Notes on data processing and analysis of available Papua New Guinea datasets

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16/08/2018

1. Processing and preparing data for analysis and mapping

Given Microsoft Excel files containing data from the Papua New Guinea NHIS per month for 2015 and 2016, we would like to read each of these files and then concatenate them into a single dataset. This can be done in R as follows:

```
#
# Get the filenames of all .XLSX files in folder named "data"
#
fileNames <- list.files(path = "data/")
#
# Create a concatenating object
#
png_maternal <- NULL
#
# Loop through each of the XLSX files in data and read them
#
for(i in fileNames) {
  #
  # Use read_xlsx() to read current filename
  #
  temp <- read_xlsx(path = paste("data/", i, sep = ""),
                    col_names = FALSE,
                    skip = 3)
  #
  # extract month of current data
  #
  month <- str_split(string = i, pattern = " ")[[1]][1]
  #
  # extract year of current data
  #
  year <- str_split(string = str_split(string = i, pattern = " ")[[1]][2],
                    pattern = ".xlsx")[[1]][1]
  #
  # Add month variable to temp dataset
  #
  temp$month <- month
  #
```

```
  # Add year variable to temp dataset
  #
  temp$year <- year
  #
  # concatenate current dataset with png_maternal
  #
  png_maternal <- data.frame(rbind(png_maternal, temp))
}
```

This results in a data frame object called `png_maternal` with 36 columns and 16096 rows. The resulting data frame is as follows (first 60 rows):

X__1	X__2	X__3	X__4	X__5	X__6	X__7	X__8	X__9	X__10	X__11	X__12	X__13	X__14	X__15	X__16	X__17	X__18	X__19	X__20	X__21	X__22	X__23	X__24	X__25	X__26	X__27	X__28	X__29	X__30	X__31	X__32	X__33	X__34	month	year
10102	BALIMO HP	1	2	0	17	1	0	0	0	0	7	28	62	0	0	0	44	32	165	0	0	0	1	42	0	6	1	0	0	4	0	0	2	apr	2015
10104	BOSSET SC	1	1	0	0	0	0	0	0	0	1	2	18	0	0	0	90	4	20	1	2	5	0	5	0	0	0	0	0	0	0	0	0	apr	2015
10106	KAMASI CLINIC	1	0	3	5	0	0	0	0	0	0	6	10	0	0	0	6	6	3	0	0	0	0	3	0	0	1	0	0	0	1	0	0	apr	2015
10107	MAPODA SC	1	0	0	0	0	0	0	0	0	0	0	4	0	0	1	10	1	14	0	0	0	0	10	0	0	0	0	0	0	0	0	0	apr	2015
10108	NOMAD HC	1	0	0	0	0	0	0	0	0	1	0	1	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	apr	2015
10109	OBO/ KAVINANGA SC	1	2	11	5	0	0	0	0	0	9	8	141	0	0	0	4	2	10	2	0	3	0	5	0	1	0	0	0	0	0	0	0	apr	2015
10110	WASUA SC	1	3	9	1	0	0	0	0	0	7	7	23	0	0	0	9	0	38	1	0	8	0	6	0	0	0	0	0	0	0	0	1	apr	2015
10111	WAWOIL SC	1	0	0	3	0	0	0	0	0	0	0	19	0	0	0	2	0	11	0	0	0	0	1	0	0	0	0	0	0	0	0	1	apr	2015
10112	ADIBA SC	1	0	1	0	0	0	0	0	0	5	3	22	0	0	0	3	0	18	0	0	0	0	5	0	0	2	0	0	0	0	0	0	apr	2015
10114	TAPILA SC	1	0	0	5	0	0	0	0	0	0	5	5	0	0	0	11	6	22	0	1	2	0	1	0	0	1	7	0	0	0	0	0	apr	2015
10202	DEBEPARI SC	1	3	0	0	0	0	2	0	0	1	1	0	25	0	0	3	1	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	apr	2015
10203	DOME SC	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	7	0	0	3	0	0	0	0	0	0	0	0	0	0	0	apr	2015
10204	GOLGOBIP SC	1	0	0	0	0	0	0	0	0	0	0	7	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	apr	2015
10205	HAEWENAE SC	1	1	0	1	0	0	0	0	0	0	0	10	0	0	0	3	0	11	2	0	0	0	0	0	0	0	0	0	0	0	0	0	apr	2015
10206	IOWARA SC	1	1	0	0	0	0	0	0	0	1	1	1	0	0	0	8	1	29	1	0	2	0	3	0	0	0	0	0	2	0	0	1	apr	2015
10208	KIUNGA HP	1	9	0	10	0	0	0	0	0	19	71	513	0	0	0	54	30	287	21	18	35	0	72	0	0	0	0	0	2	6	0	1	apr	2015
10209	KIUNGA CATHOLIC UC	1	0	5	0	0	0	0	0	0	7	21	83	0	0	0	24	5	71	6	1	14	0	0	0	0	0	0	0	0	0	0	0	apr	2015
10210	KUNGIM SC	1	0	2	4	0	0	0	0	0	0	5	27	0	0	0	2	0	0	2	0	0	0	2	0	1	0	0	0	1	0	0	0	apr	2015
10211	MATKOMNAI SC	1	4	0	2	0	0	0	0	0	19	31	35	0	0	0	4	7	6	1	3	5	0	10	0	0	0	0	0	1	1	0	1	apr	2015
10212	MOUGULU SC	1	2	1	9	0	0	0	0	0	2	3	26	0	0	0	16	9	29	0	0	0	0	9	0	0	0	0	0	0	0	0	1	apr	2015
10213	NINGERUM HC	1	1	1	5	0	0	0	0	0	11	26	93	0	0	0	13	9	38	7	0	6	0	5	0	0	0	0	0	0	0	0	0	apr	2015
10214	OLSOBIP HC	1	0	0	2	0	0	0	0	0	0	0	3	0	0	0	1	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	apr	2015
10215	RUMGINAE HC	1	1	1	20	0	0	0	0	0	1	14	68	0	0	0	6	2	38	3	1	4	0	15	0	0	0	0	0	0	4	0	0	apr	2015
10216	TABUBIL (OTM LTD) HP	1	11	0	27	0	0	0	0	0	25	63	382	0	0	0	77	0	370	24	0	57	0	69	0	5	0	1	0	3	7	0	0	apr	2015
10217	TARAKBITS SC	1	0	0	2	0	0	0	0	0	0	2	12	0	0	0	4	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	apr	2015
10218	MEMBOK SC	1	0	0	1	0	0	0	0	0	2	8	4	0	0	0	6	0	17	4	0	2	0	2	0	0	0	0	0	1	1	0	1	apr	2015
10219	TABUBIL UC	1	1	0	5	0	0	0	0	0	0	0	1	0	0	0	1	0	4	1	0	0	0	0	0	0	0	0	0	0	0	0	0	apr	2015
10301	DARU HOSPITAL	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	64	0	1	0	0	0	3	0	0	0	apr	2015
10302	DARU UC	1	4	0	12	0	0	0	0	0	62	0	259	0	0	2	61	30	167	22	4	31	0	0	0	0	0	0	0	0	0	0	0	apr	2015
10304	KUNINI SC	1	4	8	6	0	0	0	0	0	24	37	54	0	1	4	6	16	21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	apr	2015
10305	MABUDAWAN HC	1	0	0	0	0	0	0	0	0	13	9	18	0	0	11	3	5	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	apr	2015
10306	MOREHEAD SC	1	3	2	4	0	0	0	0	0	1	2	53	0	0	0	6	0	22	0	0	0	0	2	0	0	0	0	0	0	0	0	0	apr	2015
10308	SUKI (GIGWA) SC	1	1	20	41	0	0	0	0	0	14	42	31	0	0	0	35	13	21	8	5	25	0	5	0	0	0	0	0	0	0	1	0	apr	2015
10310	TEAPOPO HC	1	13	0	52	0	0	0	0	0	30	24	81	0	0	0	66	0	13	53	8	0	0	1	0	0	0	0	1	0	0	0	0	apr	2015
10311	UPIARA SC	1	0	0	1	0	0	0	0	0	0	1	6	0	0	0	4	0	8	0	0	0	0	3	0	1	0	0	0	2	1	0	0	apr	2015
20101	BEMA SC	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9	0	29	0	0	0	0	3	0	0	0	0	0	5	1	0	1	apr	2015
20102	HAWABANGO SC	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	apr	2015
20104	KAINTIBA HC	1	0	1	4	0	0	0	0	0	0	3	8	0	0	0	1	3	11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	apr	2015
20106	KAMINA HC	1	0	0	5	0	0	0	0	0	0	2	3	0	0	0	8	0	27	0	0	0	0	6	0	0	0	0	0	6	0	0	0	apr	2015
20107	KANABEA HC	1	0	0	4	0	0	0	0	0	0	0	28	0	0	0	26	10	42	15	4	6	0	2	0	1	0	0	0	2	6	0	0	apr	2015
20108	KEREMA HOSPITAL	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	36	0	13	1	0	2	0	7	0	3	apr	2015
20109	KOARU SC	1	0	2	2	0	0	0	0	0	0	3	7	0	0	0	19	8	38	0	0	0	0	8	0	0	0	0	1	2	0	0	0	apr	2015
20110	KUKIPI HC	1	0	0	3	0	0	0	0	0	0	0	5	0	0	0	6	18	0	3	0	1	0	8	0	0	0	0	0	0	0	0	0	apr	2015
20111	LESE AVIHARA SC	1	0	0	3	0	0	0	0	0	0	1	14	0	0	0	6	4	14	0	0	0	0	2	0	0	0	0	0	0	0	0	1	apr	2015
20112	MALALAUA HC	1	0	0	5	0	0	0	0	0	2	6	34	0	0	0	14	12	58	2	0	8	0	14	0	0	0	0	0	1	0	0	4	apr	2015
20113	MURUA SC	1	1	0	0	0	0	0	0	0	0	0	1	0	0	0	1	2	5	0	0	0	0	3	0	0	0	0	0	0	0	0	0	apr	2015
20114	PUTEI SC	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	apr	2015
20115	TERAPO SC	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	25	30	45	0	0	0	0	15	0	0	1	0	0	1	0	0	0	apr	2015
20116	KEREMA UC	1	1	2	13	0	0	0	0	0	1	20	101	0	0	0	48	33	130	17	3	18	0	0	0	0	0	0	0	0	0	0	0	apr	2015
20201	BAIMURU HC	1	0	0	0	0	0	0	0	0	9	17	32	0	0	4	7	1	62	0	0	0	0	3	0	0	0	0	0	2	0	0	0	apr	2015
20202	IHU HC	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7	1	2	0	0	0	4	1	0	0	apr	2015
20203	KAPUNA HC	1	2	1	5	0	0	9	1	1	0	5	40	0	0	0	17	22	55	4	0	3	0	28	0	4	1	0	0	0	10	0	0	apr	2015
20204	KARAUTI SC	1	8	0	6	0	0	0	0	144	11	15	53	0	0	300	10	3	36	0	0	0	0	5	0	0	0	0	0	0	0	0	0	apr	2015
20205	KIKORI HC	1	16	8	17	0	0	4	0	0	8	30	129	0	0	0	33	18	82	6	0	12	0	26	0	4	0	0	0	0	2	0	0	apr	2015
20208	OROKOLO SC	1	0	0	4	0	0	0	0	0	5	3	66	0	0	0	14	10	24	0	0	0	0	16	0	0	1	0	0	1	0	0	0	apr	2015
30101	BORU SC	1	0	0	0	0	0	0	0	0	0	1	7	0	0	0	1	2	0	1	2	0	0	0	0	0	0	0	0	0	0	0	0	apr	2015
30102	IRUNA HC	1	0	0	4	0	0	0	0	0	0	7	19	0	0	0	12	2	30	6	0	0	0	5	0	0	0	0	0	1	0	0	0	apr	2015
30103	KUPIANO HC	1	3	0	16	0	0	0	0	0	0	3	56	0	0	0	33	15	122	3	2	9	0	16	0	1	2	0	0	2	3	0	5	apr	2015
30104	MOREGUINA HC	1	0	1	4	0	0	0	0	0	1	3	42	0	0	0	12	3	30	1	0	3	0	1	0	0	0	0	0	0	0	0	0	apr	2015
30105	UPULIMA SC	1	0	0	0	0	0	0	0	0	2	9	18	0	0	0	4	8	13	5	3	4	0	2	0	1	1	0	0	0	1	0	1	apr	2015

