xanomeline Low Dose	Xan_Lo	Xanomeline Low Dose	USA	2013-01-07	-8
166	Xanomeline High Dose	Xan_Hi	Xanomeline High Dose	USA	2013-07-25	-8
167	Xanomeline Low Dose	Xan_Lo	Xanomeline Low Dose	USA	2013-02-16	-16
168	Screen Failure	Scrnfail	Screen Failure	USA	2013-11-18	NA
169	Screen Failure	Scrnfail	Screen Failure	USA	2014-01-17	NA
170	Xanomeline High Dose	Xan_Hi	Xanomeline High Dose	USA	2013-05-02	-13
171	Placebo	Pbo	Placebo	USA	2013-01-13	-13
172	Xanomeline Low Dose	Xan_Lo	Xanomeline Low Dose	USA	2013-03-17	-7
173	Placebo	Pbo	Placebo	USA	2013-07-14	-5
174	Placebo	Pbo	Placebo	USA	2014-01-19	-15
175	Xanomeline High Dose	Xan_Hi	Xanomeline High Dose	USA	2013-06-09	-10
176	Placebo	Pbo	Placebo	USA	2014-04-13	-7
177	Xanomeline Low Dose	Xan_Lo	Xanomeline Low Dose	USA	2013-03-21	-15
178	Xanomeline High Dose	Xan_Lo	Xanomeline Low Dose	USA	2013-08-01	-14
179	Placebo	Pbo	Placebo	USA	2012-12-15	-8
180	Xanomeline High Dose	Xan_Lo	Xanomeline Low Dose	USA	2013-02-15	-16
181	Xanomeline Low Dose	Xan_Lo	Xanomeline Low Dose	USA	2013-12-30	-15
182	Xanomeline High Dose	Xan_Hi	Xanomeline High Dose	USA	2013-01-27	-14
183	Xanomeline High Dose	Xan_Hi	Xanomeline High Dose	USA	2013-09-19	-8
184	Placebo	Pbo	Placebo	USA	2014-02-03	-25
185	Xanomeline Low Dose	Xan_Lo	Xanomeline Low Dose	USA	2013-05-20	-14
186	Xanomeline Low Dose	Xan_Lo	Xanomeline Low Dose	USA	2012-12-15	-11
187	Placebo	Pbo	Placebo	USA	2012-12-24	-8
188	Xanomeline High Dose	Xan_Hi	Xanomeline High Dose	USA	2012-08-28	-11
189	Placebo	Pbo	Placebo	USA	2013-11-03	-14
190	Placebo	Pbo	Placebo	USA	2013-09-06	-11
191	Placebo	Pbo	Placebo	USA	2013-07-09	-13
192	Screen Failure	Scrnfail	Screen Failure	USA	2013-03-05	NA
193	Xanomeline High Dose	Xan_Hi	Xanomeline High Dose	USA	2013-10-03	-8
194	Xanomeline High Dose	Xan_Hi	Xanomeline High Dose	USA	2012-09-12	-20
195	Screen Failure	Scrnfail	Screen Failure	USA	2013-11-16	NA
196	Xanomeline Low Dose	Xan_Lo	Xanomeline Low Dose	USA	2014-03-08	-21
197	Xanomeline Low Dose	Xan_Lo	Xanomeline Low Dose	USA	2012-11-10	-20

198	Placebo	Pbo	Placebo	USA	2013-10-24	-23
199	Xanomeline High Dose	Xan_Hi	Xanomeline High Dose	USA	2012-10-26	-15
200	Xanomeline Low Dose	Xan_Lo	Xanomeline Low Dose	USA	2012-09-13	-13
201	Xanomeline High Dose	Xan_Hi	Xanomeline High Dose	USA	2013-12-19	-9
202	Screen Failure	Scrnfail	Screen Failure	USA	2013-11-29	NA
203	Placebo	Pbo	Placebo	USA	2013-06-02	-11
204	Xanomeline Low Dose	Xan_Lo	Xanomeline Low Dose	USA	2014-02-01	-11
205	Placebo	Pbo	Placebo	USA	2012-09-04	-23
206	Xanomeline High Dose	Xan_Hi	Xanomeline High Dose	USA	2012-12-13	-11
207	Xanomeline Low Dose	Xan_Lo	Xanomeline Low Dose	USA	2012-12-04	-11
208	Placebo	Pbo	Placebo	USA	2013-04-21	-3
209	Placebo	Pbo	Placebo	USA	2013-02-12	-15
210	Screen Failure	Scrnfail	Screen Failure	USA	2013-12-30	NA
211	Xanomeline High Dose	Xan_Hi	Xanomeline High Dose	USA	2012-10-29	-13
212	Xanomeline Low Dose	Xan_Lo	Xanomeline Low Dose	USA	2012-09-02	-15
213	Placebo	Pbo	Placebo	USA	2013-10-21	-2
214	Screen Failure	Scrnfail	Screen Failure	USA	2014-04-21	NA
215	Screen Failure	Scrnfail	Screen Failure	USA	2013-06-02	NA
216	Xanomeline Low Dose	Xan_Lo	Xanomeline Low Dose	USA	2012-10-21	-8
217	Xanomeline High Dose	Xan_Hi	Xanomeline High Dose	USA	2012-12-26	-10
218	Screen Failure	Scrnfail	Screen Failure	USA	2013-12-13	NA
219	Xanomeline High Dose	Xan_Hi	Xanomeline High Dose	USA	2013-03-20	-14
220	Screen Failure	Scrnfail	Screen Failure	USA	2014-03-17	NA
221	Placebo	Pbo	Placebo	USA	2012-07-20	-9
222	Xanomeline Low Dose	Xan_Lo	Xanomeline Low Dose	USA	2013-03-30	-4
223	Screen Failure	Scrnfail	Screen Failure	USA	2012-11-08	NA
224	Screen Failure	Scrnfail	Screen Failure	USA	2012-10-04	NA
225	Screen Failure	Scrnfail	Screen Failure	USA	2013-10-24	NA
226	Screen Failure	Scrnfail	Screen Failure	USA	2014-02-28	NA
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228	Screen Failure	Scrnfail	Screen Failure	USA	2013-08-05	NA
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231	Xanomeline Low Dose	Xan_Lo	Xanomeline Low Dose	USA	2013-08-17	-29
232	Xanomeline Low Dose	Xan_Lo	Xanomeline Low Dose	USA	2014-03-15	-15
233	Xanomeline High Dose	Xan_Hi	Xanomeline High Dose	USA	2012-10-03	-28
234	Xanomeline High Dose	Xan_Hi	Xanomeline High Dose	USA	2013-05-23	-8
235	Placebo	Pbo	Placebo	USA	2013-07-11	-29
236	Xanomeline High Dose	Xan_Hi	Xanomeline High Dose	USA	2013-05-16	-11
237	Placebo	Pbo	Placebo	USA	2012-09-10	-9
238	Placebo	Pbo	Placebo	USA	2014-01-14	-13
239	Xanomeline Low Dose	Xan_Lo	Xanomeline Low Dose	USA	2014-01-05	-14
240	Placebo	Pbo	Placebo	USA	2014-04-03	-14

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243	Xanomeline High Dose	Xan_Hi	Xanomeline High Dose	USA	2013-11-24	-10
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245	Xanomeline High Dose	Xan_Lo	Xanomeline Low Dose	USA	2013-08-11	-4
246	Xanomeline Low Dose	Xan_Lo	Xanomeline Low Dose	USA	2013-02-03	-13
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259	Placebo	Pbo	Placebo	USA	2012-07-06	-3
260	Placebo	Pbo	Placebo	USA	2014-03-23	-10
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262	Placebo	Pbo	Placebo	USA	2013-04-20	-7
263	Screen Failure	Scrnfail	Screen Failure	USA	2014-02-14	NA
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267	Xanomeline Low Dose	Xan_Lo	Xanomeline Low Dose	USA	2014-03-18	-2
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272	Xanomeline Low Dose	Xan_Lo	Xanomeline Low Dose	USA	2012-09-30	-8
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289	Xanomeline High Dose	Xan_Hi	Xanomeline High Dose	USA	2013-01-16	-6
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295	Xanomeline Low Dose	Xan_Lo	Xanomeline Low Dose	USA	2012-09-11	-8
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303	Xanomeline High Dose	Xan_Hi	Xanomeline High Dose	USA	2013-01-28	-4
304	Placebo	Pbo	Placebo	USA	2013-02-12	-16
305	Xanomeline High Dose	Xan_Hi	Xanomeline High Dose	USA	2013-04-11	-15
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25	Xanomeline Low Dose	Xanomeline Low Dose	2012-11-15T00:00:00Z	H
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172	Xanomeline Low Dose	Xanomeline Low Dose	2013-03-24T00:00:00Z	H
173	Placebo	Placebo	2013-07-19T00:00:00Z	H
174	Placebo	Placebo	2014-02-03T00:00:00Z	H
175	Xanomeline High Dose	Xanomeline High Dose	2013-06-19T00:00:00Z	H
176	Placebo	Placebo	2014-04-20T00:00:00Z	H
177	Xanomeline Low Dose	Xanomeline Low Dose	2013-04-05T00:00:00Z	H
178	Xanomeline High Dose	Xanomeline Low Dose	2013-08-15T00:00:00Z	H
179	Placebo	Placebo	2012-12-23T00:00:00Z	H
180	Xanomeline High Dose	Xanomeline Low Dose	2013-03-03T00:00:00Z	H
181	Xanomeline Low Dose	Xanomeline Low Dose	2014-01-14T00:00:00Z	H
182	Xanomeline High Dose	Xanomeline High Dose	2013-02-10T00:00:00Z	H
183	Xanomeline High Dose	Xanomeline High Dose	2013-09-27T00:00:00Z	H
184	Placebo	Placebo	2014-02-28T00:00:00Z	H
185	Xanomeline Low Dose	Xanomeline Low Dose	2013-06-03T00:00:00Z	H
186	Xanomeline Low Dose	Xanomeline Low Dose	2012-12-26T00:00:00Z	H
187	Placebo	Placebo	2013-01-01T00:00:00Z	H
188	Xanomeline High Dose	Xanomeline High Dose	2012-09-08T00:00:00Z	H
189	Placebo	Placebo	2013-11-17T00:00:00Z	H
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198	Placebo	Placebo	2013-11-16T00:00:00Z	H
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205	Placebo	Placebo	2012-09-27T00:00:00Z	H
206	Xanomeline High Dose	Xanomeline High Dose	2012-12-24T00:00:00Z	H
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209	Placebo	Placebo	2013-02-27T00:00:00Z	H
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232	Xanomeline Low Dose	Xanomeline Low Dose	2014-03-30T00:00:00Z	H
233	Xanomeline High Dose	Xanomeline High Dose	2012-10-31T00:00:00Z	H
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235	Placebo	Placebo	2013-08-09T00:00:00Z	H
236	Xanomeline High Dose	Xanomeline High Dose	2013-05-27T00:00:00Z	H
237	Placebo	Placebo	2012-09-19T00:00:00Z	H
238	Placebo	Placebo	2014-01-27T00:00:00Z	H
239	Xanomeline Low Dose	Xanomeline Low Dose	2014-01-19T00:00:00Z	H
240	Placebo	Placebo	2014-04-17T00:00:00Z	H
241	Xanomeline Low Dose	Xanomeline Low Dose	2013-08-08T00:00:00Z	H
242	Xanomeline Low Dose	Xanomeline Low Dose	2013-04-26T00:00:00Z	H
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244	Placebo	Placebo	2013-02-26T00:00:00Z	H
245	Xanomeline High Dose	Xanomeline Low Dose	2013-08-15T00:00:00Z	H
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262	Placebo	Placebo	2013-04-27T00:00:00Z	H
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266	Xanomeline Low Dose	Xanomeline Low Dose	2012-12-19T00:00:00Z	H
267	Xanomeline Low Dose	Xanomeline Low Dose	2014-03-20T00:00:00Z	H
268	Placebo	Placebo	2013-02-12T00:00:00Z	H
269	Xanomeline Low Dose	Xanomeline Low Dose	2013-02-01T00:00:00Z	H
270	Xanomeline Low Dose	Xanomeline Low Dose	2013-10-02T00:00:00Z	H
271	Placebo	Placebo	2013-04-05T00:00:00Z	H
272	Xanomeline Low Dose	Xanomeline Low Dose	2012-10-08T00:00:00Z	H
273	Placebo	Placebo	2014-09-02T00:00:00Z	H
274	Xanomeline High Dose	Xanomeline High Dose	2012-10-09T00:00:00Z	H
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284	Xanomeline High Dose	Xanomeline High Dose	2013-05-05T00:00:00Z	H
285	Placebo	Placebo	2014-01-22T00:00:00Z	H
286	Xanomeline High Dose	Xanomeline High Dose	2013-12-16T00:00:00Z	H
287	Xanomeline Low Dose	Xanomeline Low Dose	2014-01-14T00:00:00Z	H
288	Xanomeline High Dose	Xanomeline High Dose	2014-01-27T00:00:00Z	H
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290	Placebo	Placebo	2013-12-19T00:00:00Z	H
291	Placebo	Placebo	2014-01-11T00:00:00Z	H
292	Xanomeline High Dose	Xanomeline High Dose	2013-05-01T00:00:00Z	H
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4	2014-03-31T23:59:59Z	H	14 DISCONTINUED	NA NA >=65
5	2014-12-30T23:59:59Z	H	183 COMPLETED	NA NA >=65
6	2013-03-09T23:59:59Z	H	26 DISCONTINUED	NA NA >=65
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10	2013-01-23T23:59:59Z	H	55 DISCONTINUED	NA NA >=65
11	2014-09-09T23:59:59Z	H	182 COMPLETED	NA NA 18-64
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21	2013-12-09T23:59:59Z	H	5	DISCONTINUED	NA	NA	>=65
22	2013-03-24T23:59:59Z	H	38	DISCONTINUED	NA	NA	>=65
23	2013-01-20T23:59:59Z	H	183	COMPLETED	NA	NA	>=65
24	2013-08-03T23:59:59Z	H	183	COMPLETED	NA	NA	>=65
25	2013-01-12T23:59:59Z	H	59	DISCONTINUED	61	2	>=65
26	2013-09-22T23:59:59Z	H	177	COMPLETED	NA	NA	>=65
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30	2014-07-26T23:59:59Z	H	183	COMPLETED	NA	NA	18-64
31	2013-06-14T23:59:59Z	H	83	DISCONTINUED	NA	NA	>=65
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36	2013-01-26T23:59:59Z	H	22	DISCONTINUED	NA	NA	18-64
37	2014-03-18T23:59:59Z	H	162	DISCONTINUED	NA	NA	18-64
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45	2013-04-28T23:59:59Z	H	183	COMPLETED	NA	NA	>=65
46	<NA>	<NA>	NA	<NA>	NA	NA	>=65
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49	2014-02-05T23:59:59Z	H	182	COMPLETED	NA	NA	>=65
50	2014-04-26T23:59:59Z	H	183	COMPLETED	NA	NA	18-64
51	2013-02-12T23:59:59Z	H	39	DISCONTINUED	NA	NA	18-64
52	2013-10-13T23:59:59Z	H	80	DISCONTINUED	NA	NA	>=65
53	2013-08-31T23:59:59Z	H	183	COMPLETED	NA	NA	18-64
54	2013-12-24T23:59:59Z	H	61	DISCONTINUED	NA	NA	>=65
55	2012-12-04T23:59:59Z	H	94	DISCONTINUED	NA	NA	>=65
56	2013-03-16T23:59:59Z	H	51	DISCONTINUED	NA	NA	>=65