The object `png_maternal` lacks meaningful column names. Also, it would be good to create codes corresponding to the province code and district codes from the code specified in the first column of `png_maternal`. These can be processed in R as follows:

```
################################################################################
#
# Get province, district and facility codes
#
################################################################################
#
# Extract first two digits from code
#
png_maternal$pcode <- floor(png_maternal$X__1 / 10000)
#
# pad the pcode with a 0 at the start
#
png_maternal$pcode <- str_pad(string = png_maternal$pcode,
                              width = 2, side = "left", pad = "0")
#
# Extract first 4 digits from code
#
png_maternal$dcode <- floor(png_maternal$X__1 / 100)
#
# pad the dcode with a 0 at the start
#
png_maternal$dcode <- str_pad(string = png_maternal$dcode,
                              width = 4, side = "left", pad = "0")
#
# pad the code with a 0 at the start
#
png_maternal$X__1 <- str_pad(string = png_maternal$X__1,
                             width = 6, side = "left", pad = "0")

################################################################################
#
# Created codebook for PNG maternal mortality data
#
################################################################################

longName  <- c("Five to six-digit facility code",
               "Name of facility",
               "Report recieved? 1 = YES; 2 = NO",
               "New attendance breastfeeding pills",
               "New attendance combined pills",
               "New attendance injection",
               "Unkown Number 1",
               "Permanent vasectomy",
               "New attendance IUD",
               "New attendance ovulation",
```

```
                "New attendance condom",
                "Re-attendance breastfeeding pills",
                "Re-attendance combined pills",
                "Re-attendance injection",
                "Re-attendance IUD",
                "Re-attendance ovulation",
                "Re-attendance condom",
                "Antenatal first visit",
                "Antenatal fourth visit",
                "Antenatal other",
                "Antenatal TT1",
                "Antenatal TT2",
                "Antenatal booster",
                "Unknown Number 2",
                "Deliveries in health facility",
                "Maternal deaths in facility",
                "Birthweight less than 2500 grams",
                "Stillbirths",
                "Village births supervised",
                "Village births complications",
                "Born before arrival",
                "Delivery complications",
                "Maternal deaths not in facility",
                "Transferred to hospital",
                "Month",
                "Year",
                "Province code",
                "District code")

shortName <- c("code", "facility", "report",
                "bfpills1", "combpills1", "inj1", "uno1", "vasectomy", "iud1",
                "ovulation1", "condom1", "bfpills2", "combpills2", "inj2",
                "iud2", "ovulation2", "condom2", "anc1", "anc4", "ancother",
                "tt1", "tt2", "ttbooster", "uno2", "delhf", "deadhf", "lbw",
                "still", "vbsup", "vbcomp", "bba", "delcomp", "deadnothf",
                "transhop", "month", "year", "pcode", "dcode")

names(png_maternal) <- shortName
```

Checking `png_maternal` object again, we see that the columns have been labelled with more meaningful names and corresponding province and district codes have been added.

code	facility	report	bfpills1	combpills1	inj1	uno1	vasectomy	iud1	ovulation1	condom1	bfpills2	combpills2	inj2	iud2	ovulation2	condom2	anc1	anc4	ancother	tt1	tt2	ttbooster	uno2	delhf	deadhf	lbw	still	vbsup	vbcomp	bba	delcomp	deadnothf	transhop	month	year	pcode	dcode
010102	BALIMO HP	1	2	0	17	1	0	0	0	0	7	28	62	0	0	0	44	32	165	0	0	0	1	42	0	6	1	0	0	4	0	0	2	apr	2015	01	0101
010104	BOSSET SC	1	1	0	0	0	0	0	0	0	1	2	18	0	0	0	90	4	20	1	2	5	0	5	0	0	0	0	0	0	0	0	0	apr	2015	01	0101
010106	KAMASI CLINIC	1	0	3	5	0	0	0	0	0	0	6	10	0	0	0	6	6	3	0	0	0	0	3	0	0	1	0	0	0	1	0	0	apr	2015	01	0101
010107	MAPODA SC	1	0	0	0	0	0	0	0	0	0	0	4	0	0	1	10	1	14	0	0	0	0	10	0	0	0	0	0	0	0	0	0	apr	2015	01	0101
010108	NOMAD HC	1	0	0	0	0	0	0	0	0	1	0	1	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	apr	2015	01	0101
010109	OBO/ KAVINANGA SC	1	2	11	5	0	0	0	0	0	9	8	141	0	0	0	4	2	10	2	0	3	0	5	0	1	0	0	0	0	0	0	0	apr	2015	01	0101
010110	WASUA SC	1	3	9	1	0	0	0	0	0	7	7	23	0	0	0	9	0	38	1	0	8	0	6	0	0	0	0	0	0	0	0	1	apr	2015	01	0101
010111	WAWOIL SC	1	0	0	3	0	0	0	0	0	0	0	19	0	0	0	2	0	11	0	0	0	0	1	0	0	0	0	0	0	0	0	1	apr	2015	01	0101
010112	ADIBA SC	1	0	1	0	0	0	0	0	0	5	3	22	0	0	0	3	0	18	0	0	0	0	5	0	0	2	0	0	0	0	0	0	apr	2015	01	0101
010114	TAPILA SC	1	0	0	5	0	0	0	0	0	0	5	5	0	0	0	11	6	22	0	1	2	0	1	0	0	1	7	0	0	0	0	0	apr	2015	01	0101
010202	DEBEPARI SC	1	3	0	0	0	0	2	0	0	1	1	0	25	0	0	3	1	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	apr	2015	01	0102
010203	DOME SC	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	7	0	0	3	0	0	0	0	0	0	0	0	0	0	0	apr	2015	01	0102
010204	GOLGOBIP SC	1	0	0	0	0	0	0	0	0	0	0	7	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	apr	2015	01	0102
010205	HAEWENAE SC	1	1	0	1	0	0	0	0	0	0	0	10	0	0	0	3	0	11	2	0	0	0	0	0	0	0	0	0	0	0	0	0	apr	2015	01	0102
010206	IOWARA SC	1	1	0	0	0	0	0	0	0	1	1	1	0	0	0	8	1	29	1	0	2	0	3	0	0	0	0	0	2	0	0	1	apr	2015	01	0102
010208	KIUNGA HP	1	9	0	10	0	0	0	0	0	19	71	513	0	0	0	54	30	287	21	18	35	0	72	0	0	0	0	0	2	6	0	1	apr	2015	01	0102
010209	KIUNGA CATHOLIC UC	1	0	5	0	0	0	0	0	0	7	21	83	0	0	0	24	5	71	6	1	14	0	0	0	0	0	0	0	0	0	0	0	apr	2015	01	0102
010210	KUNGIM SC	1	0	2	4	0	0	0	0	0	0	5	27	0	0	0	2	0	0	2	0	0	0	2	0	1	0	0	0	1	0	0	0	apr	2015	01	0102
010211	MATKOMNAI SC	1	4	0	2	0	0	0	0	0	19	31	35	0	0	0	4	7	6	1	3	5	0	10	0	0	0	0	0	1	1	0	1	apr	2015	01	0102
010212	MOUGULU SC	1	2	1	9	0	0	0	0	0	2	3	26	0	0	0	16	9	29	0	0	0	0	9	0	0	0	0	0	0	0	0	1	apr	2015	01	0102
010213	NINGERUM HC	1	1	1	5	0	0	0	0	0	11	26	93	0	0	0	13	9	38	7	0	6	0	5	0	0	0	0	0	0	0	0	0	apr	2015	01	0102
010214	OLSOBIP HC	1	0	0	2	0	0	0	0	0	0	0	3	0	0	0	1	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	apr	2015	01	0102
010215	RUMGINAE HC	1	1	1	20	0	0	0	0	0	1	14	68	0	0	0	6	2	38	3	1	4	0	15	0	0	0	0	0	0	4	0	0	apr	2015	01	0102
010216	TABUBIL (OTM LTD) HP	1	11	0	27	0	0	0	0	0	25	63	382	0	0	0	77	0	370	24	0	57	0	69	0	5	0	1	0	3	7	0	0	apr	2015	01	0102
010217	TARAKBITS SC	1	0	0	2	0	0	0	0	0	0	2	12	0	0	0	4	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	apr	2015	01	0102
010218	MEMBOK SC	1	0	0	1	0	0	0	0	0	2	8	4	0	0	0	6	0	17	4	0	2	0	2	0	0	0	0	0	1	1	0	1	apr	2015	01	0102
010219	TABUBIL UC	1	1	0	5	0	0	0	0	0	0	0	1	0	0	0	1	0	4	1	0	0	0	0	0	0	0	0	0	0	0	0	0	apr	2015	01	0102
010301	DARU HOSPITAL	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	64	0	1	0	0	0	3	0	0	0	apr	2015	01	0103
010302	DARU UC	1	4	0	12	0	0	0	0	0	62	0	259	0	0	2	61	30	167	22	4	31	0	0	0	0	0	0	0	0	0	0	0	apr	2015	01	0103
010304	KUNINI SC	1	4	8	6	0	0	0	0	0	24	37	54	0	1	4	6	16	21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	apr	2015	01	0103
010305	MABUDAWAN HC	1	0	0	0	0	0	0	0	0	13	9	18	0	0	11	3	5	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	apr	2015	01	0103
010306	MOREHEAD SC	1	3	2	4	0	0	0	0	0	1	2	53	0	0	0	6	0	22	0	0	0	0	2	0	0	0	0	0	0	0	0	0	apr	2015	01	0103
010308	SUKI (GIGWA) SC	1	1	20	41	0	0	0	0	0	14	42	31	0	0	0	35	13	21	8	5	25	0	5	0	0	0	0	0	0	0	1	0	apr	2015	01	0103
010310	TEAPOPO HC	1	13	0	52	0	0	0	0	0	30	24	81	0	0	0	66	0	13	53	8	0	0	1	0	0	0	0	1	0	0	0	0	apr	2015	01	0103
010311	UPIARA SC	1	0	0	1	0	0	0	0	0	0	1	6	0	0	0	4	0	8	0	0	0	0	3	0	1	0	0	0	2	1	0	0	apr	2015	01	0103
020101	BEMA SC	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9	0	29	0	0	0	0	3	0	0	0	0	0	5	1	0	1	apr	2015	02	0201
020102	HAWABANGO SC	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	apr	2015	02	0201
020104	KAINTIBA HC	1	0	1	4	0	0	0	0	0	0	3	8	0	0	0	1	3	11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	apr	2015	02	0201
020106	KAMINA HC	1	0	0	5	0	0	0	0	0	0	2	3	0	0	0	8	0	27	0	0	0	0	6	0	0	0	0	0	6	0	0	0	apr	2015	02	0201
020107	KANABEA HC	1	0	0	4	0	0	0	0	0	0	0	28	0	0	0	26	10	42	15	4	6	0	2	0	1	0	0	2	6	0	0	2	apr	2015	02	0201
020108	KEREMA HOSPITAL	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	36	0	13	1	0	2	0	7	0	3	apr	2015	02	0201
020109	KOARU SC	1	0	2	2	0	0	0	0	0	0	3	7	0	0	0	19	8	38	0	0	0	0	8	0	0	0	0	1	2	0	0	0	apr	2015	02	0201
020110	KUKIPI HC	1	0	0	3	0	0	0	0	0	0	0	5	0	0	0	6	18	0	3	0	1	0	8	0	0	0	0	0	0	0	0	0	apr	2015	02	0201
020111	LESE AVIHARA SC	1	0	0	3	0	0	0	0	0	0	1	14	0	0	0	6	4	14	0	0	0	0	2	0	0	0	0	0	0	0	0	1	apr	2015	02	0201
020112	MALALAUA HC	1	0	0	5	0	0	0	0	0	2	6	34	0	0	0	14	12	58	2	0	8	0	14	0	0	0	0	0	1	0	0	4	apr	2015	02	0201
020113	MURUA SC	1	1	0	0	0	0	0	0	0	0	0	1	0	0	0	1	2	5	0	0	0	0	3	0	0	0	0	0	0	0	0	0	apr	2015	02	0201
020114	PUTEI SC	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	apr	2015	02	0201
020115	TERAPO SC	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	25	30	45	0	0	0	0	15	0	0	1	0	0	1	0	0	0	apr	2015	02	0201
020116	KEREMA UC	1	1	2	13	0	0	0	0	0	1	20	101	0	0	0	48	33	130	17	3	18	0	0	0	0	0	0	0	0	0	0	0	apr	2015	02	0201
020201	BAIMURU HC	1	0	0	0	0	0	0	0	0	9	17	32	0	0	4	7	1	62	0	0	0	0	3	0	0	0	0	0	2	0	0	0	apr	2015	02	0202
020202	IHU HC	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7	1	2	0	0	0	4	1	0	0	apr	2015	02	0202
020203	KAPUNA HC	1	2	1	5	0	0	9	1	1	0	5	40	0	0	0	17	22	55	4	0	3	0	28	0	4	1	0	0	0	10	0	0	apr	2015	02	0202
020204	KARAUTI SC	1	8	0	6	0	0	0	0	144	11	15	53	0	0	300	10	3	36	0	0	0	0	5	0	0	0	0	0	0	0	0	0	apr	2015	02	0202
020205	KIKORI HC	1	16	8	17	0	0	4	0	0	8	30	129	0	0	0	33	18	82	6	0	12	0	26	0	4	0	0	0	0	2	0	0	apr	2015	02	0202
020208	OROKOLO SC	1	0	0	4	0	0	0	0	0	5	3	66	0	0	0	14	10	24	0	0	0	0	16	0	0	1	0	0	1	0	0	0	apr	2015	02	0202
030101	BORU SC	1	0	0	0	0	0	0	0	0	0	1	7	0	0	0	1	2	0	1	2	0	0	0	0	0	0	0	0	0	0	0	0	apr	2015	03	0301
030102	IRUNA HC	1	0	0	4	0	0	0	0	0	0	7	19	0	0	0	12	2	30	6	0	0	0	5	0	0	0	0	0	1	0	0	0	apr	2015	03	0301
030103	KUPIANO HC	1	3	0	16	0	0	0	0	0	0	3	56	0	0	0	33	15	122	3	2	9	0	16	0	1	2	0	0	2	3	0	5	apr	2015	03	0301
030104	MOREGUINA HC	1	0	1	4	0	0	0	0	0	1	3	42	0	0	0	12	3	30	1	0	3	0	1	0	0	0	0	0	0	0	0	0	apr	2015	03	0301
030105	UPULIMA SC	1	0	0	0	0	0	0	0	0	2	9	18	0	0	0	4	8	13	5	3	4	0	2	0	1	1	0	0	0	1	0	1	apr	2015	03	0301