57	2013-09-14T23:59:59Z	H	186	COMPLETED	NA	NA	>=65
58	2013-06-13T23:59:59Z	H	114	DISCONTINUED	NA	NA	>=65
59	2013-12-26T23:59:59Z	H	7	DISCONTINUED	NA	NA	>=65
60	2013-12-11T23:59:59Z	H	56	DISCONTINUED	NA	NA	>=65
61	2013-06-29T23:59:59Z	H	14	DISCONTINUED	NA	NA	>=65
62	2013-09-06T23:59:59Z	H	175	COMPLETED	NA	NA	>=65
63	2013-01-11T23:59:59Z	H	176	DISCONTINUED	NA	NA	>=65
64	2013-06-03T23:59:59Z	H	22	DISCONTINUED	NA	NA	>=65
65	2014-04-19T23:59:59Z	H	150	DISCONTINUED	NA	NA	>=65
66	2013-03-13T23:59:59Z	H	183	COMPLETED	NA	NA	>=65
67	2014-05-07T23:59:59Z	H	52	DISCONTINUED	NA	NA	>=65
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71	2014-09-11T23:59:59Z	H	184	COMPLETED	NA	NA	>=65
72	2013-02-21T23:59:59Z	H	40	DISCONTINUED	NA	NA	>=65
73	2013-09-25T23:59:59Z	H	30	DISCONTINUED	NA	NA	>=65
74	2014-07-08T23:59:59Z	H	138	DISCONTINUED	NA	NA	>=65
75	2013-11-18T23:59:59Z	H	44	DISCONTINUED	NA	NA	>=65
76	2013-10-24T23:59:59Z	H	28	DISCONTINUED	NA	NA	>=65
77	2013-12-22T23:59:59Z	H	60	DISCONTINUED	NA	NA	>=65
78	2014-03-20T23:59:59Z	H	58	DISCONTINUED	NA	NA	>=65
79	2013-06-17T23:59:59Z	H	95	DISCONTINUED	NA	NA	>=65
80	2013-07-07T23:59:59Z	H	166	DISCONTINUED	NA	NA	>=65
81	2014-02-01T23:59:59Z	H	62	DISCONTINUED	NA	NA	>=65
82	2014-03-31T23:59:59Z	H	181	COMPLETED	NA	NA	>=65
83	2014-05-16T23:59:59Z	H	198	COMPLETED	NA	NA	>=65
84	2013-04-04T23:59:59Z	H	198	COMPLETED	NA	NA	>=65
85	2013-05-27T23:59:59Z	H	190	COMPLETED	NA	NA	>=65
86	2013-04-04T23:59:59Z	H	15	DISCONTINUED	NA	NA	>=65
87	2013-10-09T23:59:59Z	H	46	DISCONTINUED	NA	NA	>=65
88	2012-11-04T23:59:59Z	H	67	DISCONTINUED	NA	NA	>=65
89	2013-12-06T23:59:59Z	H	55	DISCONTINUED	NA	NA	>=65
90	2013-08-05T23:59:59Z	H	29	DISCONTINUED	NA	NA	>=65
91	2014-07-04T23:59:59Z	H	73	DISCONTINUED	NA	NA	>=65
92	2014-02-14T23:59:59Z	H	68	DISCONTINUED	NA	NA	>=65
93	2014-04-18T23:59:59Z	H	189	COMPLETED	NA	NA	>=65
94	2013-06-11T23:59:59Z	H	187	COMPLETED	NA	NA	>=65
95	2013-01-09T23:59:59Z	H	54	DISCONTINUED	NA	NA	>=65
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108	2013-06-24T23:59:59Z	H	181	COMPLETED	NA	NA	>=65
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110	2013-12-30T23:59:59Z	H	15	DISCONTINUED	NA	NA	>=65
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119	2013-06-18T23:59:59Z	H	36	DISCONTINUED	NA	NA	18-64
120	2012-09-24T23:59:59Z	H	10	DISCONTINUED	NA	NA	>=65
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132	2013-04-28T23:59:59Z	H	189	COMPLETED	NA	NA	>=65
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139	2012-11-29T23:59:59Z	H	37	DISCONTINUED	NA	NA	>=65
140	2013-09-21T23:59:59Z	H	1	DISCONTINUED	NA	NA	>=65
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144	2014-03-08T23:59:59Z	H	180	COMPLETED	NA	NA	>=65
145	2013-12-12T23:59:59Z	H	182	COMPLETED	NA	NA	18-64
146	2013-05-03T23:59:59Z	H	99	DISCONTINUED	NA	NA	18-64
147	2014-03-01T23:59:59Z	H	191	COMPLETED	NA	NA	>=65
148	2013-06-05T23:59:59Z	H	181	COMPLETED	NA	NA	>=65
149	2013-06-28T23:59:59Z	H	182	COMPLETED	NA	NA	18-64
150	2013-06-18T23:59:59Z	H	60	DISCONTINUED	NA	NA	18-64
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154	2013-04-19T23:59:59Z	H	8	DISCONTINUED	NA	NA	>=65
155	2014-01-28T23:59:59Z	H	148	DISCONTINUED	NA	NA	>=65
156	2014-07-02T23:59:59Z	H	189	COMPLETED	NA	NA	>=65
157	2013-12-14T23:59:59Z	H	36	DISCONTINUED	NA	NA	>=65
158	2014-04-08T23:59:59Z	H	183	COMPLETED	NA	NA	>=65
159	2012-08-28T23:59:59Z	H	29	DISCONTINUED	NA	NA	18-64
160	2013-06-01T23:59:59Z	H	183	COMPLETED	NA	NA	>=65
161	2013-06-26T23:59:59Z	H	184	COMPLETED	NA	NA	>=65
162	2014-04-27T23:59:59Z	H	100	DISCONTINUED	NA	NA	>=65
163	2014-10-09T23:59:59Z	H	181	COMPLETED	NA	NA	>=65
164	2014-04-25T23:59:59Z	H	183	COMPLETED	NA	NA	>=65
165	2013-03-27T23:59:59Z	H	72	DISCONTINUED	NA	NA	>=65
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172	2013-05-23T23:59:59Z	H	61	DISCONTINUED	NA	NA	>=65
173	2014-01-17T23:59:59Z	H	183	COMPLETED	NA	NA	18-64
174	2014-06-16T23:59:59Z	H	134	DISCONTINUED	NA	NA	18-64
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177	2013-10-02T23:59:59Z	H	181	COMPLETED	NA	NA	>=65
178	2013-08-25T23:59:59Z	H	11	DISCONTINUED	NA	NA	>=65
179	2013-06-24T23:59:59Z	H	184	COMPLETED	NA	NA	>=65
180	2013-03-07T23:59:59Z	H	5	DISCONTINUED	NA	NA	>=65
181	2014-01-18T23:59:59Z	H	5	DISCONTINUED	NA	NA	>=65
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183	2013-10-29T23:59:59Z	H	33	DISCONTINUED	NA	NA	>=65
184	2014-08-29T23:59:59Z	H	183	COMPLETED	NA	NA	>=65
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186	2013-02-10T23:59:59Z	H	47	DISCONTINUED	NA	NA	>=65
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198	2014-05-17T23:59:59Z	H	183	COMPLETED	NA	NA	>=65
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205	2012-11-21T23:59:59Z	H	56	DISCONTINUED	NA	NA	>=65
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213	2014-04-24T23:59:59Z	H	184	COMPLETED	NA	NA	>=65
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232	2014-10-05T23:59:59Z	H	190	COMPLETED	NA	NA	>=65
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237	2013-03-25T23:59:59Z	H	188	COMPLETED	NA	NA	>=65
238	2014-07-28T23:59:59Z	H	183	COMPLETED	NA	NA	>=65
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246	2013-08-18T23:59:59Z	H	184	COMPLETED	NA	NA	>=65
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256	2013-07-07T23:59:59Z	H	2	DISCONTINUED	NA	NA	>=65
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265	2013-08-01T23:59:59Z	H	55	DISCONTINUED	NA	NA	>=65
266	2013-01-24T23:59:59Z	H	37	DISCONTINUED	NA	NA	>=65
267	2014-09-20T23:59:59Z	H	185	COMPLETED	NA	NA	>=65
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269	2013-05-11T23:59:59Z	H	100	DISCONTINUED	NA	NA	>=65
270	2014-04-04T23:59:59Z	H	185	COMPLETED	NA	NA	>=65
271	2013-10-11T23:59:59Z	H	190	COMPLETED	NA	NA	>=65

272	2013-04-12T23:59:59Z	H	187	COMPLETED	NA	NA	>=65
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274	2013-02-27T23:59:59Z	H	142	DISCONTINUED	NA	NA	>=65
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296	2013-07-31T23:59:59Z	H	165	DISCONTINUED	NA	NA	>=65
297	2013-11-17T23:59:59Z	H	183	COMPLETED	NA	NA	>=65
298	2013-07-29T23:59:59Z	H	192	COMPLETED	NA	NA	>=65
299	2013-10-12T23:59:59Z	H	27	DISCONTINUED	NA	NA	>=65
300	2013-11-29T23:59:59Z	H	70	DISCONTINUED	NA	NA	>=65
301	2014-01-31T23:59:59Z	H	133	DISCONTINUED	NA	NA	>=65
302	2014-01-09T23:59:59Z	H	184	COMPLETED	NA	NA	>=65
303	2013-04-18T23:59:59Z	H	77	DISCONTINUED	NA	NA	>=65
304	2013-08-29T23:59:59Z	H	183	COMPLETED	NA	NA	>=65
305	2013-08-01T23:59:59Z	H	98	DISCONTINUED	NA	NA	>=65
306	2013-02-11T23:59:59Z	H	57	DISCONTINUED	NA	NA	>=65

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205	Y	White	NA	<NA>	<NA>	NA	<NA>
206	Y	White	NA	<NA>	<NA>	NA	<NA>
207	Y	White	NA	<NA>	<NA>	NA	<NA>
208	Y	White	NA	<NA>	<NA>	NA	<NA>
209	Y	White	NA	<NA>	<NA>	NA	<NA>
210	<NA>	White	NA	<NA>	<NA>	NA	<NA>
211	Y	White	NA	<NA>	<NA>	NA	<NA>
212	Y	White	NA	<NA>	<NA>	NA	<NA>
213	Y	White	NA	<NA>	<NA>	NA	<NA>
214	<NA>	White	NA	<NA>	<NA>	NA	<NA>
215	<NA>	White	NA	<NA>	<NA>	NA	<NA>
216	Y	White	NA	<NA>	<NA>	NA	<NA>
217	Y	White	NA	<NA>	<NA>	NA	<NA>
218	<NA>	White	NA	<NA>	<NA>	NA	<NA>
219	Y	White	NA	<NA>	<NA>	NA	<NA>
220	<NA>	White	NA	<NA>	<NA>	NA	<NA>
221	Y	Non-white	NA	<NA>	<NA>	NA	<NA>
222	Y	White	NA	<NA>	<NA>	NA	<NA>

[illegible]

[illegible]



4.2.2 filter

The `filter` function allows us to look at a subset of observations. As input, the function requires a logical vector and (of course) a data-frame. This time, we first save the reduced (selected) data-frame and use that as the first argument to `filter`.

```
selected_data <- select(adsl,
                        STUDYID,
                        USUBJID,
                        ARM,
                        AGE,
                        SEX,
                        RACE)
```

The logical vector is generally created within the function call and can use any of the following logic operators:

<	less than
<=	less than or equal to
>	greater than
>=	greater than or equal to
==	equal
!=	not equal
!x	not x (negation)
x y	x OR y
x & y	x AND y
x %in% y	logical vector of length x with TRUE if element of x is in y

Within `filter`, we can chain logical vectors by separating them with a comma (,). Lets have a look at women that are 70 and older:

```
filter(selected_data,
        AGE >= 70,
        SEX == "F")
```

	STUDYID	USUBJID	ARM	AGE	SEX
1	CDISCPILLOT01	01-701-1034	Xanomeline High Dose	77	F
2	CDISCPILLOT01	01-701-1047	Placebo	85	F
3	CDISCPILLOT01	01-701-1111	Xanomeline Low Dose	81	F
4	CDISCPILLOT01	01-701-1133	Xanomeline High Dose	81	F
5	CDISCPILLOT01	01-701-1146	Xanomeline High Dose	75	F

6	CDISCPILLOT01	01-701-1153	Placebo	79	F
7	CDISCPILLOT01	01-701-1162	Screen Failure	82	F
8	CDISCPILLOT01	01-701-1181	Xanomeline High Dose	79	F
9	CDISCPILLOT01	01-701-1192	Xanomeline Low Dose	80	F
10	CDISCPILLOT01	01-701-1203	Placebo	81	F
11	CDISCPILLOT01	01-701-1211	Xanomeline Low Dose	76	F
12	CDISCPILLOT01	01-701-1307	Screen Failure	80	F
13	CDISCPILLOT01	01-701-1363	Placebo	81	F
14	CDISCPILLOT01	01-701-1383	Xanomeline High Dose	72	F
15	CDISCPILLOT01	01-701-1387	Placebo	87	F
16	CDISCPILLOT01	01-701-1429	Xanomeline Low Dose	84	F
17	CDISCPILLOT01	01-702-1082	Xanomeline Low Dose	84	F
18	CDISCPILLOT01	01-703-1096	Placebo	81	F
19	CDISCPILLOT01	01-703-1100	Placebo	84	F
20	CDISCPILLOT01	01-703-1119	Xanomeline Low Dose	81	F
21	CDISCPILLOT01	01-703-1197	Xanomeline Low Dose	76	F
22	CDISCPILLOT01	01-703-1210	Placebo	72	F
23	CDISCPILLOT01	01-703-1258	Xanomeline High Dose	78	F
24	CDISCPILLOT01	01-703-1279	Xanomeline Low Dose	72	F
25	CDISCPILLOT01	01-703-1295	Xanomeline High Dose	88	F
26	CDISCPILLOT01	01-703-1299	Placebo	81	F
27	CDISCPILLOT01	01-703-1379	Xanomeline Low Dose	81	F
28	CDISCPILLOT01	01-703-1439	Xanomeline High Dose	76	F
29	CDISCPILLOT01	01-704-1008	Xanomeline High Dose	76	F
30	CDISCPILLOT01	01-704-1025	Xanomeline Low Dose	81	F
31	CDISCPILLOT01	01-704-1074	Xanomeline High Dose	80	F
32	CDISCPILLOT01	01-704-1120	Xanomeline Low Dose	71	F
33	CDISCPILLOT01	01-704-1127	Placebo	84	F
34	CDISCPILLOT01	01-704-1135	Xanomeline Low Dose	74	F
35	CDISCPILLOT01	01-704-1218	Xanomeline Low Dose	81	F
36	CDISCPILLOT01	01-704-1233	Placebo	87	F
37	CDISCPILLOT01	01-704-1260	Placebo	71	F
38	CDISCPILLOT01	01-705-1011	Screen Failure	75	F
39	CDISCPILLOT01	01-705-1186	Placebo	84	F
40	CDISCPILLOT01	01-705-1243	Screen Failure	70	F
41	CDISCPILLOT01	01-705-1281	Xanomeline High Dose	73	F
42	CDISCPILLOT01	01-705-1282	Placebo	70	F
43	CDISCPILLOT01	01-705-1310	Xanomeline High Dose	74	F
44	CDISCPILLOT01	01-705-1349	Placebo	86	F
45	CDISCPILLOT01	01-705-1393	Xanomeline Low Dose	84	F
46	CDISCPILLOT01	01-706-1384	Xanomeline Low Dose	74	F
47	CDISCPILLOT01	01-707-1037	Xanomeline Low Dose	72	F
48	CDISCPILLOT01	01-707-1276	Screen Failure	72	F