a. Processing `png_maternal` to create datasets that can be mapped

Further processing of `png_maternal` can be done to allow for mapping of the data at province and district level.

Province level data can be produced from `png_maternal` as follows:

```
#
# Aggregate data by province and per year
#
provincedata <- aggregate(
  cbind(bfpills1, combpills1, inj1, uno1, vasectomy, iud1, ovulation1,
        condom1, bfpills2, combpills2, inj2, iud2, ovulation2, condom2,
        anc1, anc4, ancother, tt1, tt2, ttbooster, uno2,
        delhf, deadhf, lbw, still, vbsup, vbcomp, bba,
        delcomp, deadnothf, transhop) ~ pcode + year,
  data = png_maternal, FUN = sum)
```

This produces a data frame object named `provincedata`.

	pcode	year	bfpills1	combpills1	inj1	uno1	vasectomy	iud1	ovulation1	condom1	bfpills2	combpills2	inj2	iud2	ovulation2	condom2	anc1	anc4	ancother	tt1	tt2	ttbooster	uno2	delhf	deadhf	lbw	still	vbsup	vbcomp	bba	delcomp	deadnothf	transhop
1	01	2015	844	544	2187	433	3	196	80	390	2995	4255	15682	82	128	694	4973	1835	11048	1393	466	2036	433	3393	4	166	33	101	19	142	165	3	48
2	02	2015	315	177	721	3	0	46	5	1216	475	795	4154	3	6	3319	2780	1654	5903	574	135	815	3	1625	5	120	44	75	73	257	209	7	67
3	03	2015	141	171	855	72	10	93	9	110	218	568	4438	10	56	335	4253	1558	9015	1185	431	1491	72	2232	8	63	45	94	59	167	121	3	179
4	04	2015	411	417	1863	31	0	77	133	50	466	4104	18634	19	174	370	8240	3777	23229	3092	1461	4561	31	0	0	0	0	0	0	0	0	0	0
5	05	2015	547	506	2021	93	17	53	200	485	972	3490	9394	4	1529	260	6904	4692	29183	2345	1303	3861	93	5287	10	590	137	467	117	200	792	14	213
6	06	2015	312	300	1061	118	0	27	123	543	534	1316	6158	43	70	524	4132	2000	10936	1708	856	1626	118	2575	3	219	65	127	26	218	349	1	485
7	07	2015	1316	1115	2818	43	7	29	133	1438	4004	6593	11454	64	231	1551	7116	3003	11922	2671	1150	2550	43	4344	4	230	91	79	57	305	448	5	196
8	08	2015	458	728	1233	938	644	104	263	898	622	2689	4753	103	213	1185	6708	2443	8624	2384	696	3047	938	3860	13	171	72	118	29	358	402	22	191
9	09	2015	330	606	2797	69	2	85	263	642	291	4507	16185	40	92	744	8010	3796	18285	2975	1714	3567	69	6472	0	285	78	31	24	137	275	3	231
10	10	2015	829	927	2398	190	166	428	131	3027	855	1845	6932	51	130	1985	6069	2989	13548	2418	1106	3284	190	4872	8	292	98	91	17	241	794	3	408
11	11	2015	1782	1547	3284	145	427	1310	51	1608	3058	10347	14809	350	120	3404	10323	6207	23602	4825	2313	4921	145	7990	15	160	90	492	76	145	731	6	293
12	12	2015	1397	1365	3329	87	84	284	112	3195	2228	10355	21457	7	175	2748	13667	6253	33783	5320	2611	6861	87	4505	13	545	192	939	119	291	227	22	213
13	13	2015	1035	1312	4584	190	48	123	61	825	1505	3066	10910	148	120	526	11060	5356	19755	5178	2242	5507	190	5004	15	653	113	213	94	390	645	14	178
14	14	2015	495	475	1226	16	4	5	81	623	808	4061	6901	0	93	262	6598	2271	13053	3090	2636	2369	16	4203	15	278	116	99	52	275	262	6	129
15	15	2015	272	383	1245	6	16	293	36	41	412	1625	6966	28	12	98	7678	2183	10691	1694	588	2169	6	2815	12	324	93	253	151	363	331	11	150
16	16	2015	27	20	280	15	7	39	36	87	22	69	1526	38	26	77	1264	643	3441	318	143	545	15	1161	1	144	16	22	23	43	232	0	28
17	17	2015	9	35	415	32	0	88	88	161	5	75	1902	64	154	58	3861	2571	14568	901	614	1940	32	2332	5	140	48	184	62	128	229	0	152
18	18	2015	199	186	1649	80	52	170	1556	524	123	700	4076	3	1084	139	9292	5200	29804	2545	2080	6417	80	8562	15	410	137	234	94	324	968	11	494
19	19	2015	518	432	1129	448	40	686	80	638	854	2450	4924	191	77	926	8311	4175	22558	2378	1456	4627	448	5086	8	381	126	179	40	310	521	3	282
20	20	2015	125	168	383	49	2	6	5	780	214	381	1910	4	313	451	3617	1916	9347	1382	719	1597	49	2707	6	123	88	50	5	140	278	2	148
21	21	2015	1127	1058	1577	0	0	1	1069	16645	2494	3148	4478	0	213	8874	4752	2297	8491	1998	948	2263	0	3074	6	71	41	235	14	356	138	5	127
22	22	2015	717	615	1375	14	13	10	65	3099	867	2106	6588	17	37	2216	3977	1619	6819	1560	719	2039	14	2561	5	111	58	53	15	107	355	10	130
23	01	2016	580	340	1345	12	57	108	113	292	1676	4098	13623	3	299	414	3461	1537	9147	1197	342	1594	12	2174	15	199	28	101	39	102	141	9	72
24	02	2016	294	218	922	19	4	12	33	1348	408	667	5827	0	17	2706	2683	1234	5288	781	219	736	19	1279	8	85	24	102	27	168	148	1	51
25	03	2016	108	150	884	67	2	50	7	180	182	657	4965	3	33	262	4096	1571	9077	1133	297	1363	67	2168	3	69	37	119	35	123	134	7	189
26	04	2016	336	367	2590	15	3	42	95	151	438	4943	22417	80	104	491	11966	5825	29444	4082	1790	6021	15	14359	0	1200	30	3	0	408	106	0	35
27	05	2016	398	393	1842	94	39	46	41	236	748	3073	9885	1	994	690	6561	4705	27858	2297	1178	3523	94	5105	7	634	114	332	102	205	733	5	236
28	06	2016	160	176	921	90	0	63	4	531	199	922	6502	39	166	492	3443	1535	11267	1129	557	1152	90	2183	8	125	50	106	13	138	269	1	432
29	07	2016	1181	1146	2474	39	0	9	67	823	3086	10093	13141	1	315	2231	6633	2881	12095	2248	973	3002	39	3939	8	197	66	142	52	325	364	1	151
30	08	2016	390	672	1463	247	24	597	536	1715	389	2604	4389	29	365	1554	6783	2853	9773	2619	942	3652	247	4008	10	125	41	93	44	304	424	8	144
31	09	2016	504	777	3452	64	2	24	187	1465	529	3628	20108	34	90	969	8233	3784	18014	2935	1598	3916	64	6344	5	180	74	14	39	134	253	0	156
32	10	2016	979	850	2996	128	94	711	57	1863	923	1990	7081	12	76	1595	6281	3346	14650	2395	1165	3214	128	4917	1	188	124	39	5	129	794	2	396
33	11	2016	1699	1567	3270	97	254	695	30	2225	3114	12365	14623	135	115	1660	11659	7001	29322	9945	2576	5700	97	7823	28	359	147	259	36	277	1078	12	948
34	12	2016	1167	1037	3478	330	28	47	199	1000	1477	9108	22415	0	226	1765	11663	5541	25090	4451	2399	8654	330	8088	38	805	141	1496	153	641	234	38	239
35	13	2016	804	1155	3552	96	25	27	50	306	1261	2857	12492	44	102	382	9817	4319	18051	4250	1896	4878	96	6332	16	775	239	139	86	392	879	16	189
36	14	2016	475	476	1533	15	18	0	60	1397	605	3858	8123	0	73	1662	5895	2104	11799	1698	852	2254	15	4018	10	160	114	82	44	264	376	12	81
37	15	2016	427	218	1515	6	27	43	12	52	261	718	9216	23	13	94	4528	1873	10533	1563	544	1750	6	2828	19	310	88	225	69	238	195	10	131
38	16	2016	34	25	318	38	4	16	28	146	29	121	1234	4	5	213	1195	783	3911	346	147	468	38	926	0	91	19	34	10	48	77	4	23
39	17	2016	10	24	480	50	1	125	34	33	5	51	2187	3	54	108	4033	2400	14304	1581	1199	2997	50	3355	5	268	99	245	81	170	386	4	234
40	18	2016	153	95	1071	120	0	184	3530	326	59	385	3835	0	1648	115	8289	5037	27101	2565	1929	5884	120	8221	17	604	206	176	107	328	1060	6	452
41	19	2016	282	299	1038	268	18	109	39	418	460	1989	5882	5	59	1133	7760	4026	24983	2186	1019	4342	268	6170	4	431	171	269	68	295	805	2	509
42	20	2016	51	41	501	56	1	37	94	209	70	219	1687	15	348	338	3828	1884	10087	1147	539	1566	56	2773	4	123	74	82	14	115	320	0	133
43	21	2016	754	775	1130	2	0	49	148	4103	2051	2996	4383	0	130	3739	4665	2456	8048	1601	687	2075	2	2876	1	65	42	189	19	348	150	3	102
44	22	2016	922	799	1887	7	0	90	118	1703	1071	2486	7719	111	161	2153	4151	2177	8295	1816	767	5799	7	2586	12	165	35	46	17	131	505	6	104
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	NA	NA	NA	NA	NA	NA	NA	NA	NA
NA.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	NA	NA	NA	NA	NA	NA	NA	NA
NA.2	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	NA	NA	NA	NA	NA	NA	NA	NA
NA.3	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	NA	NA	NA	NA	NA	NA	NA	NA
NA.4	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	NA	NA	NA	NA	NA	NA	NA	NA
NA.5	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	NA	NA	NA	NA	NA	NA	NA	NA
NA.6	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	NA	NA	NA	NA	NA	NA	NA	NA
NA.7	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	NA	NA	NA	NA	NA	NA	NA	NA
NA.8	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	NA	NA	NA	NA	NA	NA	NA	NA
NA.9	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	NA	NA	NA	NA	NA	NA	NA	NA
NA.10	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	NA	NA	NA	NA	NA	NA	NA	NA
NA.11	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	NA	NA	NA	NA	NA	NA	NA	NA
NA.12	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	NA	NA	NA	NA	NA	NA	NA	NA
NA.13	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	NA	NA	NA	NA	NA	NA	NA	NA
NA.14	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	NA	NA	NA	NA	NA	NA	NA	NA
NA.15	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	NA	NA	NA	NA	NA	NA	NA	NA

District level data can be produced from `png_maternal` as follows:

```
#
# Aggregate data by district and per year
#
districtdata <- aggregate(
  cbind(bfpills1, combpills1, inj1, uno1, vasectomy, iud1, ovulation1,
        condom1, bfpills2, combpills2, inj2, iud2, ovulation2, condom2,
        anc1, anc4, ancother, tt1, tt2, ttbooster, uno2,
        delhf, deadhf, lbw, still, vbsup, vbcomp, bba,
        delcomp, deadnothf, transhop) ~ dcode + year,
  data = png_maternal, FUN = sum)
```

This produces a data frame object named `districtdata`.

dcode	year	bfpills1	combpills1	inj1	uno1	vasectomy	iud1	ovulation1	condom1	bfpills2	combpills2	inj2	iud2	ovulation2	condom2	anc1	anc4	ancother	tt1	tt2	ttbooster	uno2	delhf	deadhf	lbw	still	vbsup	vbcomp	bba	delcomp	deadnothf	transhop
0101	2015	139	115	383	3	0	162	6	32	378	556	2649	2	2	116	957	432	2311	228	81	480	3	656	0	35	16	32	5	26	11	2	9
0102	2015	345	170	1135	426	2	25	6	12	1023	2547	9490	80	99	16	2781	777	6576	714	331	1150	426	1904	4	91	13	63	8	81	149	0	32
0103	2015	360	259	669	4	1	9	68	346	1594	1152	3543	0	27	562	1235	626	2161	451	54	406	4	833	0	40	4	6	6	35	5	1	7
0201	2015	40	39	413	0	0	0	0	26	51	208	1622	0	2	28	1922	1055	3621	397	92	582	0	837	1	55	26	44	51	180	63	1	52
0202	2015	275	138	308	3	0	46	5	1190	424	587	2532	3	4	3291	858	599	2282	177	43	233	3	788	4	65	18	31	22	77	146	6	15
0301	2015	31	36	192	2	10	0	3	3	23	195	1201	0	12	8	740	305	1908	263	105	267	2	381	1	3	10	14	4	45	27	1	45
0302	2015	8	33	33	1	0	0	2	48	9	24	32	0	1	40	349	116	435	88	102	145	1	66	1	3	3	27	20	38	4	0	1
0303	2015	54	40	413	48	0	93	4	51	98	160	1577	10	33	270	2411	938	4868	681	197	901	48	1241	2	20	15	37	28	48	66	1	60
0304	2015	48	62	217	21	0	0	0	8	88	189	1628	0	10	17	753	199	1804	153	27	178	21	544	4	37	17	16	7	36	24	1	73
0401	2015	195	135	634	0	0	40	11	15	201	1664	7196	19	165	322	2806	1362	7530	1051	490	1510	0	0	0	0	0	0	0	0	0	0	0
0402	2015	147	166	681	14	0	25	120	34	181	1643	6893	0	7	46	3625	1707	10683	1367	612	2036	14	0	0	0	0	0	0	0	0	0	0
0403	2015	69	116	548	17	0	12	2	1	84	797	4545	0	2	2	1809	708	5016	674	359	1015	17	0	0	0	0	0	0	0	0	0	0
0501	2015	184	159	683	54	3	2	40	88	188	1001	3881	0	29	95	2500	1816	11505	1005	606	1547	54	2444	2	281	59	46	47	81	377	0	72
0502	2015	115	75	491	16	14	20	2	234	266	590	1652	0	108	87	1466	952	6061	423	218	748	16	1075	2	126	31	27	19	35	151	9	42
0503	2015	206	241	382	9	0	3	152	130	482	1602	2193	0	768	27	1816	1165	6432	566	280	842	9	875	5	83	21	327	22	36	139	3	49
0504	2015	42	31	465	14	0	28	6	33	36	297	1668	4	624	51	1122	759	5185	351	199	724	14	893	1	100	26	67	29	48	125	2	50
0601	2015	182	181	471	45	0	4	11	497	363	906	3690	1	59	423	2509	1120	7798	981	568	910	45	2163	3	215	65	59	17	182	327	0	266
0602	2015	130	119	590	73	0	23	112	46	171	410	2468	42	11	101	1623	880	3138	727	288	716	73	412	0	4	0	68	9	36	22	1	219
0701	2015	156	211	683	0	0	0	37	146	235	1275	3066	0	13	462	1340	378	2358	652	347	597	0	598	1	23	6	0	13	44	20	1	44
0702	2015	141	72	226	7	0	12	11	270	542	600	1537	64	7	127	812	594	902	348	102	202	7	283	0	3	1	19	6	10	9	0	21
0703	2015	163	121	354	0	6	0	4	354	342	1059	2401	0	64	219	1063	382	1824	470	112	397	0	243	0	4	3	2	13	27	11	2	15
0706	2015	409	417	957	5	1	17	21	474	2066	2104	1542	0	44	576	1993	597	3107	525	175	608	5	2418	1	164	49	12	8	58	354	0	35
0707	2015	447	294	598	31	0	0	60	194	819	1555	2908	0	103	167	1908	1052	3731	676	414	746	31	802	2	36	32	46	17	166	54	2	81
0801	2015	81	76	68	0	3	0	55	46	68	85	76	0	57	15	468	200	474	129	84	118	0	62	0	3	1	40	2	45	3	0	18
0802	2015	47	163	339	334	168	68	159	659	111	378	1053	75	89	1030	1044	540	1344	444	130	469	334	509	8	26	11	35	3	70	47	0	30
0803	2015	196	136	161	71	123	10	6	14	254	821	738	0	16	8	2486	1051	3131	824	268	1280	71	1319	2	97	21	13	10	116	145	13	52
0804	2015	46	179	261	162	98	0	0	30	76	389	1192	0	0	0	1290	210	1739	536	74	571	162	1290	1	13	23	25	12	75	108	8	29
0805	2015	88	174	404	371	252	26	43	149	113	1016	1694	28	51	132	1420	442	1936	451	140	609	371	680	2	32	16	5	2	52	99	1	62
0902	2015	70	169	463	37	0	13	16	501	60	391	1929	24	43	649	1079	598	2171	613	391	487	37	462	0	13	4	22	2	31	26	3	102
0903	2015	47	92	364	0	0	0	142	7	70	560	1952	0	6	7	747	386	1410	240	87	310	0	272	0	0	4	2	9	10	15	0	26
0904	2015	129	241	1396	25	0	42	11	18	103	3074	9079	16	19	30	4603	2093	11341	1644	1028	2154	25	5206	0	262	63	1	3	88	211	0	33
0907	2015	84	104	574	7	2	30	94	116	58	482	3225	0	24	58	1581	719	3363	478	208	616	7	532	0	10	7	6	10	8	23	0	70
1001	2015	116	61	300	63	18	5	5	795	153	295	1284	0	5	577	867	424	1745	425	138	430	63	453	0	16	13	13	1	15	30	0	14
1002	2015	34	37	145	5	0	10	4	1	33	90	407	0	0	0	554	187	1305	195	54	311	5	286	0	1	0	0	2	1	3	0	12
1003	2015	66	64	341	6	63	51	34	64	131	147	863	8	81	88	652	417	619	264	248	254	6	185	0	5	1	23	3	36	16	0	25
1004	2015	178	156	464	63	4	21	86	307	119	260	1231	0	37	285	1676	972	3177	649	232	1079	63	1324	1	33	10	49	5	34	135	1	278
1005	2015	389	488	991	52	81	341	0	1783	353	817	2700	43	1	990	1979	739	5953	710	287	985	52	2495	7	235	73	6	4	143	596	2	69
1006	2015	46	121	157	1	0	0	2	77	66	236	447	0	6	45	341	250	749	175	147	225	1	129	0	2	1	0	2	12	14	0	10
1101	2015	50	69	186	0	0	57	1	6	76	258	864	0	4	76	814	513	2236	249	107	404	0	416	0	2	1	3	2	2	5	1	35
1102	2015	395	254	985	20	130	582	29	250	1190	5348	5422	270	69	1630	3055	1573	8766	1286	868	1490	20	4734	10	0	47	0	1	24	505	0	1
1103	2015	311	250	438	15	14	151	3	438	534	1230	1960	14	3	716	1290	1187	2237	894	340	751	15	455	0	37	3	124	14	14	26	0	36
1104	2015	282	195	398	3	53	43	5	57	319	1376	2240	3	8	73	1612	853	3589	642	338	942	3	1420	2	93	31	142	3	52	132	0	98
1105	2015	80	130	197	5	24	201	1	56	129	518	926	1	11	65	850	492	2029	436	133	556	5	214	3	5	2	12	6	5	3	3	17
1106	2015	419	467	730	7	154	138	5	540	469	1002	1809	35	16	292	1656	936	3177	659	282	400	7	499	0	15	3	203	29	20	37	0	71
1107	2015	231	164	309	30	26	33	0	208	326	517	1400	0	0	417	695	335	986	420	168	254	30	156	0	3	1	4	15	8	4	2	8
1108	2015	14	18	41	65	26	105	7	53	15	98	188	27	9	135	351	318	582	239	77	124	65	96	0	5	2	4	6	20	19	0	27
1201	2015	245	312	528	7	2	125	35	203	217	1045	3804	0	6	227	2430	739	3497	868	380	959	7	408	1	6	5	217	7	12	16	1	30
1202	2015	119	128	383	36	0	30	3	1242	92	191	1067	0	17	1059	996	584	1543	381	247	514	36	413	5	14	11	6	7	29	9	3	52
1203	2015	45	107	149	14	0	8	12	288	36	470	1106	0	28	101	1220	384	2324	390	136	790	14	70	1	3	1	37	14	14	2	0	28
1204	2015	51	133	217	6	3	4	1	38	115	569	1194	0	9	27	558	325	1729	220	72	173	6	163	1	1	3	181	4	14	2	1	3
1205	2015	488	329	776	1	2	4	12	40	809	5378	6787	0	110	129	3726	1682	9531	1642	691	2098	1	1800	0	393	110	38	2	131	17	0	0
1206	2015	180	128	349	1	18	63	0	471	603	1674	2959	7	2	117	1656	915	7682	773	463	1055	1	568	0	31	15	123	10	43	54	1	18
1207	2015	104	69	411	22	15	21	10	422	108	325	1135	0	2	356	1211	558	2973	371	145	383	22	336	1	50	10	167	62	21	23	2	14
1208	2015	73	64	173	0	2	29	3	104	96	476	1932	0	0	129	1033	548	2439	369	239	486	0	289	1	6	5	50	3	13	29	2	29
1209	2015	92	95	343	0	42	0	36	387	152	227	1473	0	1	603	837	518	2065	306	238	403	0	458	3	41	32	120	10	14	75	12	39
1301	2015	37	39	507	3	30	76	3	25	26	166	899	121	1	36	1582	427	2287	523	129	784	3	458	0	68	17	15	31	44	34	2	26
1302	2015	736	852	2271	154	8	10	23	247	1014	1423	4989	2	71	108	4454	2518	7561	2989	1574	3230	154	2084	12	399	36	73	5	183	360	1	40
1303	2015	42	28	302	0	0	12	8	26	180	294	723	0	0	17	1100	435	1837	328	64	186	0	316	1	13	6	0	20	24	11	5	8
1304	2015	126	192	290	29	6	12	18	486	169	429	888	5	22	245	813	715	1608	226	83	198	29	289	0	22	16	53	26	32	22	2	18
1305	2015	61	59	299	0	0	1	7	5	46	251	1746	0	16	12	1578	638	3083	589	207	558	0	972	1	120	23	24	7	33	106	1	26

To be able to use `provincedata` and `districtdata`, we will need to standardise the raw counts. The usual way to standardise is by calculating rates usually expressed per 10,000 or per 100,000 of a particular population. However, data on specific populations required for the indicators of interest are not available.

As an alternative, we can use available population data per province and per district as a standardising factor to be able to compare the raw counts with each other. It should be made clear that these are not the same as the standard rates hence are not comparable to those. However, standardised values will allow comparison of values across provinces and districts to show general trends rather than on specific absolute values.

Population data at province and district level of Papua New Guinea is available via the `papuanewguinea` R package. Province population data can be accessed in R via a call to `pop_adm1`. District population data can be accessed in R via a call to `pop_adm2`.