49	CDISCPIL0T01	01-707-1430	Screen Failure	81	F
50	CDISCPIL0T01	01-707-1434	Screen Failure	76	F
51	CDISCPIL0T01	01-708-1054	Screen Failure	73	F
52	CDISCPIL0T01	01-708-1084	Xanomeline Low Dose	73	F
53	CDISCPIL0T01	01-708-1087	Placebo	74	F
54	CDISCPIL0T01	01-708-1104	Screen Failure	78	F
55	CDISCPIL0T01	01-708-1158	Placebo	81	F
56	CDISCPIL0T01	01-708-1171	Placebo	77	F
57	CDISCPIL0T01	01-708-1178	Xanomeline High Dose	77	F
58	CDISCPIL0T01	01-708-1184	Screen Failure	70	F
59	CDISCPIL0T01	01-708-1213	Xanomeline High Dose	76	F
60	CDISCPIL0T01	01-708-1236	Xanomeline High Dose	86	F
61	CDISCPIL0T01	01-708-1286	Placebo	80	F
62	CDISCPIL0T01	01-708-1316	Placebo	74	F
63	CDISCPIL0T01	01-708-1348	Xanomeline Low Dose	79	F
64	CDISCPIL0T01	01-708-1352	Screen Failure	87	F
65	CDISCPIL0T01	01-708-1353	Xanomeline Low Dose	87	F
66	CDISCPIL0T01	01-708-1406	Xanomeline High Dose	71	F
67	CDISCPIL0T01	01-708-1428	Xanomeline Low Dose	84	F
68	CDISCPIL0T01	01-709-1001	Placebo	76	F
69	CDISCPIL0T01	01-709-1020	Xanomeline Low Dose	72	F
70	CDISCPIL0T01	01-709-1081	Xanomeline Low Dose	86	F
71	CDISCPIL0T01	01-709-1099	Xanomeline High Dose	79	F
72	CDISCPIL0T01	01-709-1102	Xanomeline Low Dose	71	F
73	CDISCPIL0T01	01-709-1168	Xanomeline High Dose	72	F
74	CDISCPIL0T01	01-709-1237	Screen Failure	88	F
75	CDISCPIL0T01	01-709-1326	Xanomeline Low Dose	75	F
76	CDISCPIL0T01	01-710-1045	Xanomeline Low Dose	83	F
77	CDISCPIL0T01	01-710-1053	Xanomeline Low Dose	84	F
78	CDISCPIL0T01	01-710-1070	Xanomeline High Dose	85	F
79	CDISCPIL0T01	01-710-1077	Placebo	76	F
80	CDISCPIL0T01	01-710-1078	Placebo	81	F
81	CDISCPIL0T01	01-710-1083	Placebo	89	F
82	CDISCPIL0T01	01-710-1137	Xanomeline High Dose	79	F
83	CDISCPIL0T01	01-710-1142	Xanomeline High Dose	76	F
84	CDISCPIL0T01	01-710-1149	Screen Failure	79	F
85	CDISCPIL0T01	01-710-1166	Xanomeline Low Dose	81	F
86	CDISCPIL0T01	01-710-1183	Placebo	80	F
87	CDISCPIL0T01	01-710-1187	Xanomeline High Dose	78	F
88	CDISCPIL0T01	01-710-1257	Screen Failure	85	F
89	CDISCPIL0T01	01-710-1270	Xanomeline Low Dose	83	F
90	CDISCPIL0T01	01-710-1271	Placebo	86	F
91	CDISCPIL0T01	01-710-1300	Xanomeline Low Dose	78	F

92	CDISCPIL0T01	01-710-1314	Placebo	78	F
93	CDISCPIL0T01	01-710-1315	Placebo	83	F
94	CDISCPIL0T01	01-710-1368	Placebo	88	F
95	CDISCPIL0T01	01-710-1376	Screen Failure	89	F
96	CDISCPIL0T01	01-710-1380	Screen Failure	80	F
97	CDISCPIL0T01	01-710-1443	Screen Failure	88	F
98	CDISCPIL0T01	01-711-1022	Screen Failure	86	F
99	CDISCPIL0T01	01-711-1143	Xanomeline Low Dose	76	F
100	CDISCPIL0T01	01-711-1163	Screen Failure	74	F
101	CDISCPIL0T01	01-711-1226	Screen Failure	74	F
102	CDISCPIL0T01	01-711-1283	Screen Failure	75	F
103	CDISCPIL0T01	01-711-1284	Screen Failure	77	F
104	CDISCPIL0T01	01-711-1433	Xanomeline High Dose	84	F
105	CDISCPIL0T01	01-713-1043	Xanomeline Low Dose	78	F
106	CDISCPIL0T01	01-713-1073	Xanomeline Low Dose	74	F
107	CDISCPIL0T01	01-713-1209	Xanomeline High Dose	77	F
108	CDISCPIL0T01	01-713-1448	Xanomeline Low Dose	71	F
109	CDISCPIL0T01	01-714-1035	Placebo	88	F
110	CDISCPIL0T01	01-714-1068	Xanomeline Low Dose	79	F
111	CDISCPIL0T01	01-714-1375	Placebo	78	F
112	CDISCPIL0T01	01-715-1085	Xanomeline Low Dose	77	F
113	CDISCPIL0T01	01-715-1207	Placebo	78	F
114	CDISCPIL0T01	01-715-1225	Screen Failure	77	F
115	CDISCPIL0T01	01-715-1321	Xanomeline High Dose	75	F
116	CDISCPIL0T01	01-715-1333	Screen Failure	75	F
117	CDISCPIL0T01	01-715-1397	Placebo	76	F
118	CDISCPIL0T01	01-715-1407	Screen Failure	73	F
119	CDISCPIL0T01	01-716-1024	Placebo	87	F
120	CDISCPIL0T01	01-716-1026	Placebo	73	F
121	CDISCPIL0T01	01-716-1030	Xanomeline High Dose	83	F
122	CDISCPIL0T01	01-716-1071	Xanomeline High Dose	78	F
123	CDISCPIL0T01	01-716-1108	Placebo	86	F
124	CDISCPIL0T01	01-716-1151	Xanomeline Low Dose	83	F
125	CDISCPIL0T01	01-716-1160	Placebo	83	F
126	CDISCPIL0T01	01-716-1229	Xanomeline High Dose	73	F
127	CDISCPIL0T01	01-716-1244	Screen Failure	72	F
128	CDISCPIL0T01	01-716-1298	Xanomeline Low Dose	76	F
129	CDISCPIL0T01	01-716-1305	Screen Failure	73	F
130	CDISCPIL0T01	01-716-1308	Placebo	76	F
131	CDISCPIL0T01	01-716-1364	Xanomeline High Dose	84	F
132	CDISCPIL0T01	01-716-1418	Xanomeline High Dose	80	F
133	CDISCPIL0T01	01-716-1447	Xanomeline High Dose	72	F
134	CDISCPIL0T01	01-717-1004	Xanomeline Low Dose	80	F

135	CDISCPILLOT01	01-717-1201	Placebo	85	F
136	CDISCPILLOT01	01-717-1446	Xanomeline Low Dose	75	F
137	CDISCPILLOT01	01-718-1066	Xanomeline Low Dose	79	F
138	CDISCPILLOT01	01-718-1150	Placebo	73	F
139	CDISCPILLOT01	01-718-1170	Xanomeline Low Dose	80	F
140	CDISCPILLOT01	01-718-1250	Xanomeline Low Dose	82	F
141	CDISCPILLOT01	01-718-1427	Xanomeline High Dose	74	F

RACE

1	WHITE
2	WHITE
3	WHITE
4	WHITE
5	WHITE
6	WHITE
7	WHITE
8	WHITE
9	WHITE
10	BLACK OR AFRICAN AMERICAN
11	WHITE
12	WHITE
13	BLACK OR AFRICAN AMERICAN
14	WHITE
15	WHITE
16	WHITE
17	WHITE
18	WHITE
19	WHITE
20	WHITE
21	BLACK OR AFRICAN AMERICAN
22	WHITE
23	WHITE
24	WHITE
25	WHITE
26	WHITE
27	BLACK OR AFRICAN AMERICAN
28	WHITE
29	WHITE
30	WHITE
31	WHITE
32	WHITE
33	WHITE
34	WHITE
35	WHITE

36	WHITE
37	WHITE
38	WHITE
39	WHITE
40	WHITE
41	BLACK OR AFRICAN AMERICAN
42	BLACK OR AFRICAN AMERICAN
43	WHITE
44	WHITE
45	WHITE
46	WHITE
47	WHITE
48	WHITE
49	WHITE
50	WHITE
51	BLACK OR AFRICAN AMERICAN
52	WHITE
53	WHITE
54	ASIAN
55	WHITE
56	WHITE
57	BLACK OR AFRICAN AMERICAN
58	WHITE
59	WHITE
60	WHITE
61	BLACK OR AFRICAN AMERICAN
62	WHITE
63	WHITE
64	WHITE
65	BLACK OR AFRICAN AMERICAN
66	WHITE
67	WHITE
68	WHITE
69	WHITE
70	WHITE
71	WHITE
72	WHITE
73	WHITE
74	WHITE
75	WHITE
76	WHITE
77	WHITE
78	WHITE

79	WHITE
80	WHITE
81	WHITE
82	BLACK OR AFRICAN AMERICAN
83	WHITE
84	WHITE
85	WHITE
86	WHITE
87	WHITE
88	WHITE
89	WHITE
90	WHITE
91	WHITE
92	WHITE
93	WHITE
94	WHITE
95	WHITE
96	WHITE
97	WHITE
98	WHITE
99	WHITE
100	BLACK OR AFRICAN AMERICAN
101	WHITE
102	BLACK OR AFRICAN AMERICAN
103	WHITE
104	WHITE
105	WHITE
106	BLACK OR AFRICAN AMERICAN
107	WHITE
108	WHITE
109	WHITE
110	WHITE
111	WHITE
112	WHITE
113	WHITE
114	WHITE
115	WHITE
116	WHITE
117	WHITE
118	WHITE
119	WHITE
120	WHITE
121	WHITE

```

122             WHITE
123             WHITE
124             WHITE
125             WHITE
126             WHITE
127             WHITE
128             WHITE
129             WHITE
130             WHITE
131             WHITE
132             WHITE
133             WHITE
134             WHITE
135             WHITE
136             WHITE
137             WHITE
138             WHITE
139             WHITE
140             WHITE
141 BLACK OR AFRICAN AMERICAN

```

Now we have a reduced data frame with female patients over 70. However, the nested call is not very intuitive to read. If any more functions get added to this code, it becomes even less readable. That is where the pipe operator (`%>%`) comes in.

i The pipe operator let us chain multiple `dplyr` commands, so we can always forward the previously filtered / selected / arranged dataframe and keep working with it. The pipe operator let's us write nested function calls in a sequential way. Traditionally, we start a new line after every pipe operator.

```

# select, filter, & pipe:
adsl %>% # This pipe forwards adsl to the select function as its first argument
  select(STUDYID,
         USUBJID,
         ARM,
         AGE,
         SEX,
         RACE) %>% # this pipe forwards the selected variables to the filter function
  filter(AGE >= 70,
         SEX == "F")

```

```

STUDYID    USUBJID
ARM AGE SEX

```

1	CDISCPILLOT01	01-701-1034	Xanomeline High Dose	77	F
2	CDISCPILLOT01	01-701-1047	Placebo	85	F
3	CDISCPILLOT01	01-701-1111	Xanomeline Low Dose	81	F
4	CDISCPILLOT01	01-701-1133	Xanomeline High Dose	81	F
5	CDISCPILLOT01	01-701-1146	Xanomeline High Dose	75	F
6	CDISCPILLOT01	01-701-1153	Placebo	79	F
7	CDISCPILLOT01	01-701-1162	Screen Failure	82	F
8	CDISCPILLOT01	01-701-1181	Xanomeline High Dose	79	F
9	CDISCPILLOT01	01-701-1192	Xanomeline Low Dose	80	F
10	CDISCPILLOT01	01-701-1203	Placebo	81	F
11	CDISCPILLOT01	01-701-1211	Xanomeline Low Dose	76	F
12	CDISCPILLOT01	01-701-1307	Screen Failure	80	F
13	CDISCPILLOT01	01-701-1363	Placebo	81	F
14	CDISCPILLOT01	01-701-1383	Xanomeline High Dose	72	F
15	CDISCPILLOT01	01-701-1387	Placebo	87	F
16	CDISCPILLOT01	01-701-1429	Xanomeline Low Dose	84	F
17	CDISCPILLOT01	01-702-1082	Xanomeline Low Dose	84	F
18	CDISCPILLOT01	01-703-1096	Placebo	81	F
19	CDISCPILLOT01	01-703-1100	Placebo	84	F
20	CDISCPILLOT01	01-703-1119	Xanomeline Low Dose	81	F
21	CDISCPILLOT01	01-703-1197	Xanomeline Low Dose	76	F
22	CDISCPILLOT01	01-703-1210	Placebo	72	F
23	CDISCPILLOT01	01-703-1258	Xanomeline High Dose	78	F
24	CDISCPILLOT01	01-703-1279	Xanomeline Low Dose	72	F
25	CDISCPILLOT01	01-703-1295	Xanomeline High Dose	88	F
26	CDISCPILLOT01	01-703-1299	Placebo	81	F
27	CDISCPILLOT01	01-703-1379	Xanomeline Low Dose	81	F
28	CDISCPILLOT01	01-703-1439	Xanomeline High Dose	76	F
29	CDISCPILLOT01	01-704-1008	Xanomeline High Dose	76	F
30	CDISCPILLOT01	01-704-1025	Xanomeline Low Dose	81	F
31	CDISCPILLOT01	01-704-1074	Xanomeline High Dose	80	F
32	CDISCPILLOT01	01-704-1120	Xanomeline Low Dose	71	F
33	CDISCPILLOT01	01-704-1127	Placebo	84	F
34	CDISCPILLOT01	01-704-1135	Xanomeline Low Dose	74	F
35	CDISCPILLOT01	01-704-1218	Xanomeline Low Dose	81	F
36	CDISCPILLOT01	01-704-1233	Placebo	87	F
37	CDISCPILLOT01	01-704-1260	Placebo	71	F
38	CDISCPILLOT01	01-705-1011	Screen Failure	75	F
39	CDISCPILLOT01	01-705-1186	Placebo	84	F
40	CDISCPILLOT01	01-705-1243	Screen Failure	70	F
41	CDISCPILLOT01	01-705-1281	Xanomeline High Dose	73	F
42	CDISCPILLOT01	01-705-1282	Placebo	70	F
43	CDISCPILLOT01	01-705-1310	Xanomeline High Dose	74	F