The data frame `pop_adm1` is as follows:

ADM1_EN	ADM1_PCODE	ADM0_EN	ADM0_PCODE	WARDS	UNITS	HOUSEHOLDS	PERSONS	MALES	FEMALES	WRA
Western Province	PG01	Papua New Guinea	PG	307	872	36800	234745	120970	113775	59618
Gulf Province	PG02	Papua New Guinea	PG	144	531	25819	158197	81814	76383	40025
Central Province	PG03	Papua New Guinea	PG	209	1109	41309	269756	142231	127525	66823
National Capital District	PG04	Papua New Guinea	PG	9	520	47559	364125	194834	169291	88708
Milne Bay Province	PG05	Papua New Guinea	PG	391	1169	55262	276512	143791	132721	69546
Northern (Oro) Province	PG06	Papua New Guinea	PG	158	948	34117	186309	97188	89121	46699
Southern Highlands Province	PG07	Papua New Guinea	PG	465	2628	88041	510245	263523	246722	129282
Hela Province	PG21	Papua New Guinea	PG	260	1616	65271	249449	128895	120554	63170
Enga Province	PG08	Papua New Guinea	PG	365	1015	76421	432045	224663	207382	108668
Jiwaka Province	PG22	Papua New Guinea	PG	190	1191	49298	243886	125458	118628	62161
Western Highlands Province	PG09	Papua New Guinea	PG	298	1145	85101	362850	183791	179059	93827
Chimbu (Simbu) Province	PG10	Papua New Guinea	PG	315	1494	81668	407567	214219	193348	101314
Eastern Highlands Province	PG11	Papua New Guinea	PG	259	3393	136992	579825	301048	278777	146079
Morobe Province	PG12	Papua New Guinea	PG	521	2429	130109	674810	350902	323908	169728
Madang Province	PG13	Papua New Guinea	PG	442	1708	86140	493906	257581	236325	123834
East Sepik Province	PG14	Papua New Guinea	PG	625	1481	87465	450343	225933	224468	117621
West Sepik (Sandaun) Province	PG15	Papua New Guinea	PG	336	926	44934	248411	127771	120640	63215
Manus Province	PG16	Papua New Guinea	PG	122	224	10360	60485	31161	29324	15366
New Ireland Province	PG17	Papua New Guinea	PG	138	631	29634	194067	102494	91573	47984
East New Britain Province	PG18	Papua New Guinea	PG	370	790	58458	328369	168760	159609	83635
West New Britain Province	PG19	Papua New Guinea	PG	107	734	50744	264264	138942	125322	65669
Autonomous Region of Bougainville	PG20	Papua New Guinea	PG	81	1069	48233	249358	127990	121368	63597

The data frame `pop_adm2` is as follows:

ADM2_EN	ADM2_PCODE	ADM1_EN	ADM1_PCODE	ADM0_EN	ADM0_PCODE	WARDS	UNITS	HOUSEHOLDS	PERSONS	MALES	FEMALES	WRA
North Fly District	PG0102	Western Province	PG01	Papua New Guinea	PG	110	336	15828	96244	49596	46648	24444
Middle Fly District	PG0101	Western Province	PG01	Papua New Guinea	PG	125	308	11661	79349	40891	38458	20152
South Fly District	PG0103	Western Province	PG01	Papua New Guinea	PG	72	228	9311	59152	30483	28669	15023
Kikori District	PG0202	Gulf Province	PG02	Papua New Guinea	PG	77	215	7810	50966	25812	25154	13181
Kerema District	PG0201	Gulf Province	PG02	Papua New Guinea	PG	67	316	18009	107231	56002	51229	26844
Kairuku - Hiri District	PG0303	Central Province	PG03	Papua New Guinea	PG	76	448	18147	121586	64150	57436	30096
Rigo District	PG0304	Central Province	PG03	Papua New Guinea	PG	68	259	9099	56509	29539	26970	14132
Abau District	PG0301	Central Province	PG03	Papua New Guinea	PG	42	194	7925	55569	29321	26248	13754
Goilala District	PG0302	Central Province	PG03	Papua New Guinea	PG	23	208	6138	36092	19221	16871	8840
National Capital District	PG0401	National Capital District	PG04	Papua New Guinea	PG	9	520	47559	364125	194834	169291	88708
Alotau District	PG0501	Milne Bay Province	PG05	Papua New Guinea	PG	153	470	19226	99539	52076	47463	24871
Samarai-Murua District	PG0502	Milne Bay Province	PG05	Papua New Guinea	PG	89	341	11258	58590	30138	28452	14909
Esa'ala District	PG0504	Milne Bay Province	PG05	Papua New Guinea	PG	88	171	11570	54467	28323	26144	13699
Kiriwina-Goodenough District	PG0503	Milne Bay Province	PG05	Papua New Guinea	PG	61	187	13208	63916	33254	30662	16067
Sohe District	PG0602	Northern (Oro) Province	PG06	Papua New Guinea	PG	74	461	14413	86547	44977	41570	21783
Ijivitari District	PG0601	Northern (Oro) Province	PG06	Papua New Guinea	PG	84	487	19704	99762	52211	47551	24917
Nipa/Kutubu District	PG0707	Southern Highlands Province	PG07	Papua New Guinea	PG	122	1014	22682	147005	75426	71579	37507
Ialibu/Pangia District	PG0701	Southern Highlands Province	PG07	Papua New Guinea	PG	92	442	12821	63478	32913	30565	16016
Kagua/Erave District	PG0703	Southern Highlands Province	PG07	Papua New Guinea	PG	93	483	14389	74139	39069	35070	18377
Mendi/Munihu District	PG0706	Southern Highlands Province	PG07	Papua New Guinea	PG	92	287	23236	144629	74865	69764	36556
Imbonggu District	PG0702	Southern Highlands Province	PG07	Papua New Guinea	PG	66	402	14913	80994	41250	39744	20826
Koroba/Kopiago District	PG2105	Hela Province	PG21	Papua New Guinea	PG	93	651	22616	73855	38478	35377	18538
Tari/Pori District	PG2108	Hela Province	PG21	Papua New Guinea	PG	69	492	15844	79441	40977	38464	20155
Komo/Magarima District	PG2104	Hela Province	PG21	Papua New Guinea	PG	98	473	26811	96153	49440	46713	24478
Kompiam District	PG0802	Enga Province	PG08	Papua New Guinea	PG	77	194	10465	54624	28404	26220	13739
Wabag District	PG0804	Enga Province	PG08	Papua New Guinea	PG	59	207	12736	73649	38297	35352	18524
Lagaip/Pogera District	PG0803	Enga Province	PG08	Papua New Guinea	PG	103	280	26238	158873	82614	76259	39960
Kandep District	PG0801	Enga Province	PG08	Papua New Guinea	PG	75	222	12177	73102	38013	35089	18387
Wapenamanda District	PG0805	Enga Province	PG08	Papua New Guinea	PG	51	112	14805	71797	37335	34462	18058
Anglimp/South Waghi District	PG2201	Jiwaka Province	PG22	Papua New Guinea	PG	84	665	19229	94008	48042	46166	24191
Mul/Baiyer District	PG0905	Western Highlands Province	PG09	Papua New Guinea	PG	119	217	19387	83036	41886	41150	21563
Tambul/Nebilyer District	PG0907	Western Highlands Province	PG09	Papua New Guinea	PG	86	217	16969	75499	37800	37699	19754
Mt Hagen District	PG0903	Western Highlands Province	PG09	Papua New Guinea	PG	42	367	25822	123299	62787	60512	31708
Dei District	PG0902	Western Highlands Province	PG09	Papua New Guinea	PG	51	344	22923	81016	41318	39698	20802
Jimi District	PG2204	Jiwaka Province	PG22	Papua New Guinea	PG	61	176	14177	71379	37381	33998	17815
North Waghi District	PG2206	Jiwaka Province	PG22	Papua New Guinea	PG	45	350	15892	78499	40035	38464	20155
Karimui/Nomane District	PG1003	Chimbu (Simbu) Province	PG10	Papua New Guinea	PG	64	216	10276	52159	27359	24800	12995
Chuave District	PG1001	Chimbu (Simbu) Province	PG10	Papua New Guinea	PG	57	253	10461	39021	20151	18870	9888
Kundiawa/Gembogl District	PG1005	Chimbu (Simbu) Province	PG10	Papua New Guinea	PG	48	311	14327	78521	41394	37127	19455
Sina Sina Yonggomugl District	PG1006	Chimbu (Simbu) Province	PG10	Papua New Guinea	PG	49	222	11790	56805	29539	27266	14287
Gumine District	PG1002	Chimbu (Simbu) Province	PG10	Papua New Guinea	PG	45	177	12728	56860	30136	26724	14003
Kerowagi District	PG1004	Chimbu (Simbu) Province	PG10	Papua New Guinea	PG	52	315	22086	124201	65640	58561	30686
Obura/Wonenara District	PG1106	Eastern Highlands Province	PG11	Papua New Guinea	PG	64	284	8126	39919	20537	19382	10156
Kainanatu District	PG1104	Eastern Highlands Province	PG11	Papua New Guinea	PG	42	382	28686	126248	65723	60525	31715
Goroka District	PG1102	Eastern Highlands Province	PG11	Papua New Guinea	PG	14	611	23565	103396	53292	50104	26254
Daulo District	PG1101	Eastern Highlands Province	PG11	Papua New Guinea	PG	23	534	14378	45783	24029	21754	11399
Unggai/Benna District	PG1108	Eastern Highlands Province	PG11	Papua New Guinea	PG	20	573	15391	67125	35050	32075	16807
Henganofi District	PG1103	Eastern Highlands Province	PG11	Papua New Guinea	PG	30	543	15191	62904	32503	30401	15930
Lufa District	PG1105	Eastern Highlands Province	PG11	Papua New Guinea	PG	32	209	15387	61057	31749	29308	15357
Okapa District	PG1107	Eastern Highlands Province	PG11	Papua New Guinea	PG	34	257	16268	73393	38165	35228	18459
Tawae/Siassi District	PG1209	Morobe Province	PG12	Papua New Guinea	PG	57	193	10727	54340	28257	26083	13667
Nawae District	PG1208	Morobe Province	PG12	Papua New Guinea	PG	46	190	9030	44556	23169	21387	11207
Huon District	PG1203	Morobe Province	PG12	Papua New Guinea	PG	65	250	16075	77564	40333	37231	19509
Menyamya District	PG1207	Morobe Province	PG12	Papua New Guinea	PG	60	342	17163	87209	45349	41860	21935
Bulolo District	PG1201	Morobe Province	PG12	Papua New Guinea	PG	91	393	20865	101568	52816	48752	25546
Kabwum District	PG1204	Morobe Province	PG12	Papua New Guinea	PG	66	193	9242	43472	22605	20867	10934
Markham District	PG1206	Morobe Province	PG12	Papua New Guinea	PG	63	306	13352	62495	32497	29998	15719
Lae District	PG1205	Morobe Province	PG12	Papua New Guinea	PG	2	298	21901	148934	77446	71488	37460
Finschafen District	PG1202	Morobe Province	PG12	Papua New Guinea	PG	71	264	11754	54672	28430	26242	13751
Bogia District	PG1301	Madang Province	PG13	Papua New Guinea	PG	91	260	13770	75067	39035	36032	18881
Sumkar District	PG1305	Madang Province	PG13	Papua New Guinea	PG	64	235	15530	84944	45021	39923	20920
Rai Coast District	PG1304	Madang Province	PG13	Papua New Guinea	PG	89	349	14138	83218	42877	40341	21139
Usino Bundi District	PG1306	Madang Province	PG13	Papua New Guinea	PG	66	230	10372	60807	32424	28383	14873
Middle Ramu District	PG1303	Madang Province	PG13	Papua New Guinea	PG	93	282	13334	78892	40515	38377	20110
Madang District	PG1302	Madang Province	PG13	Papua New Guinea	PG	39	352	18996	110978	57709	53269	27913
Ambunti/Drekikier District	PG1401	East Sepik Province	PG14	Papua New Guinea	PG	123	326	15150	71304	35662	35700	18707
Wewak District	PG1404	East Sepik Province	PG14	Papua New Guinea	PG	84	319	16278	87761	43955	43806	22954
Angoram District	PG1402	East Sepik Province	PG14	Papua New Guinea	PG	153	294	16603	98135	50331	47804	25049
Yangoru Saussia District	PG1406	East Sepik Province	PG14	Papua New Guinea	PG	96	186	11680	58878	29247	29631	15527
Wosera Gawi District	PG1405	East Sepik Province	PG14	Papua New Guinea	PG	104	189	12506	62030	30807	31223	16361
Maprik District	PG1403	East Sepik Province	PG14	Papua New Guinea	PG	65	167	15248	72235	35931	36304	19023
Vanimo/Green River District	PG1504	West Sepik (Sandaun) Province	PG15	Papua New Guinea	PG	95	293	11609	69052	36105	32947	17264
Aitape/Lumi District	PG1501	West Sepik (Sandaun) Province	PG15	Papua New Guinea	PG	79	226	11919	72319	37218	35101	18393
Nuku District	PG1502	West Sepik (Sandaun) Province	PG15	Papua New Guinea	PG	80	193	13459	58158	29722	28436	14900
Telefomin District	PG1503	West Sepik (Sandaun) Province	PG15	Papua New Guinea	PG	82	214	7947	48882	24726	24156	12658
Manus District	PG1601	Manus Province	PG16	Papua New Guinea	PG	122	224	10360	60485	31161	29324	15366
Namatanai District	PG1702	New Ireland Province	PG17	Papua New Guinea	PG	90	348	16437	110905	59043	51862	27176
Kavieng District	PG1701	New Ireland Province	PG17	Papua New Guinea	PG	48	283	13197	83162	43451	39711	20809
Gazelle District	PG1801	East New Britain Province	PG18	Papua New Guinea	PG	129	211	24823	129317	66428	62889	32954
Pomio District	PG1803	East New Britain Province	PG18	Papua New Guinea	PG	118	333	13315	71836	36865	34971	18325
Kokopo District	PG1802	East New Britain Province	PG18	Papua New Guinea	PG	84	146	13591	87829	45284	42545	22294
Rabaul District	PG1804	East New Britain Province	PG18	Papua New Guinea	PG	39	100	6729	39387	20183	19204	10063
Kandrian/Gloucester District	PG1901	West New Britain Province	PG19	Papua New Guinea	PG	52	332	16278	74265	38412	35853	18787
Talasea District	PG1902	West New Britain Province	PG19	Papua New Guinea	PG	55	402	34466	189999	100530	89469	46882
South Bougainville District	PG2003	Autonomous Region of Bougainville	PG20	Papua New Guinea	PG	28	351	16330	81675	41654	40021	20971
North Bougainville District	PG2001	Autonomous Region of Bougainville	PG20	Papua New Guinea	PG	27	276	18892	109023	55833	53190	27872
Central Bougainville District	PG2002	Autonomous Region of Bougainville	PG20	Papua New Guinea	PG	26	442	13011	58660	30503	28157	14754

We will need to extract the appropriate information from these population datasets to use for standardising the raw counts. For the type of indicators we will be looking at, the data on population of women of reproductive age would be the most appropriate. This is the data identified as `WRA` in the population datasets.

The most efficient way to work with this population data and the province and district data we produced awhile ago will be to extract the population of women of reproductive age and then attaching it to the province and district data accordingly.

To do this, we will first need to organise the population data in such a way that it can be merged with the province data.

First, we need to extract the data columns that we need from the population data. These will be the province name, the province code and the women of reproductive age population.

For the province population, this can be done as follows:

```
wra_adm1 <- pop_adm1[ , c("ADM1_PCODE", "ADM1_EN", "WRA")]
```

This produces the following data frame object:

ADM1_PCODE	ADM1_EN	WRA
PG01	Western Province	59618
PG02	Gulf Province	40025
PG03	Central Province	66823
PG04	National Capital District	88708
PG05	Milne Bay Province	69546
PG06	Northern (Oro) Province	46699
PG07	Southern Highlands Province	129282
PG21	Hela Province	63170
PG08	Enga Province	108668
PG22	Jiwaka Province	62161
PG09	Western Highlands Province	93827
PG10	Chimbu (Simbu) Province	101314
PG11	Eastern Highlands Province	146079
PG12	Morobe Province	169728
PG13	Madang Province	123834
PG14	East Sepik Province	117621
PG15	West Sepik (Sandaun) Province	63215
PG16	Manus Province	15366
PG17	New Ireland Province	47984
PG18	East New Britain Province	83635
PG19	West New Britain Province	65669
PG20	Autonomous Region of Bougainville	63597

For the district population, this can be done as follows:

```
wra_adm2 <- pop_adm2[ , c("ADM2_PCODE", "ADM2_EN", "ADM1_PCODE", "ADM1_EN", "WRA")]
```

This produces the following data frame object:

ADM2_PCODE	ADM2_EN	ADM1_PCODE	ADM1_EN	WRA
PG0102	North Fly District	PG01	Western Province	24444
PG0101	Middle Fly District	PG01	Western Province	20152
PG0103	South Fly District	PG01	Western Province	15023
PG0202	Kikori District	PG02	Gulf Province	13181
PG0201	Kerema District	PG02	Gulf Province	26844
PG0303	Kairuku - Hiri District	PG03	Central Province	30096
PG0304	Rigo District	PG03	Central Province	14132
PG0301	Abau District	PG03	Central Province	13754
PG0302	Goilala District	PG03	Central Province	8840
PG0401	National Capital District	PG04	National Capital District	88708
PG0501	Alotau District	PG05	Milne Bay Province	24871
PG0502	Samarai-Murua District	PG05	Milne Bay Province	14909
PG0504	Esa'ala District	PG05	Milne Bay Province	13699
PG0503	Kiriwina-Goodenough District	PG05	Milne Bay Province	16067
PG0602	Sohe District	PG06	Northern (Oro) Province	21783
PG0601	Ijivitari District	PG06	Northern (Oro) Province	24917
PG0707	Nipa/Kutubu District	PG07	Southern Highlands Province	37507
PG0701	Ialibu/Pangia District	PG07	Southern Highlands Province	16016
PG0703	Kagua/Erave District	PG07	Southern Highlands Province	18377
PG0706	Mendi/Munihu District	PG07	Southern Highlands Province	36556
PG0702	Imbonggu District	PG07	Southern Highlands Province	20826
PG2105	Koroba/Kopiago District	PG21	Hela Province	18538
PG2108	Tari/Pori District	PG21	Hela Province	20155
PG2104	Komo/Magarima District	PG21	Hela Province	24478
PG0802	Kompiam District	PG08	Enga Province	13739
PG0804	Wabag District	PG08	Enga Province	18524
PG0803	Lagaip/Pogera District	PG08	Enga Province	39960
PG0801	Kandep District	PG08	Enga Province	18387
PG0805	Wapenamanda District	PG08	Enga Province	18058
PG2201	Anglimp/South Waghi District	PG22	Jiwaka Province	24191
PG0905	Mul/Baiyer District	PG09	Western Highlands Province	21563
PG0907	Tambul/Nebilyer District	PG09	Western Highlands Province	19754
PG0903	Mt Hagen District	PG09	Western Highlands Province	31708
PG0902	Dei District	PG09	Western Highlands Province	20802
PG2204	Jimi District	PG22	Jiwaka Province	17815
PG2206	North Waghi District	PG22	Jiwaka Province	20155
PG1003	Karimui/Nomane District	PG10	Chimbu (Simbu) Province	12995
PG1001	Chuave District	PG10	Chimbu (Simbu) Province	9888
PG1005	Kundiawa/Gembogl District	PG10	Chimbu (Simbu) Province	19455
PG1006	Sina Sina Yonggomugl District	PG10	Chimbu (Simbu) Province	14287

Then, we need to organise the population datasets such that the rows of data are in the same sequence as that of the province and district data. This means, the population datasets will have to be ordered in such a way that the province code and district code are sequential. We see that the population datasets are not sequential and as such will need to be re-ordered. This can be done in R as follows:

```
wra_adm1 <- wra_adm1[order(wra_adm1$ADM1_PCODE), ]
wra_adm2 <- wra_adm2[order(wra_adm2$ADM2_PCODE), ]
```

We now need to adjust the admin codes to match the admin codes in the province and district data. We notice that the population admin codes start with `PG` whilst the province and district data don't have this. So, we should adjust the population codes by removing the appended `PG`. This can be done as follows:

```
wra_adm1$ADM1_PCODE <- as.numeric(str_replace(wra_adm1$ADM1_PCODE, "PG", ""))
wra_adm2$ADM2_PCODE <- as.numeric(str_replace(wra_adm2$ADM2_PCODE, "PG", ""))
wra_adm2$ADM1_PCODE <- as.numeric(str_replace(wra_adm2$ADM1_PCODE, "PG", ""))
```

Once the admin codes have been adjusted, we should now calculate a standardising factor which we will call `sf`. Using the population size for women of reproductive age (WRA), we divide this by 100,000 to get a standardising factor that will give an indicator value that is per 100,000 WRA population. This can be done as follows:

```
wra_adm1$sf <- wra_adm1$WRA / 100000
wra_adm2$sf <- wra_adm2$WRA / 100000
```

Once the standardising factor (`sf`) is calculated, the population data can now be merged with the province and district data respectively.

For the province data, this can be done in R as follows:

```
provincedata <- merge(wra_adm1,
                      provincedata,
                      by.x = "ADM1_PCODE",
                      by.y = "pcode")
```

For the district data, we will need to do some processing of the district data because there are two additional districts for the National Capital District whilst in the population data and the map data, there is only one. This can be adjusted in such a way that we can collapse the district data for the National Capital District into a single district. This can be done as follows:

```
x <- colSums(districtdata[districtdata$dcode %in% c(401, 402, 403) &
                            districtdata$year == 2015, ])
y <- colSums(districtdata[districtdata$dcode %in% c(401, 402, 403) &
                            districtdata$year == 2016, ])

xy <- rbind(x, y)

xy[1,1] <- 401
xy[2,1] <- 401

xy[1,2] <- 2015
```

```
xy[2,2] <- 2016

districtdata <- data.frame(rbind(
  districtdata[!districtdata$dcode %in% c(401, 402, 403), ], xy))
```

Once the district data has been adjusted, we can now merge the district data with the district population data. This can be done in R as follows:

```
districtdata <- merge(wra_adm2,
                      districtdata,
                      by.x = "ADM2_PCODE",
                      by.y = "dcode")
```

We now have processed datasets for province and district data that has all the information needed to produce various analysis outputs.

b. Processing png_maternal to create datasets that can be used for time series analysis

Further processing of `png_maternal` can be done to allow for time series analysis of the data at monthly intervals for year 2015 and 2016.

Monthly province level data can be produced from `png_maternal` as follows:

```
#
# Aggregate data by month and per year
#
mProvince <- aggregate(
  cbind(bfpills1, combpills1, inj1, uno1, vasectomy, iud1, ovulation1,
        condom1, bfpills2, combpills2, inj2, iud2, ovulation2, condom2,
        anc1, anc4, ancother, tt1, tt2, ttbooster, uno2,
        delhf, deadhf, lbw, still, vbsup, vbcomp, bba,
        delcomp, deadnothf, transhop) ~ month + pcode + year,
  data = png_maternal, FUN = sum)
```

This produces a data frame object named `mProvince`.