44	CDISCPILLOT01	01-705-1349	Placebo	86	F
45	CDISCPILLOT01	01-705-1393	Xanomeline Low Dose	84	F
46	CDISCPILLOT01	01-706-1384	Xanomeline Low Dose	74	F
47	CDISCPILLOT01	01-707-1037	Xanomeline Low Dose	72	F
48	CDISCPILLOT01	01-707-1276	Screen Failure	72	F
49	CDISCPILLOT01	01-707-1430	Screen Failure	81	F
50	CDISCPILLOT01	01-707-1434	Screen Failure	76	F
51	CDISCPILLOT01	01-708-1054	Screen Failure	73	F
52	CDISCPILLOT01	01-708-1084	Xanomeline Low Dose	73	F
53	CDISCPILLOT01	01-708-1087	Placebo	74	F
54	CDISCPILLOT01	01-708-1104	Screen Failure	78	F
55	CDISCPILLOT01	01-708-1158	Placebo	81	F
56	CDISCPILLOT01	01-708-1171	Placebo	77	F
57	CDISCPILLOT01	01-708-1178	Xanomeline High Dose	77	F
58	CDISCPILLOT01	01-708-1184	Screen Failure	70	F
59	CDISCPILLOT01	01-708-1213	Xanomeline High Dose	76	F
60	CDISCPILLOT01	01-708-1236	Xanomeline High Dose	86	F
61	CDISCPILLOT01	01-708-1286	Placebo	80	F
62	CDISCPILLOT01	01-708-1316	Placebo	74	F
63	CDISCPILLOT01	01-708-1348	Xanomeline Low Dose	79	F
64	CDISCPILLOT01	01-708-1352	Screen Failure	87	F
65	CDISCPILLOT01	01-708-1353	Xanomeline Low Dose	87	F
66	CDISCPILLOT01	01-708-1406	Xanomeline High Dose	71	F
67	CDISCPILLOT01	01-708-1428	Xanomeline Low Dose	84	F
68	CDISCPILLOT01	01-709-1001	Placebo	76	F
69	CDISCPILLOT01	01-709-1020	Xanomeline Low Dose	72	F
70	CDISCPILLOT01	01-709-1081	Xanomeline Low Dose	86	F
71	CDISCPILLOT01	01-709-1099	Xanomeline High Dose	79	F
72	CDISCPILLOT01	01-709-1102	Xanomeline Low Dose	71	F
73	CDISCPILLOT01	01-709-1168	Xanomeline High Dose	72	F
74	CDISCPILLOT01	01-709-1237	Screen Failure	88	F
75	CDISCPILLOT01	01-709-1326	Xanomeline Low Dose	75	F
76	CDISCPILLOT01	01-710-1045	Xanomeline Low Dose	83	F
77	CDISCPILLOT01	01-710-1053	Xanomeline Low Dose	84	F
78	CDISCPILLOT01	01-710-1070	Xanomeline High Dose	85	F
79	CDISCPILLOT01	01-710-1077	Placebo	76	F
80	CDISCPILLOT01	01-710-1078	Placebo	81	F
81	CDISCPILLOT01	01-710-1083	Placebo	89	F
82	CDISCPILLOT01	01-710-1137	Xanomeline High Dose	79	F
83	CDISCPILLOT01	01-710-1142	Xanomeline High Dose	76	F
84	CDISCPILLOT01	01-710-1149	Screen Failure	79	F
85	CDISCPILLOT01	01-710-1166	Xanomeline Low Dose	81	F
86	CDISCPILLOT01	01-710-1183	Placebo	80	F

87	CDISCPILLOT01	01-710-1187	Xanomeline High Dose	78	F
88	CDISCPILLOT01	01-710-1257	Screen Failure	85	F
89	CDISCPILLOT01	01-710-1270	Xanomeline Low Dose	83	F
90	CDISCPILLOT01	01-710-1271	Placebo	86	F
91	CDISCPILLOT01	01-710-1300	Xanomeline Low Dose	78	F
92	CDISCPILLOT01	01-710-1314	Placebo	78	F
93	CDISCPILLOT01	01-710-1315	Placebo	83	F
94	CDISCPILLOT01	01-710-1368	Placebo	88	F
95	CDISCPILLOT01	01-710-1376	Screen Failure	89	F
96	CDISCPILLOT01	01-710-1380	Screen Failure	80	F
97	CDISCPILLOT01	01-710-1443	Screen Failure	88	F
98	CDISCPILLOT01	01-711-1022	Screen Failure	86	F
99	CDISCPILLOT01	01-711-1143	Xanomeline Low Dose	76	F
100	CDISCPILLOT01	01-711-1163	Screen Failure	74	F
101	CDISCPILLOT01	01-711-1226	Screen Failure	74	F
102	CDISCPILLOT01	01-711-1283	Screen Failure	75	F
103	CDISCPILLOT01	01-711-1284	Screen Failure	77	F
104	CDISCPILLOT01	01-711-1433	Xanomeline High Dose	84	F
105	CDISCPILLOT01	01-713-1043	Xanomeline Low Dose	78	F
106	CDISCPILLOT01	01-713-1073	Xanomeline Low Dose	74	F
107	CDISCPILLOT01	01-713-1209	Xanomeline High Dose	77	F
108	CDISCPILLOT01	01-713-1448	Xanomeline Low Dose	71	F
109	CDISCPILLOT01	01-714-1035	Placebo	88	F
110	CDISCPILLOT01	01-714-1068	Xanomeline Low Dose	79	F
111	CDISCPILLOT01	01-714-1375	Placebo	78	F
112	CDISCPILLOT01	01-715-1085	Xanomeline Low Dose	77	F
113	CDISCPILLOT01	01-715-1207	Placebo	78	F
114	CDISCPILLOT01	01-715-1225	Screen Failure	77	F
115	CDISCPILLOT01	01-715-1321	Xanomeline High Dose	75	F
116	CDISCPILLOT01	01-715-1333	Screen Failure	75	F
117	CDISCPILLOT01	01-715-1397	Placebo	76	F
118	CDISCPILLOT01	01-715-1407	Screen Failure	73	F
119	CDISCPILLOT01	01-716-1024	Placebo	87	F
120	CDISCPILLOT01	01-716-1026	Placebo	73	F
121	CDISCPILLOT01	01-716-1030	Xanomeline High Dose	83	F
122	CDISCPILLOT01	01-716-1071	Xanomeline High Dose	78	F
123	CDISCPILLOT01	01-716-1108	Placebo	86	F
124	CDISCPILLOT01	01-716-1151	Xanomeline Low Dose	83	F
125	CDISCPILLOT01	01-716-1160	Placebo	83	F
126	CDISCPILLOT01	01-716-1229	Xanomeline High Dose	73	F
127	CDISCPILLOT01	01-716-1244	Screen Failure	72	F
128	CDISCPILLOT01	01-716-1298	Xanomeline Low Dose	76	F
129	CDISCPILLOT01	01-716-1305	Screen Failure	73	F

130	CDISCPILLOT01	01-716-1308	Placebo	76	F
131	CDISCPILLOT01	01-716-1364	Xanomeline High Dose	84	F
132	CDISCPILLOT01	01-716-1418	Xanomeline High Dose	80	F
133	CDISCPILLOT01	01-716-1447	Xanomeline High Dose	72	F
134	CDISCPILLOT01	01-717-1004	Xanomeline Low Dose	80	F
135	CDISCPILLOT01	01-717-1201	Placebo	85	F
136	CDISCPILLOT01	01-717-1446	Xanomeline Low Dose	75	F
137	CDISCPILLOT01	01-718-1066	Xanomeline Low Dose	79	F
138	CDISCPILLOT01	01-718-1150	Placebo	73	F
139	CDISCPILLOT01	01-718-1170	Xanomeline Low Dose	80	F
140	CDISCPILLOT01	01-718-1250	Xanomeline Low Dose	82	F
141	CDISCPILLOT01	01-718-1427	Xanomeline High Dose	74	F

RACE

1	WHITE
2	WHITE
3	WHITE
4	WHITE
5	WHITE
6	WHITE
7	WHITE
8	WHITE
9	WHITE
10	BLACK OR AFRICAN AMERICAN
11	WHITE
12	WHITE
13	BLACK OR AFRICAN AMERICAN
14	WHITE
15	WHITE
16	WHITE
17	WHITE
18	WHITE
19	WHITE
20	WHITE
21	BLACK OR AFRICAN AMERICAN
22	WHITE
23	WHITE
24	WHITE
25	WHITE
26	WHITE
27	BLACK OR AFRICAN AMERICAN
28	WHITE
29	WHITE
30	WHITE

31	WHITE
32	WHITE
33	WHITE
34	WHITE
35	WHITE
36	WHITE
37	WHITE
38	WHITE
39	WHITE
40	WHITE
41	BLACK OR AFRICAN AMERICAN
42	BLACK OR AFRICAN AMERICAN
43	WHITE
44	WHITE
45	WHITE
46	WHITE
47	WHITE
48	WHITE
49	WHITE
50	WHITE
51	BLACK OR AFRICAN AMERICAN
52	WHITE
53	WHITE
54	ASIAN
55	WHITE
56	WHITE
57	BLACK OR AFRICAN AMERICAN
58	WHITE
59	WHITE
60	WHITE
61	BLACK OR AFRICAN AMERICAN
62	WHITE
63	WHITE
64	WHITE
65	BLACK OR AFRICAN AMERICAN
66	WHITE
67	WHITE
68	WHITE
69	WHITE
70	WHITE
71	WHITE
72	WHITE
73	WHITE

74	WHITE
75	WHITE
76	WHITE
77	WHITE
78	WHITE
79	WHITE
80	WHITE
81	WHITE
82	BLACK OR AFRICAN AMERICAN
83	WHITE
84	WHITE
85	WHITE
86	WHITE
87	WHITE
88	WHITE
89	WHITE
90	WHITE
91	WHITE
92	WHITE
93	WHITE
94	WHITE
95	WHITE
96	WHITE
97	WHITE
98	WHITE
99	WHITE
100	BLACK OR AFRICAN AMERICAN
101	WHITE
102	BLACK OR AFRICAN AMERICAN
103	WHITE
104	WHITE
105	WHITE
106	BLACK OR AFRICAN AMERICAN
107	WHITE
108	WHITE
109	WHITE
110	WHITE
111	WHITE
112	WHITE
113	WHITE
114	WHITE
115	WHITE
116	WHITE


```

117          WHITE
118          WHITE
119          WHITE
120          WHITE
121          WHITE
122          WHITE
123          WHITE
124          WHITE
125          WHITE
126          WHITE
127          WHITE
128          WHITE
129          WHITE
130          WHITE
131          WHITE
132          WHITE
133          WHITE
134          WHITE
135          WHITE
136          WHITE
137          WHITE
138          WHITE
139          WHITE
140          WHITE
141 BLACK OR AFRICAN AMERICAN

```

There is another inline operator which can be very useful within the filter function; `%in%`. With this operator, we can select rows based on a prespecified vector of values. This can be useful if there are specified values (e.g., specific USUBJID) which we would like to look at.

```

# we save 4 USUBJID's in a vector:
lookup_ids <- c("01-716-1151", "01-710-1443", "01-708-1184", "01-705-1186")

# and then create a logical vector which returns TRUE for every entry in the
# USUBJID vector which are represented in the lookup_ids, and else FALSE
adsl$USUBJID %in% lookup_ids

```

```

[1] FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
[13] FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
[25] FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
[37] FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE

```

```

[49] FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
[61] FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
[73] FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
[85] FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
[97] FALSE FALSE FALSE FALSE FALSE FALSE TRUE FALSE FALSE FALSE FALSE FALSE
[109] FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
[121] FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
[133] FALSE FALSE FALSE FALSE TRUE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
[145] FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
[157] FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
[169] FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
[181] FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
[193] FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
[205] FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
[217] FALSE TRUE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
[229] FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
[241] FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
[253] FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
[265] FALSE FALSE FALSE FALSE TRUE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
[277] FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
[289] FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
[301] FALSE FALSE FALSE FALSE FALSE FALSE

```

```

# this approach can be used in the filter function:
adsl %>%
  select(STUDYID, USUBJID, ARM, AGE, SEX, RACE) %>%
  filter(USUBJID %in% lookup_ids)

```

	STUDYID	USUBJID	ARM	AGE	SEX	RACE
1	CDISCPILLOT01	01-705-1186	Placebo	84	F	WHITE
2	CDISCPILLOT01	01-708-1184	Screen Failure	70	F	WHITE
3	CDISCPILLOT01	01-710-1443	Screen Failure	88	F	WHITE
4	CDISCPILLOT01	01-716-1151	Xanomeline Low Dose	83	F	WHITE

Note that within the `filter` function (and in all major `dplyr` functions) R looks for the requested variables first within the supplied data-frame and afterwards in the global environment.

4.2.3 arrange

We can sort the dataframe with the `arrange()` function. It allows the sorting based on multiple variables. Note that the order of arranging variables determines the sorting hierarchy, so in this example we first order by `AGE` and

```
adsl %>%
  select(STUDYID, USUBJID, ARM, AGE, SEX, RACE) %>%
  filter(AGE >= 70,
         SEX == "F") %>%
  arrange(ARM, AGE)
```

	STUDYID	USUBJID	ARM	AGE	SEX
1	CDISCPIL0T01	01-705-1282	Placebo	70	F
2	CDISCPIL0T01	01-704-1260	Placebo	71	F
3	CDISCPIL0T01	01-703-1210	Placebo	72	F
4	CDISCPIL0T01	01-716-1026	Placebo	73	F
5	CDISCPIL0T01	01-718-1150	Placebo	73	F
6	CDISCPIL0T01	01-708-1087	Placebo	74	F
7	CDISCPIL0T01	01-708-1316	Placebo	74	F
8	CDISCPIL0T01	01-709-1001	Placebo	76	F
9	CDISCPIL0T01	01-710-1077	Placebo	76	F
10	CDISCPIL0T01	01-715-1397	Placebo	76	F
11	CDISCPIL0T01	01-716-1308	Placebo	76	F
12	CDISCPIL0T01	01-708-1171	Placebo	77	F
13	CDISCPIL0T01	01-710-1314	Placebo	78	F
14	CDISCPIL0T01	01-714-1375	Placebo	78	F
15	CDISCPIL0T01	01-715-1207	Placebo	78	F
16	CDISCPIL0T01	01-701-1153	Placebo	79	F
17	CDISCPIL0T01	01-708-1286	Placebo	80	F
18	CDISCPIL0T01	01-710-1183	Placebo	80	F
19	CDISCPIL0T01	01-701-1203	Placebo	81	F
20	CDISCPIL0T01	01-701-1363	Placebo	81	F
21	CDISCPIL0T01	01-703-1096	Placebo	81	F
22	CDISCPIL0T01	01-703-1299	Placebo	81	F
23	CDISCPIL0T01	01-708-1158	Placebo	81	F
24	CDISCPIL0T01	01-710-1078	Placebo	81	F
25	CDISCPIL0T01	01-710-1315	Placebo	83	F
26	CDISCPIL0T01	01-716-1160	Placebo	83	F
27	CDISCPIL0T01	01-703-1100	Placebo	84	F
28	CDISCPIL0T01	01-704-1127	Placebo	84	F
29	CDISCPIL0T01	01-705-1186	Placebo	84	F

30	CDISCPIL0T01	01-701-1047	Placebo	85	F
31	CDISCPIL0T01	01-717-1201	Placebo	85	F
32	CDISCPIL0T01	01-705-1349	Placebo	86	F
33	CDISCPIL0T01	01-710-1271	Placebo	86	F
34	CDISCPIL0T01	01-716-1108	Placebo	86	F
35	CDISCPIL0T01	01-701-1387	Placebo	87	F
36	CDISCPIL0T01	01-704-1233	Placebo	87	F
37	CDISCPIL0T01	01-716-1024	Placebo	87	F
38	CDISCPIL0T01	01-710-1368	Placebo	88	F
39	CDISCPIL0T01	01-714-1035	Placebo	88	F
40	CDISCPIL0T01	01-710-1083	Placebo	89	F
41	CDISCPIL0T01	01-705-1243	Screen Failure	70	F
42	CDISCPIL0T01	01-708-1184	Screen Failure	70	F
43	CDISCPIL0T01	01-707-1276	Screen Failure	72	F
44	CDISCPIL0T01	01-716-1244	Screen Failure	72	F
45	CDISCPIL0T01	01-708-1054	Screen Failure	73	F
46	CDISCPIL0T01	01-715-1407	Screen Failure	73	F
47	CDISCPIL0T01	01-716-1305	Screen Failure	73	F
48	CDISCPIL0T01	01-711-1163	Screen Failure	74	F
49	CDISCPIL0T01	01-711-1226	Screen Failure	74	F
50	CDISCPIL0T01	01-705-1011	Screen Failure	75	F
51	CDISCPIL0T01	01-711-1283	Screen Failure	75	F
52	CDISCPIL0T01	01-715-1333	Screen Failure	75	F
53	CDISCPIL0T01	01-707-1434	Screen Failure	76	F
54	CDISCPIL0T01	01-711-1284	Screen Failure	77	F
55	CDISCPIL0T01	01-715-1225	Screen Failure	77	F
56	CDISCPIL0T01	01-708-1104	Screen Failure	78	F
57	CDISCPIL0T01	01-710-1149	Screen Failure	79	F
58	CDISCPIL0T01	01-701-1307	Screen Failure	80	F
59	CDISCPIL0T01	01-710-1380	Screen Failure	80	F
60	CDISCPIL0T01	01-707-1430	Screen Failure	81	F
61	CDISCPIL0T01	01-701-1162	Screen Failure	82	F
62	CDISCPIL0T01	01-710-1257	Screen Failure	85	F
63	CDISCPIL0T01	01-711-1022	Screen Failure	86	F
64	CDISCPIL0T01	01-708-1352	Screen Failure	87	F
65	CDISCPIL0T01	01-709-1237	Screen Failure	88	F
66	CDISCPIL0T01	01-710-1443	Screen Failure	88	F
67	CDISCPIL0T01	01-710-1376	Screen Failure	89	F
68	CDISCPIL0T01	01-708-1406	Xanomeline High Dose	71	F
69	CDISCPIL0T01	01-701-1383	Xanomeline High Dose	72	F
70	CDISCPIL0T01	01-709-1168	Xanomeline High Dose	72	F
71	CDISCPIL0T01	01-716-1447	Xanomeline High Dose	72	F
72	CDISCPIL0T01	01-705-1281	Xanomeline High Dose	73	F