month	pcode	year	bfpills1	combpills1	inj1	uno1	vasectomy	iud1	ovulation1	condom1	bfpills2	combpills2	inj2	iud2	ovulation2	condom2	anc1	anc4	ancother	tt1	tt2	ttbooster	uno2	delhf	deadhf	lbw	still	vbsup	vbcomp	bba	delcomp	deadnothf	transhop
apr	01	2015	67	64	240	1	0	2	0	0	262	420	2072	25	1	18	585	183	1471	160	43	202	1	346	0	15	5	8	1	19	21	1	9
aug	01	2015	67	34	224	0	0	0	0	6	208	310	1112	0	56	50	277	152	746	147	25	144	0	192	1	12	1	14	3	10	12	0	4
dec	01	2015	43	35	146	0	0	114	0	5	184	235	1004	0	6	115	180	113	543	81	21	61	0	209	0	16	3	7	1	11	16	0	6
feb	01	2015	105	87	193	426	0	8	58	8	201	399	1140	0	7	21	437	155	1011	158	85	387	426	239	0	24	2	7	0	16	10	0	0
jan	01	2015	104	62	157	1	1	10	0	3	303	604	2045	0	12	13	969	203	1014	146	42	247	1	258	0	17	4	7	2	13	14	0	2
jul	01	2015	69	35	148	4	2	0	2	13	239	271	1420	2	5	33	283	122	910	98	39	170	4	221	0	18	3	10	1	10	14	0	6
jun	01	2015	51	23	132	0	0	5	8	2	161	278	954	50	23	17	272	113	702	65	20	100	0	866	0	16	3	5	0	12	20	0	2
mar	01	2015	73	47	162	0	0	0	0	3	311	360	1296	0	1	14	502	225	1265	149	75	235	0	289	0	21	4	12	3	16	21	2	3
may	01	2015	76	31	117	1	0	0	0	2	326	533	1548	0	0	15	336	178	1231	85	55	168	1	307	3	8	3	20	1	14	10	0	12
nov	01	2015	67	41	227	0	0	50	1	2	326	255	809	0	1	44	289	138	693	100	22	121	0	130	0	5	2	2	5	6	12	0	1
oct	01	2015	73	63	308	0	0	7	4	311	262	317	935	5	7	224	545	115	671	103	11	95	0	179	0	7	1	6	2	11	10	0	2
sep	01	2015	49	22	133	0	0	0	7	35	212	273	1347	0	9	130	298	138	791	101	28	106	0	157	0	7	2	3	0	4	5	0	1
apr	02	2015	28	14	71	0	0	13	1	145	36	105	521	0	0	304	248	184	658	47	7	48	0	182	1	24	4	0	5	28	21	0	11
aug	02	2015	14	13	74	0	0	2	0	0	54	63	354	0	1	2	237	144	471	45	24	63	0	149	0	7	4	2	0	27	11	0	3
dec	02	2015	11	5	18	3	0	0	1	164	17	20	298	0	1	437	98	92	294	19	11	35	3	76	0	3	1	5	1	5	3	0	1
feb	02	2015	58	33	73	0	0	0	1	14	36	49	417	2	1	300	301	101	528	71	11	86	0	130	0	8	7	9	5	22	25	0	4
jan	02	2015	35	25	53	0	0	1	0	11	45	79	368	0	0	3	289	123	357	31	3	78	0	149	0	8	3	14	18	41	14	1	12
jul	02	2015	36	11	43	0	0	0	0	301	50	81	435	0	0	301	169	81	366	23	3	29	0	134	0	10	3	1	4	18	14	0	14
jun	02	2015	26	7	43	0	0	5	0	21	36	71	240	0	0	577	267	132	590	77	10	68	0	163	2	12	2	1	5	17	15	1	3
mar	02	2015	16	13	62	0	0	2	0	202	68	42	273	1	0	102	251	186	571	47	18	127	0	141	0	5	4	4	7	29	21	2	6
may	02	2015	19	5	38	0	0	13	2	0	46	84	334	0	0	435	243	155	653	55	17	61	0	169	2	15	6	10	11	25	36	1	5
nov	02	2015	15	13	72	0	0	0	0	16	26	42	251	0	0	457	188	115	345	39	7	67	0	74	0	5	1	7	4	5	3	0	0
oct	02	2015	36	29	88	0	0	7	0	1	25	83	335	0	0	0	245	187	483	61	15	73	0	112	0	15	2	14	5	8	14	1	3
sep	02	2015	21	9	86	0	0	3	0	341	36	76	328	0	3	401	244	154	587	59	9	80	0	146	0	8	7	8	8	32	32	1	5
apr	03	2015	7	19	90	9	0	3	0	1	9	70	410	0	0	1	368	122	891	82	28	113	9	224	1	11	7	4	8	16	8	0	19
aug	03	2015	26	17	126	4	4	2	0	21	21	49	343	0	2	51	340	137	776	88	19	74	4	182	3	5	3	18	7	6	6	2	20
dec	03	2015	8	7	43	18	0	7	4	1	8	35	390	3	11	30	266	124	679	80	21	99	18	168	0	0	0	1	3	14	12	0	20
feb	03	2015	8	25	81	5	0	0	0	36	13	60	357	0	0	62	376	103	631	108	36	130	5	166	1	9	3	13	2	10	12	0	14
jan	03	2015	19	27	62	2	0	9	5	6	23	46	425	0	19	15	551	133	674	121	122	227	2	213	0	6	8	14	6	24	14	0	8
jul	03	2015	12	15	91	3	0	10	0	0	18	66	470	0	2	27	377	173	821	107	43	127	3	204	0	5	5	3	5	15	24	0	27
jun	03	2015	10	4	58	0	0	3	0	7	18	44	336	7	0	7	275	152	740	86	30	116	0	131	1	6	5	11	5	7	10	0	13
mar	03	2015	16	23	80	7	0	10	0	36	9	40	313	0	0	27	456	168	846	106	17	109	7	192	0	4	2	3	5	18	5	0	16
may	03	2015	6	5	57	3	0	8	0	0	11	40	358	0	9	16	334	119	743	112	35	146	3	222	1	11	6	5	5	13	10	1	13
nov	03	2015	13	5	49	2	0	8	0	1	50	38	336	0	0	37	283	141	685	81	27	127	2	182	1	0	1	2	2	16	12	0	12
oct	03	2015	8	17	53	12	0	1	0	0	19	45	366	0	0	39	339	95	787	109	21	90	12	140	0	2	2	9	10	18	1	0	6
sep	03	2015	8	7	65	7	6	32	0	1	19	35	334	0	13	23	288	91	742	105	32	133	7	208	0	4	3	11	1	10	7	0	11
apr	04	2015	32	42	159	0	0	10	0	6	53	430	2172	9	20	38	915	527	2920	339	177	518	0	0	0	0	0	0	0	0	0	0	0
aug	04	2015	29	35	198	0	0	21	5	6	45	391	1841	1	9	28	541	286	1932	248	120	252	0	0	0	0	0	0	0	0	0	0	0
dec	04	2015	13	22	56	14	0	0	0	7	12	126	709	0	7	3	368	186	1193	184	81	326	14	0	0	0	0	0	0	0	0	0	0
feb	04	2015	46	35	214	0	0	0	2	1	51	448	1991	0	5	47	1081	387	2467	420	149	658	0	0	0	0	0	0	0	0	0	0	0
jan	04	2015	26	39	201	0	0	0	0	0	26	377	1579	0	2	4	563	203	1372	206	79	290	0	0	0	0	0	0	0	0	0	0	0
jul	04	2015	42	24	139	0	0	0	0	1	50	311	1677	0	19	43	643	340	1780	217	103	327	0	0	0	0	0	0	0	0	0	0	0
jun	04	2015	36	31	166	0	0	7	10	1	54	353	1682	0	33	22	705	300	2130	250	114	300	0	0	0	0	0	0	0	0	0	0	0
mar	04	2015	79	74	188	0	0	12	1	4	56	475	1867	1	26	60	861	368	2213	318	123	604	0	0	0	0	0	0	0	0	0	0	0
may	04	2015	27	38	199	0	0	6	2	0	44	402	1673	3	18	22	766	495	2445	266	193	459	0	0	0	0	0	0	0	0	0	0	0
nov	04	2015	9	12	37	0	0	6	35	2	4	73	455	0	0	8	352	132	928	148	64	165	0	0	0	0	0	0	0	0	0	0	0
oct	04	2015	39	41	136	0	0	6	27	16	26	353	1187	0	16	57	611	226	1556	216	100	293	0	0	0	0	0	0	0	0	0	0	0
sep	04	2015	33	24	170	17	0	9	51	6	45	365	1801	5	19	38	834	327	2293	280	158	369	17	0	0	0	0	0	0	0	0	0	0
apr	05	2015	73	38	217	9	0	17	34	1	78	282	764	2	130	10	647	449	2640	197	141	348	9	450	1	25	8	45	11	14	62	1	11
aug	05	2015	51	30	178	6	0	0	1	12	64	234	653	0	69	17	526	404	2574	186	98	299	6	527	1	71	13	68	15	19	90	1	13
dec	05	2015	35	51	104	1	1	2	1	49	76	347	751	0	62	4	416	277	1957	160	87	203	1	353	0	41	12	24	4	24	49	1	11
feb	05	2015	19	28	109	8	0	0	14	9	44	290	683	0	654	70	647	372	2324	220	81	350	8	403	0	48	13	67	11	16	76	2	31
jan	05	2015	35	36	165	5	0	1	16	25	38	331	768	0	92	29	668	375	2288	239	117	305	5	407	1	47	11	20	7	18	57	0	19
jul	05	2015	86	46	150	9	2	11	25	131	85	225	903	2	69	21	598	516	2988	213	153	347	9	456	1	65	8	43	15	15	70	2	13
jun	05	2015	68	34	204	13	0	0	44	20	129	255	838	0	92	33	598	469	2623	225	164	611	13	473	1	44	7	18	2	15	70	2	19
mar	05	2015	51	44	211	6	13	0	0	1	89	380	1001	0	62	8	726	451	2738	248	115	358	6	470	0	40	12	24	9	31	40	1	17
may	05	2015	49	44	178	17	0	11	27	0	179	233	708	0	62	10	639	423	2528	234	106	351	17	488	0	45	9	29	2	14	60	1	15
nov	05	2015	25	71	166	9	0	0	1	201	56	199	594	0	55	40	451	260	1854	147	97	209	9	279	0	20	6	9	6	9	31	1	10
oct	05	2015	27	39	132	7	1	1	34	0	39	303	957	0	70	11	516	320	2298	150	72	256	7	466	1	73	13	57	22	13	82	1	15
sep	05	2015	28	45	207	3	0	10	3	36	95	411	774	0	112	7	472	376	2371	126	72	224	3	515	4	71	25	63	13	12	105	1	39

Monthly district level data can be produced from `png_maternal` as follows:

```
#
# Aggregate data by district and per year
#
mDistrict <- aggregate(
  cbind(bfpills1, combpills1, inj1, uno1, vasectomy, iud1, ovulation1,
        condom1, bfpills2, combpills2, inj2, iud2, ovulation2, condom2,
        anc1, anc4, ancother, tt1, tt2, ttbooster, uno2,
        delhf, deadhf, lbw, still, vbsup, vbcomp, bba,
        delcomp, deadnothf, transhop) ~ month + dcode + year,
  data = png_maternal, FUN = sum)
```

This produces a data frame object named `mDistrict`.