73	CDISCPILLOT01	01-716-1229	Xanomeline	High Dose	73	F
74	CDISCPILLOT01	01-705-1310	Xanomeline	High Dose	74	F
75	CDISCPILLOT01	01-718-1427	Xanomeline	High Dose	74	F
76	CDISCPILLOT01	01-701-1146	Xanomeline	High Dose	75	F
77	CDISCPILLOT01	01-715-1321	Xanomeline	High Dose	75	F
78	CDISCPILLOT01	01-703-1439	Xanomeline	High Dose	76	F
79	CDISCPILLOT01	01-704-1008	Xanomeline	High Dose	76	F
80	CDISCPILLOT01	01-708-1213	Xanomeline	High Dose	76	F
81	CDISCPILLOT01	01-710-1142	Xanomeline	High Dose	76	F
82	CDISCPILLOT01	01-701-1034	Xanomeline	High Dose	77	F
83	CDISCPILLOT01	01-708-1178	Xanomeline	High Dose	77	F
84	CDISCPILLOT01	01-713-1209	Xanomeline	High Dose	77	F
85	CDISCPILLOT01	01-703-1258	Xanomeline	High Dose	78	F
86	CDISCPILLOT01	01-710-1187	Xanomeline	High Dose	78	F
87	CDISCPILLOT01	01-716-1071	Xanomeline	High Dose	78	F
88	CDISCPILLOT01	01-701-1181	Xanomeline	High Dose	79	F
89	CDISCPILLOT01	01-709-1099	Xanomeline	High Dose	79	F
90	CDISCPILLOT01	01-710-1137	Xanomeline	High Dose	79	F
91	CDISCPILLOT01	01-704-1074	Xanomeline	High Dose	80	F
92	CDISCPILLOT01	01-716-1418	Xanomeline	High Dose	80	F
93	CDISCPILLOT01	01-701-1133	Xanomeline	High Dose	81	F
94	CDISCPILLOT01	01-716-1030	Xanomeline	High Dose	83	F
95	CDISCPILLOT01	01-711-1433	Xanomeline	High Dose	84	F
96	CDISCPILLOT01	01-716-1364	Xanomeline	High Dose	84	F
97	CDISCPILLOT01	01-710-1070	Xanomeline	High Dose	85	F
98	CDISCPILLOT01	01-708-1236	Xanomeline	High Dose	86	F
99	CDISCPILLOT01	01-703-1295	Xanomeline	High Dose	88	F
100	CDISCPILLOT01	01-704-1120	Xanomeline	Low Dose	71	F
101	CDISCPILLOT01	01-709-1102	Xanomeline	Low Dose	71	F
102	CDISCPILLOT01	01-713-1448	Xanomeline	Low Dose	71	F
103	CDISCPILLOT01	01-703-1279	Xanomeline	Low Dose	72	F
104	CDISCPILLOT01	01-707-1037	Xanomeline	Low Dose	72	F
105	CDISCPILLOT01	01-709-1020	Xanomeline	Low Dose	72	F
106	CDISCPILLOT01	01-708-1084	Xanomeline	Low Dose	73	F
107	CDISCPILLOT01	01-704-1135	Xanomeline	Low Dose	74	F
108	CDISCPILLOT01	01-706-1384	Xanomeline	Low Dose	74	F
109	CDISCPILLOT01	01-713-1073	Xanomeline	Low Dose	74	F
110	CDISCPILLOT01	01-709-1326	Xanomeline	Low Dose	75	F
111	CDISCPILLOT01	01-717-1446	Xanomeline	Low Dose	75	F
112	CDISCPILLOT01	01-701-1211	Xanomeline	Low Dose	76	F
113	CDISCPILLOT01	01-703-1197	Xanomeline	Low Dose	76	F
114	CDISCPILLOT01	01-711-1143	Xanomeline	Low Dose	76	F
115	CDISCPILLOT01	01-716-1298	Xanomeline	Low Dose	76	F

116	CDISCPILLOT01	01-715-1085	Xanomeline	Low Dose	77	F
117	CDISCPILLOT01	01-710-1300	Xanomeline	Low Dose	78	F
118	CDISCPILLOT01	01-713-1043	Xanomeline	Low Dose	78	F
119	CDISCPILLOT01	01-708-1348	Xanomeline	Low Dose	79	F
120	CDISCPILLOT01	01-714-1068	Xanomeline	Low Dose	79	F
121	CDISCPILLOT01	01-718-1066	Xanomeline	Low Dose	79	F
122	CDISCPILLOT01	01-701-1192	Xanomeline	Low Dose	80	F
123	CDISCPILLOT01	01-717-1004	Xanomeline	Low Dose	80	F
124	CDISCPILLOT01	01-718-1170	Xanomeline	Low Dose	80	F
125	CDISCPILLOT01	01-701-1111	Xanomeline	Low Dose	81	F
126	CDISCPILLOT01	01-703-1119	Xanomeline	Low Dose	81	F
127	CDISCPILLOT01	01-703-1379	Xanomeline	Low Dose	81	F
128	CDISCPILLOT01	01-704-1025	Xanomeline	Low Dose	81	F
129	CDISCPILLOT01	01-704-1218	Xanomeline	Low Dose	81	F
130	CDISCPILLOT01	01-710-1166	Xanomeline	Low Dose	81	F
131	CDISCPILLOT01	01-718-1250	Xanomeline	Low Dose	82	F
132	CDISCPILLOT01	01-710-1045	Xanomeline	Low Dose	83	F
133	CDISCPILLOT01	01-710-1270	Xanomeline	Low Dose	83	F
134	CDISCPILLOT01	01-716-1151	Xanomeline	Low Dose	83	F
135	CDISCPILLOT01	01-701-1429	Xanomeline	Low Dose	84	F
136	CDISCPILLOT01	01-702-1082	Xanomeline	Low Dose	84	F
137	CDISCPILLOT01	01-705-1393	Xanomeline	Low Dose	84	F
138	CDISCPILLOT01	01-708-1428	Xanomeline	Low Dose	84	F
139	CDISCPILLOT01	01-710-1053	Xanomeline	Low Dose	84	F
140	CDISCPILLOT01	01-709-1081	Xanomeline	Low Dose	86	F
141	CDISCPILLOT01	01-708-1353	Xanomeline	Low Dose	87	F

RACE

1	BLACK OR AFRICAN AMERICAN
2	WHITE
3	WHITE
4	WHITE
5	WHITE
6	WHITE
7	WHITE
8	WHITE
9	WHITE
10	WHITE
11	WHITE
12	WHITE
13	WHITE
14	WHITE
15	WHITE
16	WHITE

17	BLACK OR AFRICAN AMERICAN
18	WHITE
19	BLACK OR AFRICAN AMERICAN
20	BLACK OR AFRICAN AMERICAN
21	WHITE
22	WHITE
23	WHITE
24	WHITE
25	WHITE
26	WHITE
27	WHITE
28	WHITE
29	WHITE
30	WHITE
31	WHITE
32	WHITE
33	WHITE
34	WHITE
35	WHITE
36	WHITE
37	WHITE
38	WHITE
39	WHITE
40	WHITE
41	WHITE
42	WHITE
43	WHITE
44	WHITE
45	BLACK OR AFRICAN AMERICAN
46	WHITE
47	WHITE
48	BLACK OR AFRICAN AMERICAN
49	WHITE
50	WHITE
51	BLACK OR AFRICAN AMERICAN
52	WHITE
53	WHITE
54	WHITE
55	WHITE
56	ASIAN
57	WHITE
58	WHITE
59	WHITE

60	WHITE
61	WHITE
62	WHITE
63	WHITE
64	WHITE
65	WHITE
66	WHITE
67	WHITE
68	WHITE
69	WHITE
70	WHITE
71	WHITE
72	BLACK OR AFRICAN AMERICAN
73	WHITE
74	WHITE
75	BLACK OR AFRICAN AMERICAN
76	WHITE
77	WHITE
78	WHITE
79	WHITE
80	WHITE
81	WHITE
82	WHITE
83	BLACK OR AFRICAN AMERICAN
84	WHITE
85	WHITE
86	WHITE
87	WHITE
88	WHITE
89	WHITE
90	BLACK OR AFRICAN AMERICAN
91	WHITE
92	WHITE
93	WHITE
94	WHITE
95	WHITE
96	WHITE
97	WHITE
98	WHITE
99	WHITE
100	WHITE
101	WHITE
102	WHITE

103	WHITE
104	WHITE
105	WHITE
106	WHITE
107	WHITE
108	WHITE
109	BLACK OR AFRICAN AMERICAN
110	WHITE
111	WHITE
112	WHITE
113	BLACK OR AFRICAN AMERICAN
114	WHITE
115	WHITE
116	WHITE
117	WHITE
118	WHITE
119	WHITE
120	WHITE
121	WHITE
122	WHITE
123	WHITE
124	WHITE
125	WHITE
126	WHITE
127	BLACK OR AFRICAN AMERICAN
128	WHITE
129	WHITE
130	WHITE
131	WHITE
132	WHITE
133	WHITE
134	WHITE
135	WHITE
136	WHITE
137	WHITE
138	WHITE
139	WHITE
140	WHITE
141	BLACK OR AFRICAN AMERICAN

To sort by descending order, we can use the helper function `desc()` within `arrange()`:

```

adsl %>%
  select(STUDYID, USUBJID, ARM, AGE, SEX, RACE) %>%
  filter(AGE >= 70,
         SEX == "F") %>%
  arrange(ARM, desc(AGE))

```

	STUDYID	USUBJID	ARM	AGE	SEX
1	CDISCPIL0T01	01-710-1083	Placebo	89	F
2	CDISCPIL0T01	01-710-1368	Placebo	88	F
3	CDISCPIL0T01	01-714-1035	Placebo	88	F
4	CDISCPIL0T01	01-701-1387	Placebo	87	F
5	CDISCPIL0T01	01-704-1233	Placebo	87	F
6	CDISCPIL0T01	01-716-1024	Placebo	87	F
7	CDISCPIL0T01	01-705-1349	Placebo	86	F
8	CDISCPIL0T01	01-710-1271	Placebo	86	F
9	CDISCPIL0T01	01-716-1108	Placebo	86	F
10	CDISCPIL0T01	01-701-1047	Placebo	85	F
11	CDISCPIL0T01	01-717-1201	Placebo	85	F
12	CDISCPIL0T01	01-703-1100	Placebo	84	F
13	CDISCPIL0T01	01-704-1127	Placebo	84	F
14	CDISCPIL0T01	01-705-1186	Placebo	84	F
15	CDISCPIL0T01	01-710-1315	Placebo	83	F
16	CDISCPIL0T01	01-716-1160	Placebo	83	F
17	CDISCPIL0T01	01-701-1203	Placebo	81	F
18	CDISCPIL0T01	01-701-1363	Placebo	81	F
19	CDISCPIL0T01	01-703-1096	Placebo	81	F
20	CDISCPIL0T01	01-703-1299	Placebo	81	F
21	CDISCPIL0T01	01-708-1158	Placebo	81	F
22	CDISCPIL0T01	01-710-1078	Placebo	81	F
23	CDISCPIL0T01	01-708-1286	Placebo	80	F
24	CDISCPIL0T01	01-710-1183	Placebo	80	F
25	CDISCPIL0T01	01-701-1153	Placebo	79	F
26	CDISCPIL0T01	01-710-1314	Placebo	78	F
27	CDISCPIL0T01	01-714-1375	Placebo	78	F
28	CDISCPIL0T01	01-715-1207	Placebo	78	F
29	CDISCPIL0T01	01-708-1171	Placebo	77	F
30	CDISCPIL0T01	01-709-1001	Placebo	76	F
31	CDISCPIL0T01	01-710-1077	Placebo	76	F
32	CDISCPIL0T01	01-715-1397	Placebo	76	F
33	CDISCPIL0T01	01-716-1308	Placebo	76	F
34	CDISCPIL0T01	01-708-1087	Placebo	74	F
35	CDISCPIL0T01	01-708-1316	Placebo	74	F

36	CDISCPIL0T01	01-716-1026	Placebo	73	F
37	CDISCPIL0T01	01-718-1150	Placebo	73	F
38	CDISCPIL0T01	01-703-1210	Placebo	72	F
39	CDISCPIL0T01	01-704-1260	Placebo	71	F
40	CDISCPIL0T01	01-705-1282	Placebo	70	F
41	CDISCPIL0T01	01-710-1376	Screen Failure	89	F
42	CDISCPIL0T01	01-709-1237	Screen Failure	88	F
43	CDISCPIL0T01	01-710-1443	Screen Failure	88	F
44	CDISCPIL0T01	01-708-1352	Screen Failure	87	F
45	CDISCPIL0T01	01-711-1022	Screen Failure	86	F
46	CDISCPIL0T01	01-710-1257	Screen Failure	85	F
47	CDISCPIL0T01	01-701-1162	Screen Failure	82	F
48	CDISCPIL0T01	01-707-1430	Screen Failure	81	F
49	CDISCPIL0T01	01-701-1307	Screen Failure	80	F
50	CDISCPIL0T01	01-710-1380	Screen Failure	80	F
51	CDISCPIL0T01	01-710-1149	Screen Failure	79	F
52	CDISCPIL0T01	01-708-1104	Screen Failure	78	F
53	CDISCPIL0T01	01-711-1284	Screen Failure	77	F
54	CDISCPIL0T01	01-715-1225	Screen Failure	77	F
55	CDISCPIL0T01	01-707-1434	Screen Failure	76	F
56	CDISCPIL0T01	01-705-1011	Screen Failure	75	F
57	CDISCPIL0T01	01-711-1283	Screen Failure	75	F
58	CDISCPIL0T01	01-715-1333	Screen Failure	75	F
59	CDISCPIL0T01	01-711-1163	Screen Failure	74	F
60	CDISCPIL0T01	01-711-1226	Screen Failure	74	F
61	CDISCPIL0T01	01-708-1054	Screen Failure	73	F
62	CDISCPIL0T01	01-715-1407	Screen Failure	73	F
63	CDISCPIL0T01	01-716-1305	Screen Failure	73	F
64	CDISCPIL0T01	01-707-1276	Screen Failure	72	F
65	CDISCPIL0T01	01-716-1244	Screen Failure	72	F
66	CDISCPIL0T01	01-705-1243	Screen Failure	70	F
67	CDISCPIL0T01	01-708-1184	Screen Failure	70	F
68	CDISCPIL0T01	01-703-1295	Xanomeline High Dose	88	F
69	CDISCPIL0T01	01-708-1236	Xanomeline High Dose	86	F
70	CDISCPIL0T01	01-710-1070	Xanomeline High Dose	85	F
71	CDISCPIL0T01	01-711-1433	Xanomeline High Dose	84	F
72	CDISCPIL0T01	01-716-1364	Xanomeline High Dose	84	F
73	CDISCPIL0T01	01-716-1030	Xanomeline High Dose	83	F
74	CDISCPIL0T01	01-701-1133	Xanomeline High Dose	81	F
75	CDISCPIL0T01	01-704-1074	Xanomeline High Dose	80	F
76	CDISCPIL0T01	01-716-1418	Xanomeline High Dose	80	F
77	CDISCPIL0T01	01-701-1181	Xanomeline High Dose	79	F
78	CDISCPIL0T01	01-709-1099	Xanomeline High Dose	79	F

79	CDISCPILLOT01	01-710-1137	Xanomeline	High Dose	79	F
80	CDISCPILLOT01	01-703-1258	Xanomeline	High Dose	78	F
81	CDISCPILLOT01	01-710-1187	Xanomeline	High Dose	78	F
82	CDISCPILLOT01	01-716-1071	Xanomeline	High Dose	78	F
83	CDISCPILLOT01	01-701-1034	Xanomeline	High Dose	77	F
84	CDISCPILLOT01	01-708-1178	Xanomeline	High Dose	77	F
85	CDISCPILLOT01	01-713-1209	Xanomeline	High Dose	77	F
86	CDISCPILLOT01	01-703-1439	Xanomeline	High Dose	76	F
87	CDISCPILLOT01	01-704-1008	Xanomeline	High Dose	76	F
88	CDISCPILLOT01	01-708-1213	Xanomeline	High Dose	76	F
89	CDISCPILLOT01	01-710-1142	Xanomeline	High Dose	76	F
90	CDISCPILLOT01	01-701-1146	Xanomeline	High Dose	75	F
91	CDISCPILLOT01	01-715-1321	Xanomeline	High Dose	75	F
92	CDISCPILLOT01	01-705-1310	Xanomeline	High Dose	74	F
93	CDISCPILLOT01	01-718-1427	Xanomeline	High Dose	74	F
94	CDISCPILLOT01	01-705-1281	Xanomeline	High Dose	73	F
95	CDISCPILLOT01	01-716-1229	Xanomeline	High Dose	73	F
96	CDISCPILLOT01	01-701-1383	Xanomeline	High Dose	72	F
97	CDISCPILLOT01	01-709-1168	Xanomeline	High Dose	72	F
98	CDISCPILLOT01	01-716-1447	Xanomeline	High Dose	72	F
99	CDISCPILLOT01	01-708-1406	Xanomeline	High Dose	71	F
100	CDISCPILLOT01	01-708-1353	Xanomeline	Low Dose	87	F
101	CDISCPILLOT01	01-709-1081	Xanomeline	Low Dose	86	F
102	CDISCPILLOT01	01-701-1429	Xanomeline	Low Dose	84	F
103	CDISCPILLOT01	01-702-1082	Xanomeline	Low Dose	84	F
104	CDISCPILLOT01	01-705-1393	Xanomeline	Low Dose	84	F
105	CDISCPILLOT01	01-708-1428	Xanomeline	Low Dose	84	F
106	CDISCPILLOT01	01-710-1053	Xanomeline	Low Dose	84	F
107	CDISCPILLOT01	01-710-1045	Xanomeline	Low Dose	83	F
108	CDISCPILLOT01	01-710-1270	Xanomeline	Low Dose	83	F
109	CDISCPILLOT01	01-716-1151	Xanomeline	Low Dose	83	F
110	CDISCPILLOT01	01-718-1250	Xanomeline	Low Dose	82	F
111	CDISCPILLOT01	01-701-1111	Xanomeline	Low Dose	81	F
112	CDISCPILLOT01	01-703-1119	Xanomeline	Low Dose	81	F
113	CDISCPILLOT01	01-703-1379	Xanomeline	Low Dose	81	F
114	CDISCPILLOT01	01-704-1025	Xanomeline	Low Dose	81	F
115	CDISCPILLOT01	01-704-1218	Xanomeline	Low Dose	81	F
116	CDISCPILLOT01	01-710-1166	Xanomeline	Low Dose	81	F
117	CDISCPILLOT01	01-701-1192	Xanomeline	Low Dose	80	F
118	CDISCPILLOT01	01-717-1004	Xanomeline	Low Dose	80	F
119	CDISCPILLOT01	01-718-1170	Xanomeline	Low Dose	80	F
120	CDISCPILLOT01	01-708-1348	Xanomeline	Low Dose	79	F
121	CDISCPILLOT01	01-714-1068	Xanomeline	Low Dose	79	F

122	CDISCPILLOT01	01-718-1066	Xanomeline	Low Dose	79	F
123	CDISCPILLOT01	01-710-1300	Xanomeline	Low Dose	78	F
124	CDISCPILLOT01	01-713-1043	Xanomeline	Low Dose	78	F
125	CDISCPILLOT01	01-715-1085	Xanomeline	Low Dose	77	F
126	CDISCPILLOT01	01-701-1211	Xanomeline	Low Dose	76	F
127	CDISCPILLOT01	01-703-1197	Xanomeline	Low Dose	76	F
128	CDISCPILLOT01	01-711-1143	Xanomeline	Low Dose	76	F
129	CDISCPILLOT01	01-716-1298	Xanomeline	Low Dose	76	F
130	CDISCPILLOT01	01-709-1326	Xanomeline	Low Dose	75	F
131	CDISCPILLOT01	01-717-1446	Xanomeline	Low Dose	75	F
132	CDISCPILLOT01	01-704-1135	Xanomeline	Low Dose	74	F
133	CDISCPILLOT01	01-706-1384	Xanomeline	Low Dose	74	F
134	CDISCPILLOT01	01-713-1073	Xanomeline	Low Dose	74	F
135	CDISCPILLOT01	01-708-1084	Xanomeline	Low Dose	73	F
136	CDISCPILLOT01	01-703-1279	Xanomeline	Low Dose	72	F
137	CDISCPILLOT01	01-707-1037	Xanomeline	Low Dose	72	F
138	CDISCPILLOT01	01-709-1020	Xanomeline	Low Dose	72	F
139	CDISCPILLOT01	01-704-1120	Xanomeline	Low Dose	71	F
140	CDISCPILLOT01	01-709-1102	Xanomeline	Low Dose	71	F
141	CDISCPILLOT01	01-713-1448	Xanomeline	Low Dose	71	F

RACE

1	WHITE
2	WHITE
3	WHITE
4	WHITE
5	WHITE
6	WHITE
7	WHITE
8	WHITE
9	WHITE
10	WHITE
11	WHITE
12	WHITE
13	WHITE
14	WHITE
15	WHITE
16	WHITE
17	BLACK OR AFRICAN AMERICAN
18	BLACK OR AFRICAN AMERICAN
19	WHITE
20	WHITE
21	WHITE
22	WHITE

23	BLACK OR AFRICAN AMERICAN
24	WHITE
25	WHITE
26	WHITE
27	WHITE
28	WHITE
29	WHITE
30	WHITE
31	WHITE
32	WHITE
33	WHITE
34	WHITE
35	WHITE
36	WHITE
37	WHITE
38	WHITE
39	WHITE
40	BLACK OR AFRICAN AMERICAN
41	WHITE
42	WHITE
43	WHITE
44	WHITE
45	WHITE
46	WHITE
47	WHITE
48	WHITE
49	WHITE
50	WHITE
51	WHITE
52	ASIAN
53	WHITE
54	WHITE
55	WHITE
56	WHITE
57	BLACK OR AFRICAN AMERICAN
58	WHITE
59	BLACK OR AFRICAN AMERICAN
60	WHITE
61	BLACK OR AFRICAN AMERICAN
62	WHITE
63	WHITE
64	WHITE
65	WHITE

66	WHITE
67	WHITE
68	WHITE
69	WHITE
70	WHITE
71	WHITE
72	WHITE
73	WHITE
74	WHITE
75	WHITE
76	WHITE
77	WHITE
78	WHITE
79	BLACK OR AFRICAN AMERICAN
80	WHITE
81	WHITE
82	WHITE
83	WHITE
84	BLACK OR AFRICAN AMERICAN
85	WHITE
86	WHITE
87	WHITE
88	WHITE
89	WHITE
90	WHITE
91	WHITE
92	WHITE
93	BLACK OR AFRICAN AMERICAN
94	BLACK OR AFRICAN AMERICAN
95	WHITE
96	WHITE
97	WHITE
98	WHITE
99	WHITE
100	BLACK OR AFRICAN AMERICAN
101	WHITE
102	WHITE
103	WHITE
104	WHITE
105	WHITE
106	WHITE
107	WHITE
108	WHITE

109	WHITE
110	WHITE
111	WHITE
112	WHITE
113	BLACK OR AFRICAN AMERICAN
114	WHITE
115	WHITE
116	WHITE
117	WHITE
118	WHITE
119	WHITE
120	WHITE
121	WHITE
122	WHITE
123	WHITE
124	WHITE
125	WHITE
126	WHITE
127	BLACK OR AFRICAN AMERICAN
128	WHITE
129	WHITE
130	WHITE
131	WHITE
132	WHITE
133	WHITE
134	BLACK OR AFRICAN AMERICAN
135	WHITE
136	WHITE
137	WHITE
138	WHITE
139	WHITE
140	WHITE
141	WHITE

5 dplyr exercises

Stefan Thoma

```
library("tidyverse")

-- Attaching packages ----- tidyverse 1.3.2 --
v ggplot2 3.3.6      v purrr   0.3.5
v tibble  3.1.8      v dplyr  1.0.10
v tidyr   1.2.1      v stringr 1.4.1
v readr   2.1.3      v forcats 0.5.2
-- Conflicts ----- tidyverse_conflicts() --
x dplyr::filter() masks stats::filter()
x dplyr::lag()    masks stats::lag()

# load data
ads1 <- haven::read_sas("data/ads1.sas7bdat") %>%
  mutate_if(is_character, na_if, "")
```

5.1 Data wrangling with dplyr

Load the `ads1` data-frame and select the following variables:

- USUBJID
- ARM
- SEX
- AGE
- AGEU
- AGEGR1

- COUNTRY
- EOSSTT

```
# we use starts_with("AGE") because we want to include every AGE variable that is in the o
adsl %>%
```

```
  select(USUBJID, ARM, SEX, starts_with("AGE"), COUNTRY, EOSSTT)
```

```
# A tibble: 306 x 8
```

	USUBJID	ARM	SEX	AGE	AGEU	AGEGR1	COUNTRY	EOSSTT
	<chr>	<chr>	<chr>	<dbl>	<chr>	<dbl>	<chr>	<chr>
1	01-701-1015	Placebo	F	63	YEARS	2	USA	COMPLETED
2	01-701-1023	Placebo	M	64	YEARS	2	USA	DISCONTINU~
3	01-701-1028	Xanomeline High Dose	M	71	YEARS	3	USA	COMPLETED
4	01-701-1033	Xanomeline Low Dose	M	74	YEARS	3	USA	DISCONTINU~
5	01-701-1034	Xanomeline High Dose	F	77	YEARS	3	USA	COMPLETED
6	01-701-1047	Placebo	F	85	YEARS	3	USA	DISCONTINU~
7	01-701-1057	Screen Failure	F	59	YEARS	2	USA	<NA>
8	01-701-1097	Xanomeline Low Dose	M	68	YEARS	3	USA	COMPLETED
9	01-701-1111	Xanomeline Low Dose	F	81	YEARS	3	USA	DISCONTINU~
10	01-701-1115	Xanomeline Low Dose	M	84	YEARS	3	USA	DISCONTINU~

```
# ... with 296 more rows
```

On the selected variables, include only patients in the placebo arm who are 66, 77, 88, or 99 years old.

```
# There are different ways to solve this. The best way to filter the AGE is to create a ve
```

```
age_vec <- c(66, 77, 88, 99)
```

```
# or
```

```
age_vec <- 6:9 * 11
```

```
# we can then use either the age_vec or the code that created the age_vec directly as a st
```

```
adsl %>%
```

```
  select(USUBJID, SEX, ARM, EOSSTT, starts_with("AGE")) %>%
```

```
  filter(ARM == "Placebo",
```

```
         AGE %in% c(66, 77, 88, 99))
```

```
# A tibble: 5 x 7
```

USUBJID	SEX	ARM	EOSSTT	AGE	AGEU	AGEGR1
<chr>	<chr>	<chr>	<chr>	<dbl>	<chr>	<dbl>

1	01-705-1059	F	Placebo	DISCONTINUED	66 YEARS	3
2	01-708-1171	F	Placebo	COMPLETED	77 YEARS	3
3	01-710-1368	F	Placebo	COMPLETED	88 YEARS	3
4	01-714-1035	F	Placebo	COMPLETED	88 YEARS	3
5	01-718-1139	M	Placebo	COMPLETED	77 YEARS	3

Further include the variable TRTSDTM (datetime of first exposure to treatment) and sort the previous data-frame according to this variable from most recent to least recent first exposure.

```
adsl %>%
  select(USUBJID, SEX, ARM, EOSSTT, starts_with("AGE"), TRTSDTM) %>%
  filter(ARM == "Placebo",
         AGE %in% c(66, 77, 88, 99)) %>%
  arrange(desc(TRTSDTM))
```

```
# A tibble: 5 x 8
  USUBJID    SEX  ARM    EOSSTT      AGE AGEU  AGEGR1 TRTSDTM
  <chr>    <chr> <chr>   <chr>    <dbl> <chr>  <dbl>  <dtm>
1 01-714-1035 F    Placebo COMPLETED    88 YEARS      3 2014-04-17 00:00:00
2 01-710-1368 F    Placebo COMPLETED    88 YEARS      3 2013-10-23 00:00:00
3 01-705-1059 F    Placebo DISCONTINUED    66 YEARS      3 2013-08-05 00:00:00
4 01-718-1139 M    Placebo COMPLETED    77 YEARS      3 2013-05-19 00:00:00
5 01-708-1171 F    Placebo COMPLETED    77 YEARS      3 2012-12-06 00:00:00
```

Part III

mutate

6 mutate

Creating New Columns Using `mutate()`

Thomas

```
library(dplyr)
library(lubridate)
dm <- readRDS("data/dm.rds")
ae <- readRDS("data/ae.rds")
```

The equivalent of creating a new variables in SAS inside a `data` step is to use the `mutate()` function. In the simplest case a static value is assigned to the new column.

```
adsl <- dm %>% mutate(DATASET = "ADSL")
```

This will set the value of the new variable `DATASET` to "ADSL" for all records.

```
adsl %>% select(DATASET)
```

```
  DATASET
  <chr>
1 ADSL
2 ADSL
3 ADSL
4 ADSL
5 ADSL
6 ADSL
7 ADSL
8 ADSL
9 ADSL
10 ADSL
# ... with 296 more rows
```

Note that new variables are always appended after existing columns such that `DATASET` is now the last column of `adsl`.

```
colnames(adsl)
```

```
[1] "STUDYID" "DOMAIN" "USUBJID" "SUBJID" "RFSTDTC" "RFENDTC"
[7] "RFXSTDTC" "RFXENDTC" "RFICDTC" "RFPENDTC" "DTHDTC" "DTHFL"
[13] "SITEID" "AGE" "AGEU" "SEX" "RACE" "ETHNIC"
[19] "ARMCD" "ARM" "ACTARMCD" "ACTARM" "COUNTRY" "DMDTC"
[25] "DMDY" "DATASET"
```

Assigning the value of an existing column to a new column is the same as in SAS. The new column name goes to the left of `=` and the existing column to the right.

```
adsl <- adsl %>% mutate(TRT01P = ARM)
adsl %>% select(ARM, TRT01P)
```

```
# A tibble: 306 x 2
  ARM          TRT01P
<chr>        <chr>
1 Placebo     Placebo
2 Placebo     Placebo
3 Xanomeline High Dose Xanomeline High Dose
4 Xanomeline Low Dose  Xanomeline Low Dose
5 Xanomeline High Dose Xanomeline High Dose
6 Placebo     Placebo
7 Screen Failure Screen Failure
8 Xanomeline Low Dose  Xanomeline Low Dose
9 Xanomeline Low Dose  Xanomeline Low Dose
10 Xanomeline Low Dose  Xanomeline Low Dose
# ... with 296 more rows
```

In most cases new variables are created by applying functions on existing variables to somehow transform them.

```
adsl <- adsl %>% mutate(RFSTDT = ymd(RFSTDTC))
```

You can create multiple new variables inside `mutate()` similar to how you would do it inside a `data` step.

```
adae <- ae %>% mutate(
  ASTDT = ymd(AESTDTC),
  ASTDY = ASTDT - TRTSDT + 1
)
adae %>% select(AESTDTC, ASTDT, TRTSDT, ASTDY)
```

```
# A tibble: 1,191 x 4
  AESTDTC    ASTDT    TRTSDT    ASTDY
  <chr>      <date>      <date>      <drtn>
1 2014-01-03 2014-01-03 2014-01-02 2 days
2 2014-01-03 2014-01-03 2014-01-02 2 days
3 2014-01-09 2014-01-09 2014-01-02 8 days
4 2012-08-26 2012-08-26 2012-08-05 22 days
5 2012-08-07 2012-08-07 2012-08-05 3 days
6 2012-08-07 2012-08-07 2012-08-05 3 days
7 2012-08-07 2012-08-07 2012-08-05 3 days
8 2013-07-21 2013-07-21 2013-07-19 3 days
9 2013-08-08 2013-08-08 2013-07-19 21 days
10 2014-08-27 2014-08-27 2014-07-01 58 days
# ... with 1,181 more rows
```

Just like in SAS you can use conditional logic to assign different values to a new variable depending on which value another variable has using `if_else()`.

```
adae %>%
  mutate(ASTDY = if_else(ASTDY <= TRTSDT, ASTDT - TRTSDT, ASTDT - TRTSDT + 1)) %>%
  select(USUBJID, TRTSDT, ASTDT, ASTDY)
```

```
# A tibble: 1,191 x 4
  USUBJID    TRTSDT    ASTDT    ASTDY
  <chr>      <date>      <date>      <drtn>
1 01-701-1015 2014-01-02 2014-01-03 2 days
2 01-701-1015 2014-01-02 2014-01-03 2 days
3 01-701-1015 2014-01-02 2014-01-09 8 days
4 01-701-1023 2012-08-05 2012-08-26 22 days
5 01-701-1023 2012-08-05 2012-08-07 3 days
6 01-701-1023 2012-08-05 2012-08-07 3 days
7 01-701-1023 2012-08-05 2012-08-07 3 days
8 01-701-1028 2013-07-19 2013-07-21 3 days
9 01-701-1028 2013-07-19 2013-08-08 21 days
10 01-701-1034 2014-07-01 2014-08-27 58 days
```

```
# ... with 1,181 more rows
```

At this point let's make a small excursion to cover how R handles missing values, i.e. NA, when using conditional logic. Unlike in SAS where missing numbers are the smallest possible values such that `. < 10` is true, in R any comparison involving NA returns NA as a result.

```
NA < 9
```

```
[1] NA
```

```
NA == 0
```

```
[1] NA
```

This is the same when using `if_else()`.

```
adsl$AGE[1] <- NA
adsl %>%
  mutate(AGEGR = if_else(AGE >= 65, "Elderly", "Adult")) %>%
  select(USUBJID, AGE, AGEGR)
```

```
# A tibble: 306 x 3
  USUBJID      AGE AGEGR
  <chr>      <int> <chr>
1 01-701-1015    NA <NA>
2 01-701-1023    64 Adult
3 01-701-1028    71 Elderly
4 01-701-1033    74 Elderly
5 01-701-1034    77 Elderly
6 01-701-1047    85 Elderly
7 01-701-1057    59 Adult
8 01-701-1097    68 Elderly
9 01-701-1111    81 Elderly
10 01-701-1115    84 Elderly
# ... with 296 more rows
```

To check whether a value is missing use the `is.na()` function.

```
is.na(NA)
```



```
[1] TRUE
```

```
is.na("NA")
```

```
[1] FALSE
```

Finally, it's noteworthy that there are actually different types of NAs in R. We'll make use of them next.

Table 6.1: Types of 'NA' in R

Type	Example	Missing Value
character	"Brazil"	NA_character_
double	2.51	NA_real_
integer	1L	NA_integer_
logical	FALSE	NA

If the logic is more complex than a simple `if_else()` then use `case_when()` instead.

```
adsl %>%  
  mutate(  
    AGEGR1 = case_when(  
      AGE < 18 ~ "<18",  
      AGE < 45 ~ "<45",  
      AGE < 65 ~ "<65",  
      TRUE ~ ">=65"  
    )  
  ) %>%  
  select(USUBJID, AGE, AGEGR1)
```

```
# A tibble: 306 x 3  
  USUBJID    AGE AGEGR1  
  <chr>    <int> <chr>  
1 01-701-1015    NA >=65  
2 01-701-1023    64 <65  
3 01-701-1028    71 >=65  
4 01-701-1033    74 >=65  
5 01-701-1034    77 >=65  
6 01-701-1047    85 >=65
```

```

7 01-701-1057    59 <65
8 01-701-1097    68 >=65
9 01-701-1111    81 >=65
10 01-701-1115   84 >=65
# ... with 296 more rows

```

The final condition `TRUE` is the is a catch all term and must be used with some caution. Notice what happened to the `AGE` of the first subject whose value we set to `NA` above.

To mitigate this you should either explicitly handle missing values as a separate condition or be explicit for all cases. The former would look something like this.

```

adsl %>%
  mutate(
    AGEGR1 = case_when(
      is.na(AGE) ~ NA_character_,
      AGE < 18 ~ "<18",
      AGE < 45 ~ "<45",
      AGE < 65 ~ "<65",
      TRUE ~ ">=65"
    )
  ) %>%
  select(USUBJID, AGE, AGEGR1)

```

```

# A tibble: 306 x 3
  USUBJID      AGE AGEGR1
  <chr>      <int> <chr>
1 01-701-1015     NA <NA>
2 01-701-1023     64 <65
3 01-701-1028     71 >=65
4 01-701-1033     74 >=65
5 01-701-1034     77 >=65
6 01-701-1047     85 >=65
7 01-701-1057     59 <65
8 01-701-1097     68 >=65
9 01-701-1111     81 >=65
10 01-701-1115    84 >=65
# ... with 296 more rows

```

And the latter like this.

```

ads1 %>%
  mutate(
    AGEGR1 = case_when(
      AGE < 18 ~ "<18",
      AGE < 45 ~ "<45",
      AGE < 65 ~ "<65",
      AGE >= 65 ~ ">=65"
    )
  ) %>%
  select(USUBJID, AGE, AGEGR1)

```

```

# A tibble: 306 x 3
  USUBJID      AGE AGEGR1
  <chr>      <int> <chr>
1 01-701-1015    NA <NA>
2 01-701-1023    64 <65
3 01-701-1028    71 >=65
4 01-701-1033    74 >=65
5 01-701-1034    77 >=65
6 01-701-1047    85 >=65
7 01-701-1057    59 <65
8 01-701-1097    68 >=65
9 01-701-1111    81 >=65
10 01-701-1115    84 >=65
# ... with 296 more rows

```

Finally, note that when a value does not match any of the conditions given which may be the case when not using a final TRUE then it is assigned NA.

```

ads1 %>%
  mutate(
    AGEGR1 = case_when(
      AGE < 18 ~ "<18",
      AGE < 45 ~ "<45",
      AGE < 65 ~ "<65"
    )
  ) %>%
  select(USUBJID, AGE, AGEGR1)

```

```

# A tibble: 306 x 3
  USUBJID      AGE AGEGR1

```

	<chr>	<int>	<chr>
1	01-701-1015	NA	<NA>
2	01-701-1023	64	<65
3	01-701-1028	71	<NA>
4	01-701-1033	74	<NA>
5	01-701-1034	77	<NA>
6	01-701-1047	85	<NA>
7	01-701-1057	59	<65
8	01-701-1097	68	<NA>
9	01-701-1111	81	<NA>
10	01-701-1115	84	<NA>

... with 296 more rows

7 mutate() Exercises

Thomas Neitmann

```
library(dplyr)
library(lubridate)
dm <- readRDS("data/dm.rds")
ae <- readRDS("data/ae.rds")
```

7.1 Exercise 1

A treatment emergent adverse event is defined as an adverse event whose start date is on or after the treatment start date (TRTSDT) and at the latest starts 7 days after the treatment end date (TRTEDT). Given this definition calculate TRTEMFL.

Hint: Turn the --DTC variables into proper dates first using the ymd() function.

```
ae %>%
  mutate(
    ASTDT = ymd(AESTDTC),
    AENDT = ymd(AEENDTC),
    TRTEMFL = if_else(ASTDT >= TRTSDT & ASTDT <= TRTEDT + 7, "Y", NA_character_)
  ) %>%
  select(USUBJID, ASTDT, AENDT, TRTSDT, TRTEDT, TRTEMFL)
```

Warning: 19 failed to parse.

```
# A tibble: 1,191 x 6
  USUBJID   ASTDT   AENDT   TRTSDT   TRTEDT   TRTEMFL
  <chr>     <date>   <date>   <date>   <date>   <chr>
1 01-701-1015 2014-01-03 NA      2014-01-02 2014-07-02 Y
2 01-701-1015 2014-01-03 NA      2014-01-02 2014-07-02 Y
```

```

3 01-701-1015 2014-01-09 2014-01-11 2014-01-02 2014-07-02 Y
4 01-701-1023 2012-08-26 NA          2012-08-05 2012-09-01 Y
5 01-701-1023 2012-08-07 2012-08-30 2012-08-05 2012-09-01 Y
6 01-701-1023 2012-08-07 NA          2012-08-05 2012-09-01 Y
7 01-701-1023 2012-08-07 2012-08-30 2012-08-05 2012-09-01 Y
8 01-701-1028 2013-07-21 NA          2013-07-19 2014-01-14 Y
9 01-701-1028 2013-08-08 NA          2013-07-19 2014-01-14 Y
10 01-701-1034 2014-08-27 NA          2014-07-01 2014-12-30 Y
# ... with 1,181 more rows

```

7.2 Exercise 2

Create a new variable `REGION1` based upon `COUNTRY` as shown in the table below.

Countries	Region
Mexico, USA, Canada	North America
Spain, Greece, Germany, Switzerland	Europe
China, Japan	Asia

```

dm %>%
  mutate(
    REGION1 = case_when(
      COUNTRY %in% c("Mexico", "USA", "Canada") ~ "North America",
      COUNTRY %in% c("Spain", "Greece", "Germany", "Switzerland") ~ "Europe",
      COUNTRY %in% c("China", "Japan") ~ "Asia"
    )
  ) %>%
  select(USUBJID, COUNTRY, REGION1)

```

```

# A tibble: 306 x 3
  USUBJID    COUNTRY REGION1
  <chr>      <chr>    <chr>
1 01-701-1015 USA      North America
2 01-701-1023 USA      North America
3 01-701-1028 USA      North America
4 01-701-1033 USA      North America
5 01-701-1034 USA      North America
6 01-701-1047 USA      North America
7 01-701-1057 USA      North America

```

```
8 01-701-1097 USA      North America
9 01-701-1111 USA      North America
10 01-701-1115 USA     North America
# ... with 296 more rows
```

Part IV

summarize

8 Summarizing Data

Thomas Neitmann

```
library(dplyr)
dm <- readRDS("data/dm.rds")
ae <- readRDS("data/ae.rds")
```

While `mutate()` adds a new variable for all existing records to a dataset, `summarize()` aggregates one or more columns of a dataset thereby “collapsing” it. In the simplest case a single variable is aggregated using a summary function such as `mean()`.

```
dm %>%
  summarize(avg_age = mean(AGE, na.rm = TRUE))
```

```
avg_age
<dbl>
1      75.1
```

Just like you can create multiple variables inside a single call to `mutate()` you can aggregate multiple variables (or the same variable with multiple summary functions) inside `summarize()`.

```
dm %>%
  summarize(
    avg_age = mean(AGE, na.rm = TRUE),
    median_age = median(AGE, na.rm = TRUE)
  )
```

```
# A tibble: 1 x 2
  avg_age median_age
  <dbl>      <dbl>
1      75.1         77
```

So far we aggregated only numeric variables. Another useful aggregation is counting the number of records.

```
dm %>%
  summarize(N = n())

# A tibble: 1 x 1
      N
  <int>
1   306
```

This becomes quite powerful when combining `summarize()` with `group_by()`. This should look rather familiar to you if you ever aggregated data using `proc sql`.

```
dm %>%
  group_by(COUNTRY) %>%
  summarize(n = n()) %>%
  ungroup()

# A tibble: 9 x 2
  COUNTRY      n
  <chr>    <int>
1 Canada      86
2 China       55
3 Germany     49
4 Greece      13
5 Japan       12
6 Mexico       5
7 Spain        6
8 Switzerland  9
9 USA         71
```

Note that it is best practice to `ungroup()` the dataset after you aggregated it. Failing to do so can lead to some rather bogus error when continuing to manipulate the aggregated dataset, e.g. using `mutate()`.

`group_by()` and `summarize()` can be used with numeric variables as well. In addition one can group by more than a single variable.

```
dm %>%
  group_by(ARM, COUNTRY) %>%
```

```

summarize(avg_age = mean(AGE, na.rm = TRUE)) %>%
ungroup()

```

```

# A tibble: 32 x 3

```

	ARM	COUNTRY	avg_age
	<chr>	<chr>	<dbl>
1	Placebo	Canada	79.2
2	Placebo	China	70.5
3	Placebo	Germany	75.2
4	Placebo	Greece	75.8
5	Placebo	Japan	70
6	Placebo	Mexico	65
7	Placebo	Spain	83
8	Placebo	Switzerland	69.3
9	Placebo	USA	74.9
10	Screen Failure	Canada	75.1

```

# ... with 22 more rows

```

9 Summarizing Data Exercises

Thomas Neitmann

```
library(dplyr)
dm <- readRDS("data/dm.rds")
ae <- readRDS("data/ae.rds")
```

9.1 Exercise 1

Count the number of *overall* adverse events per subject and sort the output such that the subject with the highest overall number of adverse events appears first.

```
ae %>%
  group_by(USUBJID) %>%
  summarise(n_ae = n()) %>%
  arrange(desc(n_ae))
```

```
# A tibble: 225 x 2
  USUBJID      n_ae
  <chr>      <int>
1 01-701-1302    23
2 01-717-1004    19
3 01-704-1266    16
4 01-709-1029    16
5 01-718-1427    16
6 01-701-1192    15
7 01-701-1275    15
8 01-709-1309    15
9 01-713-1179    15
10 01-711-1143    14
# ... with 215 more rows
```

9.2 Exercise 2

Count the overall number of *serious* adverse events per treatment arm (ACTARM).

```
ae %>%  
  filter(AESER == "Y") %>%  
  group_by(ACTARM) %>%  
  summarise(n = n())
```

A tibble: 2 x 2

	ACTARM	n
	<chr>	<int>
1	Xanomeline High Dose	1
2	Xanomeline Low Dose	2

9.3 Exercise 3

Find the lowest and highest AGE per treatment arm.

```
dm %>%  
  group_by(ARM) %>%  
  summarise(youngest = min(AGE, na.rm = TRUE), oldest = max(AGE, na.rm = TRUE))
```

A tibble: 4 x 3

	ARM	youngest	oldest
	<chr>	<int>	<int>
1	Placebo	52	89
2	Screen Failure	50	89
3	Xanomeline High Dose	56	88
4	Xanomeline Low Dose	51	88

Part V

tidyr

10 tidy

Zelos Zhu

10.0.1 Some Context

As we know, data can often be represented in several ways. Multiple observations of a variable can be organized by rows or by columns.

Table A.

ID	Pre	Post
x	1	2
y	3	4

Table B.

ID	Time	Value
x	Pre	1
x	Post	2
y	Pre	3
y	Post	4

When observations are spread along a row as multiple columns, we refer to the data as being in “wide” format (See Table A). When observations are spread along a column as multiple rows, we refer to the data as being in “long” format (See Table B). SDTM data for the most part generally adheres to the “long” structure, but as programmers we need to know how to work with both to suit our needs.

To get the desired shape of data, there are two useful functions from the `tidyr` package to make this transformation, aptly named: `pivot_longer()` and `pivot_wider()`. These can be seen as the R-equivalent of `proc transpose` in SAS.

10.0.2 Setup

```
library(admiral)
library(admiral.test)
library(dplyr)
library(tidyr)

suppdm <- admiral.test::admiral_suppdm %>%
  select(USUBJID, QNAM, QVAL)

head(suppdm, 10)
```

```
# A tibble: 10 x 3
  USUBJID      QNAM      QVAL
  <chr>      <chr>    <chr>
1 01-701-1015 COMPLT16 Y
2 01-701-1015 COMPLT24 Y
3 01-701-1015 COMPLT8  Y
4 01-701-1015 EFFICACY Y
5 01-701-1015 ITT      Y
6 01-701-1015 SAFETY   Y
7 01-701-1023 EFFICACY Y
8 01-701-1023 ITT      Y
9 01-701-1023 SAFETY   Y
10 01-701-1028 COMPLT16 Y
```

As we see here, in our SUPPDM domain, the data is currently in the “long” format. If we wanted to transform the dataset such that each of the unique values of QNAM was their own column, we are looking to transpose the data from “long” to “wide”. In this case, we use `pivot_wider()`.

```
suppdm_wide <- suppdm %>%
  pivot_wider(
    names_from = "QNAM", # assign column names based on QNAM
    values_from = "QVAL" # retrieve values from QVAL
  )
suppdm_wide
```

```
# A tibble: 254 x 7
  USUBJID      COMPLT16 COMPLT24 COMPLT8 EFFICACY ITT      SAFETY
  <chr>      <chr>      <chr>    <chr>    <chr>    <chr> <chr>
```



```

1 01-701-1015 Y      Y      Y      Y      Y      Y
2 01-701-1023 <NA>    <NA>    <NA>    Y      Y      Y
3 01-701-1028 Y      Y      Y      Y      Y      Y
4 01-701-1033 <NA>    <NA>    <NA>    Y      Y      Y
5 01-701-1034 Y      Y      Y      Y      Y      Y
6 01-701-1047 <NA>    <NA>    <NA>    Y      Y      Y
7 01-701-1097 Y      Y      Y      Y      Y      Y
8 01-701-1111 <NA>    <NA>    <NA>    Y      Y      Y
9 01-701-1115 <NA>    <NA>    Y      Y      Y      Y
10 01-701-1118 Y      Y      Y      Y      Y      Y
# ... with 244 more rows

```

Voila! This “wide” dataset may prove useful for joins (to be discussed later). But for now, let’s pretend that this “wide” format is how our original data came to us in. If we wanted to take these respective flagging columns and turn them into a “long” format, we use `pivot_longer()`.

```

suppdm_long <- suppdm_wide %>%
  pivot_longer(
    cols = c("COMPLT16", "COMPLT24", "COMPLT8", "EFFICACY", "ITT", "SAFETY"),
    names_to = "QNAM",
    values_to = "QVAL"
  )
suppdm_long

```

```

# A tibble: 1,524 x 3
  USUBJID      QNAM      QVAL
  <chr>      <chr>    <chr>
1 01-701-1015 COMPLT16 Y
2 01-701-1015 COMPLT24 Y
3 01-701-1015 COMPLT8  Y
4 01-701-1015 EFFICACY Y
5 01-701-1015 ITT      Y
6 01-701-1015 SAFETY   Y
7 01-701-1023 COMPLT16 <NA>
8 01-701-1023 COMPLT24 <NA>
9 01-701-1023 COMPLT8  <NA>
10 01-701-1023 EFFICACY Y
# ... with 1,514 more rows

```

As you can see, as we pivoted back, we didn’t come up with an *exact* duplicate of our original `suppdm` dataframe. This is because the default of `pivot_longer()` is **not** to drop NA values,

which can be modified with the `values_drop_na` function input, just one of the many powerful additional function inputs from both of these pivoting functions. `pivot_wider()` and `pivot_longer()` were designed to handle a variety of situations when transposing data in the most flexible of ways.

```
suppdm_long <- suppdm_wide %>%  
  pivot_longer(  
    cols = c("COMPLT16", "COMPLT24", "COMPLT8", "EFFICACY", "ITT", "SAFETY"),  
    names_to = "flag",  
    values_to = "flag_value",  
    values_drop_na = TRUE  
  )  
suppdm_long
```

```
# A tibble: 1,197 x 3  
  USUBJID      flag      flag_value  
  <chr>      <chr>      <chr>  
1 01-701-1015 COMPLT16 Y  
2 01-701-1015 COMPLT24 Y  
3 01-701-1015 COMPLT8  Y  
4 01-701-1015 EFFICACY Y  
5 01-701-1015 ITT      Y  
6 01-701-1015 SAFETY   Y  
7 01-701-1023 EFFICACY Y  
8 01-701-1023 ITT      Y  
9 01-701-1023 SAFETY   Y  
10 01-701-1028 COMPLT16 Y  
# ... with 1,187 more rows
```

Bonus Trick: The `names_to/values_to` function arguments can prove to be helpful as a renaming step during the data cleaning process too!

10.1 Relational Data (Joins)

When a pair of tables need to be joined together, we have a variety of functions that can achieve such a task:

- `left_join()`
- `right_join()`
- `full_join()`

- `inner_join()`

The use of these functions is very similar to `proc sql` in SAS. `left_join()` will cover most of use cases and is demonstrated below:

```
dm <- admiral.test::admiral_dm %>%
  select(STUDYID, USUBJID, AGE, ARM)

dm_suppdm <- dm %>%
  left_join(suppdm_wide, by = "USUBJID")

head(dm_suppdm)
```

A tibble: 6 x 10

	STUDYID	USUBJID	AGE	ARM	COMPL~1	COMPL~2	COMPLT8	EFFIC~3	ITT	SAFETY
	<chr>	<chr>	<dbl>	<chr>	<chr>	<chr>	<chr>	<chr>	<chr>	<chr>
1	CDISCPIL0T01	01-701~	63	Plac~	Y	Y	Y	Y	Y	Y
2	CDISCPIL0T01	01-701~	64	Plac~	<NA>	<NA>	<NA>	Y	Y	Y
3	CDISCPIL0T01	01-701~	71	Xano~	Y	Y	Y	Y	Y	Y
4	CDISCPIL0T01	01-701~	74	Xano~	<NA>	<NA>	<NA>	Y	Y	Y
5	CDISCPIL0T01	01-701~	77	Xano~	Y	Y	Y	Y	Y	Y
6	CDISCPIL0T01	01-701~	85	Plac~	<NA>	<NA>	<NA>	Y	Y	Y

... with abbreviated variable names 1: COMPLT16, 2: COMPLT24, 3: EFFICACY

The join can also be completed with different column names as long as you define the join-key relationship, demonstrated below:

```
dummy1 <- data.frame(
  STUDYID = c("TRIALX", "TRIALX"),
  USUBJID = c("1001", "1002"),
  AGE = c(18, 22)
)

dummy2 <- data.frame(
  STUDYID = c("TRIALX", "TRIALX"),
  SUBJECT = c("1001", "1002"),
  SEX = c("M", "F")
)

dummy3 <- dummy1 %>%
  left_join(dummy2, by = c("STUDYID" = "STUDYID", "USUBJID" = "SUBJECT"))
```

```
head(dummy3)
```

	STUDYID	USUBJID	AGE	SEX
1	TRIALX	1001	18	M
2	TRIALX	1002	22	F

11 tidy exercises

Zelos Zhu

```
library(tidyverse)
library(admiral)
library(admiral.test)
library(dplyr)
library(tidyr)

# load data
ex <- admiral_ex
dm <- admiral_dm
ds <- admiral_ds
suppds <- admiral_suppds
```

11.1 Pivoting with tidyr

Load the `ex` data-frame from `admiral_ex` and select the following variables:

- USUBJID
- EXTRT
- VISIT
- EXSTDTC

```
ex %>%
  select(USUBJID, EXTRT, VISIT, EXSTDTC)
```

```
# A tibble: 591 x 4
  USUBJID    EXTRT    VISIT    EXSTDTC
```

```

      <chr>      <chr>      <chr>      <chr>
1 01-701-1015 PLACEBO    BASELINE 2014-01-02
2 01-701-1015 PLACEBO    WEEK 2   2014-01-17
3 01-701-1015 PLACEBO    WEEK 24   2014-06-19
4 01-701-1023 PLACEBO    BASELINE 2012-08-05
5 01-701-1023 PLACEBO    WEEK 2   2012-08-28
6 01-701-1028 XANOMELINE BASELINE 2013-07-19
7 01-701-1028 XANOMELINE WEEK 2   2013-08-02
8 01-701-1028 XANOMELINE WEEK 24   2014-01-07
9 01-701-1033 XANOMELINE BASELINE 2014-03-18
10 01-701-1034 XANOMELINE BASELINE 2014-07-01
# ... with 581 more rows

```

Using `pivot_wider()` create a table that would shaped this way

USUBJID	EXTRT	BASELINE	WEEK 2	WEEK 24
...

```

ex %>%
  select(USUBJID, EXTRT, VISIT, EXSTDTC) %>%
  pivot_wider(names_from = "VISIT", values_from = "EXSTDTC")

```

```

# A tibble: 254 x 5
  USUBJID    EXTRT    BASELINE `WEEK 2` `WEEK 24`
  <chr>      <chr>      <chr>      <chr>      <chr>
1 01-701-1015 PLACEBO    2014-01-02 2014-01-17 2014-06-19
2 01-701-1023 PLACEBO    2012-08-05 2012-08-28 <NA>
3 01-701-1028 XANOMELINE 2013-07-19 2013-08-02 2014-01-07
4 01-701-1033 XANOMELINE 2014-03-18 <NA>      <NA>
5 01-701-1034 XANOMELINE 2014-07-01 2014-07-16 2014-12-18
6 01-701-1047 PLACEBO    2013-02-12 2013-02-26 <NA>
7 01-701-1097 XANOMELINE 2014-01-01 2014-01-16 2014-06-19
8 01-701-1111 XANOMELINE 2012-09-07 <NA>      <NA>
9 01-701-1115 XANOMELINE 2012-11-30 2012-12-14 <NA>
10 01-701-1118 PLACEBO    2014-03-12 2014-03-27 2014-08-28
# ... with 244 more rows

```

Load the `dm` data-frame from `admiral_dmand` and select the following variables:

- USUBJID

- RACE
- SEX

```
dm %>%
  select(USUBJID, RACE, SEX)
```

```
# A tibble: 306 x 3
  USUBJID      RACE SEX
  <chr>      <chr> <chr>
1 01-701-1015 WHITE F
2 01-701-1023 WHITE M
3 01-701-1028 WHITE M
4 01-701-1033 WHITE M
5 01-701-1034 WHITE F
6 01-701-1047 WHITE F
7 01-701-1057 WHITE F
8 01-701-1097 WHITE M
9 01-701-1111 WHITE F
10 01-701-1115 WHITE M
# ... with 296 more rows
```

Using `pivot_longer()` create a table that would shaped this way

USUBJID	VAR	VAL
1001	RACE	WHITE
1001	SEX	M

```
dm %>%
  select(USUBJID, RACE, SEX) %>%
  pivot_longer(cols = c(RACE, SEX),
               names_to = "VAR",
               values_to = "VAL")
```

```
# A tibble: 612 x 3
  USUBJID      VAR  VAL
  <chr>      <chr> <chr>
1 01-701-1015 RACE  WHITE
2 01-701-1015 SEX    F
3 01-701-1023 RACE  WHITE
```

```

4 01-701-1023 SEX    M
5 01-701-1028 RACE  WHITE
6 01-701-1028 SEX    M
7 01-701-1033 RACE  WHITE
8 01-701-1033 SEX    M
9 01-701-1034 RACE  WHITE
10 01-701-1034 SEX    F
# ... with 602 more rows

```

11.2 Joining using dplyr

Load the `ds` data-frame from `admiral_ds` and `suppds` data-frame from `admiral_suppds`. Prior to joining the two datasets together, we may need to do some cleaning of the data on `suppds`.

- Filter IDVAR for “DSSEQ”
- Mutate IDVARVAL from type character to type numeric.
- Select USUBJID IDVARVAL QNAM QLABEL QVAL

```

suppds <- suppds %>%
  filter(IDVAR == "DSSEQ") %>%
  mutate(IDVARVAL = as.numeric(IDVARVAL)) %>%
  select(USUBJID, IDVARVAL, QNAM, QLABEL, QVAL)

```

`suppds`

```

# A tibble: 3 x 5
  USUBJID      IDVARVAL QNAM      QLABEL      QVAL
  <chr>      <dbl> <chr>    <chr>      <chr>
1 01-703-1175      2 ENTCRIT PROTOCOL ENTRY CRITERIA NOT MET 16
2 01-705-1382      2 ENTCRIT PROTOCOL ENTRY CRITERIA NOT MET 25
3 01-708-1372      3 ENTCRIT PROTOCOL ENTRY CRITERIA NOT MET 16

```

Join the two tables together using USUBJID and DSSEQ as the key joining variables.

```

ds %>%
  left_join(suppds, by = c("USUBJID" = "USUBJID", "DSSEQ" = "IDVARVAL"))

```


A tibble: 850 x 16

	STUDYID	DOMAIN	USUBJID	DSSEQ	DSSPID	DSTERM	DSDECOD	DSCAT	VISIT~1	VISIT	DSDTC
	<chr>	<chr>	<chr>	<dbl>	<chr>	<chr>	<chr>	<chr>	<dbl>	<chr>	<chr>
1	CDISCPI~	DS	01-701~	1	<NA>	RANDO~	RANDOM~	PROT~	3	BASE~	2014~
2	CDISCPI~	DS	01-701~	2	<NA>	PROTO~	COMPLE~	DISP~	13	WEEK~	2014~
3	CDISCPI~	DS	01-701~	3	<NA>	FINAL~	FINAL ~	OTHE~	13	WEEK~	2014~
4	CDISCPI~	DS	01-701~	1	<NA>	RANDO~	RANDOM~	PROT~	3	BASE~	2012~
5	CDISCPI~	DS	01-701~	2	24	ADVER~	ADVERS~	DISP~	5	WEEK~	2012~
6	CDISCPI~	DS	01-701~	3	<NA>	FINAL~	FINAL ~	OTHE~	5	WEEK~	2012~
7	CDISCPI~	DS	01-701~	4	<NA>	FINAL~	FINAL ~	OTHE~	201	RETR~	2013~
8	CDISCPI~	DS	01-701~	1	<NA>	RANDO~	RANDOM~	PROT~	3	BASE~	2013~
9	CDISCPI~	DS	01-701~	2	<NA>	PROTO~	COMPLE~	DISP~	13	WEEK~	2014~
10	CDISCPI~	DS	01-701~	3	<NA>	FINAL~	FINAL ~	OTHE~	13	WEEK~	2014~

... with 840 more rows, 5 more variables: DSSTDTC <chr>, DSSTDY <dbl>,
QNAM <chr>, QLABEL <chr>, QVAL <chr>, and abbreviated variable name
1: VISITNUM