month	dcode	year	bfpills1	combpills1	inj1	uno1	vasectomy	iud1	ovulation1	condom1	bfpills2	combpills2	inj2	iud2	ovulation2	condom2	anc1	anc4	ancother	tt1	tt2	ttbooster	uno2	delhf	deadhf	lbw	still	vbsup	vbcomp	bba	delcomp	deadnothf	transhop
apr	0101	2015	8	24	36	1	0	0	0	0	30	59	305	0	0	1	181	51	301	4	3	18	1	78	0	7	5	7	0	4	1	0	4
aug	0101	2015	3	10	17	0	0	0	0	1	23	37	136	0	1	5	41	50	164	18	2	34	0	31	0	0	0	3	2	4	1	0	0
dec	0101	2015	6	7	8	0	0	109	0	0	8	42	150	0	0	85	27	13	84	17	0	8	0	78	0	0	1	2	0	1	0	0	0
feb	0101	2015	15	1	57	0	0	0	0	2	39	57	159	0	0	3	137	42	221	64	56	249	0	71	0	12	2	0	0	4	1	0	0
jan	0101	2015	24	8	45	1	0	0	0	1	60	84	352	0	1	2	114	69	346	41	2	41	1	66	0	3	2	3	1	4	0	0	1
jul	0101	2015	25	12	37	0	0	0	0	5	38	35	175	2	0	5	36	13	87	10	0	12	0	31	0	0	1	0	0	2	1	0	3
jun	0101	2015	15	8	40	0	0	2	4	0	30	44	194	0	0	6	86	31	135	17	1	17	0	98	0	0	1	1	0	1	1	0	0
mar	0101	2015	10	17	44	0	0	0	0	2	40	48	252	0	0	3	148	52	345	26	3	34	0	81	0	10	3	7	1	0	4	2	0
may	0101	2015	18	9	36	1	0	0	0	0	30	66	278	0	0	1	91	50	326	8	8	24	1	52	0	0	1	4	0	2	0	0	1
nov	0101	2015	11	8	36	0	0	45	1	2	26	32	115	0	0	0	40	20	115	9	3	21	0	20	0	2	0	0	1	0	0	0	0
oct	0101	2015	2	3	14	0	0	6	0	0	31	23	128	0	0	0	28	14	95	7	1	8	0	30	0	1	0	3	0	3	0	0	0
sep	0101	2015	2	8	13	0	0	0	1	19	23	29	405	0	0	5	28	27	92	7	2	14	0	20	0	0	0	2	0	1	2	0	0
apr	0102	2015	34	10	88	0	0	2	0	0	88	246	1265	25	0	0	223	68	918	73	23	128	0	188	0	6	0	1	0	10	19	0	5
aug	0102	2015	22	11	25	0	0	0	0	0	55	227	787	0	53	2	150	53	433	88	23	85	0	90	1	9	0	11	1	5	10	0	2
dec	0102	2015	16	14	102	0	0	5	0	5	55	147	555	0	2	0	68	46	260	28	15	31	0	56	0	13	1	5	1	8	16	0	5
feb	0102	2015	30	10	97	426	0	0	0	1	88	244	874	0	6	4	215	61	665	68	25	100	426	92	0	9	0	7	0	10	9	0	0
jan	0102	2015	37	21	55	0	1	10	0	0	158	345	1056	0	10	0	817	98	622	98	36	195	0	123	0	7	1	4	0	5	14	0	1
jul	0102	2015	16	12	69	0	1	0	0	1	75	193	932	0	1	0	141	63	605	57	34	110	0	125	0	13	2	10	1	5	12	0	1
jun	0102	2015	15	6	59	0	0	3	4	2	65	157	607	50	23	0	123	55	495	35	19	74	0	694	0	6	2	4	0	8	19	0	2
mar	0102	2015	47	9	99	0	0	0	0	0	98	236	943	0	1	0	247	96	710	94	69	155	0	138	0	10	1	5	2	10	17	0	3
may	0102	2015	41	6	67	0	0	0	0	0	93	272	921	0	0	2	173	86	706	55	45	114	0	183	3	6	2	12	0	6	10	0	11
nov	0102	2015	34	12	163	0	0	5	0	0	119	119	422	0	1	6	120	65	335	42	14	55	0	78	0	3	1	2	1	6	10	0	0
oct	0102	2015	28	49	249	0	0	0	2	2	59	188	437	5	1	2	376	40	339	31	7	39	0	74	0	3	1	1	2	5	10	0	2
sep	0102	2015	25	10	62	0	0	0	0	1	70	173	691	0	1	0	128	46	488	45	21	64	0	63	0	6	2	1	0	3	3	0	0
apr	0103	2015	25	30	116	0	0	0	0	0	144	115	502	0	1	17	181	64	252	83	17	56	0	80	0	2	0	0	1	5	1	1	0
aug	0103	2015	42	13	182	0	0	0	0	5	130	46	189	0	2	43	86	49	149	41	0	25	0	71	0	3	1	0	0	1	1	0	2
dec	0103	2015	21	14	36	0	0	0	0	0	121	46	299	0	4	30	85	54	199	36	6	22	0	75	0	3	1	0	0	2	0	0	1
feb	0103	2015	60	76	39	0	0	8	58	5	74	98	107	0	1	14	85	52	125	26	4	38	0	76	0	3	0	0	0	2	0	0	0
jan	0103	2015	43	33	57	0	0	0	0	2	85	175	637	0	1	11	38	36	46	7	4	11	0	69	0	7	1	0	1	4	0	0	0
jul	0103	2015	28	11	42	4	1	0	2	7	126	43	313	0	4	28	106	46	218	31	5	48	4	65	0	5	0	0	0	3	1	0	2
jun	0103	2015	21	9	33	0	0	0	0	0	66	77	153	0	0	11	63	27	72	13	0	9	0	74	0	10	0	0	0	3	0	0	0
mar	0103	2015	16	21	19	0	0	0	0	1	173	76	101	0	0	11	107	77	210	29	3	46	0	70	0	1	0	0	0	6	0	0	0
may	0103	2015	17	16	14	0	0	0	0	2	203	195	349	0	0	12	72	42	199	22	2	30	0	72	0	2	0	4	1	6	0	0	0
nov	0103	2015	22	21	28	0	0	0	0	0	181	104	272	0	0	38	129	53	243	49	5	45	0	32	0	0	1	0	3	0	2	0	1
oct	0103	2015	43	11	45	0	0	1	2	309	172	106	370	0	6	222	141	61	237	65	3	48	0	75	0	3	0	2	0	3	0	0	0
sep	0103	2015	22	4	58	0	0	0	6	15	119	71	251	0	8	125	142	65	211	49	5	28	0	74	0	1	0	0	0	0	0	0	1
apr	0201	2015	2	5	39	0	0	0	0	0	3	35	201	0	0	0	167	130	399	37	7	33	0	97	0	14	2	0	5	21	8	0	11
aug	0201	2015	1	3	55	0	0	0	0	0	3	15	127	0	1	2	171	91	266	35	14	45	0	73	0	1	2	1	0	23	1	0	3
dec	0201	2015	1	2	9	0	0	0	0	0	5	10	135	0	0	0	68	74	190	9	9	28	0	26	0	0	0	3	1	3	2	0	1
feb	0201	2015	7	4	40	0	0	0	0	0	7	21	208	0	1	0	194	67	336	47	7	82	0	76	0	7	5	3	3	17	9	0	4
jan	0201	2015	5	2	32	0	0	0	0	8	2	25	155	0	0	3	184	43	216	28	3	66	0	76	0	7	3	8	13	31	2	1	11
jul	0201	2015	1	1	8	0	0	0	0	0	5	7	84	0	0	0	75	45	151	8	0	2	0	69	0	3	2	1	2	10	1	0	2
jun	0201	2015	7	0	21	0	0	0	0	0	3	15	124	0	0	1	209	105	372	56	8	61	0	96	0	3	2	1	5	15	3	0	3
mar	0201	2015	3	13	41	0	0	0	0	2	1	22	111	0	0	0	186	133	335	31	13	54	0	69	0	1	2	0	3	20	7	0	6
may	0201	2015	2	0	29	0	0	0	0	0	10	22	154	0	0	0	163	96	388	28	6	45	0	83	1	8	3	1	6	9	12	0	3
nov	0201	2015	1	5	27	0	0	0	0	16	3	15	132	0	0	21	147	86	283	34	6	29	0	44	0	4	1	7	4	3	0	0	0
oct	0201	2015	4	3	57	0	0	0	0	0	5	8	73	0	0	0	157	96	290	32	11	64	0	41	0	3	0	11	2	4	4	0	3
sep	0201	2015	6	1	55	0	0	0	0	0	4	13	118	0	0	1	201	89	395	52	8	73	0	87	0	4	4	8	7	24	14	0	5
apr	0202	2015	26	9	32	0	0	13	1	145	33	70	320	0	0	304	81	54	259	10	0	15	0	85	1	10	2	0	0	7	13	0	0
aug	0202	2015	13	10	19	0	0	2	0	0	51	48	227	0	0	0	66	53	205	10	10	18	0	76	0	6	2	1	0	4	10	0	0
dec	0202	2015	10	3	9	3	0	0	1	164	12	10	163	0	1	437	30	18	104	10	2	7	3	50	0	3	1	2	0	2	1	0	0
feb	0202	2015	51	29	33	0	0	0	1	14	29	28	209	2	0	300	107	34	192	24	4	4	0	54	0	1	2	6	2	5	16	0	0
jan	0202	2015	30	23	21	0	0	1	0	3	43	54	213	0	0	0	105	80	141	3	0	12	0	73	0	1	0	6	5	10	12	0	1
jul	0202	2015	35	10	35	0	0	0	0	301	45	74	351	0	0	301	94	36	215	15	3	27	0	65	0	7	1	0	2	8	13	0	12
jun	0202	2015	19	7	22	0	0	5	0	21	33	56	116	0	0	576	58	27	218	21	2	7	0	67	2	9	0	0	0	2	12	1	0
mar	0202	2015	13	0	21	0	0	2	0	200	67	20	162	1	0	102	65	53	236	16	5	73	0	72	0	4	2	4	4	9	14	2	0
may	0202	2015	17	5	9	0	0	13	2	0	36	62	180	0	0	435	80	59	265	27	11	16	0	86	1	7	3	9	5	16	24	1	2
nov	0202	2015	14	8	45	0	0	0	0	0	23	27	119	0	0	436	41	29	62	5	1	38	0	30	0	1	0	0	0	2	3	0	0
oct	0202	2015	32	26	31	0	0	7	0	1	20	75	262	0	0	0	88	91	193	29	4	9	0	71	0	12	2	3	3	4	10	1	0
sep	0202	2015	15	8	31	0	0	3	0	341	32	63	210	0	3	400	43	65	192	7	1	7	0	59	0	4	3	0	1	8	18	1	0

We can then merge these datasets with the population data that contains the standardising factor. This can be done as follows:

```
mProvince <- merge(wra_adm1, mProvince, by.x = "ADM1_PCODE", by.y = "pcode")
```

For the district data, we will need to make the same adjustments we did to the district data. This can be done as follows:

```
x <- aggregate(
       cbind(dcode, year, bfpills1, combpills1, inj1, uno1, vasectomy, iud1,
             ovulation1, condom1, bfpills2, combpills2, inj2, iud2, ovulation2,
             condom2, anc1, anc4, ancother, tt1, tt2, ttbooster, uno2,
             delhf, deadhf, lbw, still, vbsup, vbcomp, bba, delcomp, deadnothf,
             transhop) ~ month,
       data = mDistrict[mDistrict$dcode %in% c(401, 402, 403) &
                        mDistrict$year == 2015, ],
       FUN = sum)

y <- aggregate(
       cbind(dcode, year, bfpills1, combpills1, inj1, uno1, vasectomy, iud1,
             ovulation1, condom1, bfpills2, combpills2, inj2, iud2, ovulation2,
             condom2, anc1, anc4, ancother, tt1, tt2, ttbooster, uno2,
             delhf, deadhf, lbw, still, vbsup, vbcomp, bba, delcomp, deadnothf,
             transhop) ~ month,
       data = mDistrict[mDistrict$dcode %in% c(401, 402, 403) &
                        mDistrict$year == 2016, ],
       FUN = sum)

xy <- rbind(x, y)

xy$dcode <- 401

xy[ 1:12, 3] <- 2015
xy[13:24, 3] <- 2016

mDistrict <- data.frame(rbind(
  mDistrict[!mDistrict$dcode %in% c(401, 402, 403), ], xy))
```

The resulting `mDistrict` data can now be merged with the district population data as follows:

```
mDistrict <- merge(wra_adm2, mDistrict, by.x = "ADM2_PCODE", by.y = "dcode")
```

We now have processed datasets for time series province and district data that has all the

information needed to produce various analysis outputs.

3. Indicators

Given the Papua New Guinea NHIS data, the following indicators can be possibly calculated:

- Number of pregnant women who has had at least one antenatal care visit (ANC) with a trained health worker per 100,000 women of reproductive age

$$n_{anc1} \div \frac{n_{WRA}}{100000}$$

$where:$

$$\begin{aligned} n_{anc1} &= \text{Number of pregnant women who has had at least 1 ANC visit with a trained health worker} \\ n_{WRA} &= \text{Number of women of reproductive age} \end{aligned}$$

- Number of pregnant women who has had at least four antenatal care visits (ANC) with any service provider per 100,000 women of reproductive age

$$n_{anc4} \div \frac{n_{WRA}}{100000}$$

$where:$

$$\begin{aligned} n_{anc4} &= \text{Number of pregnant women who has had at least 4 ANC visits with any service provider} \\ n_{WRA} &= \text{Number of women of reproductive age} \end{aligned}$$

- Number of pregnant women who received first tetanus toxoid vaccination per 100,000 women of reproductive age

$$n_{tt1} \div \frac{n_{WRA}}{100000}$$

$$where:$$

$$\begin{aligned} n_{tt1} &= \text{Number of pregnant women who received} \\ &\quad \text{first tetanus toxoid vaccination} \\ n_{WRA} &= \text{Number of women of reproductive age} \end{aligned}$$

- Number of pregnant women who received second tetanus toxoid vaccination per 100,000 women of reproductive age

$$n_{tt2} \div \frac{n_{WRA}}{100000}$$

$$where:$$

$$\begin{aligned} n_{tt2} &= \text{Number of pregnant women who received} \\ &\quad \text{second tetanus toxoid vaccination} \\ n_{WRA} &= \text{Number of women of reproductive age} \end{aligned}$$

- Number of pregnant women who received tetanus toxoid booster vaccination per 100,000 women of reproductive age

$$n_{ttbooster} \div \frac{n_{WRA}}{100000}$$

$$where:$$

$$\begin{aligned} n_{ttbooster} &= \text{Number of pregnant women who received} \\ &\quad \text{tetanus toxoid booster vaccination} \\ n_{WRA} &= \text{Number of women of reproductive age} \end{aligned}$$

- Number of pregnant women who delivered in a health facility per 100,000 women of reproductive age

$$n_{delhf} \div \frac{n_{WRA}}{100000}$$

$$where:$$

$$\begin{aligned} n_{delhf} &= \text{Number of pregnant women who delivered} \\ &\quad \text{in a health facility} \\ n_{WRA} &= \text{Number of women of reproductive age} \end{aligned}$$

- Number of pregnant women who delivered a low birth weight child per 100,000 women of reproductive age

$$n_{lbw} \div \frac{n_{WRA}}{100000}$$

$$where:$$

$$\begin{aligned} n_{lbw} &= \text{Number of pregnant women who delivered} \\ &\quad \text{a low birth weight child} \\ n_{WRA} &= \text{Number of women of reproductive age} \end{aligned}$$

- Number of pregnant women who delivered a stillbirth per 100,000 women of reproductive age

$$n_{still} \div \frac{n_{WRA}}{100000}$$

$$where:$$

$$\begin{aligned} n_{still} &= \text{Number of pregnant women who delivered} \\ &\quad \text{a stillbirth} \\ n_{WRA} &= \text{Number of women of reproductive age} \end{aligned}$$

- Number of pregnant women who died during childbirth per 100,000 women of reproductive age

$$n_{deadhf} + n_{deadnothf} \div \frac{n_{WRA}}{100000}$$

$$where:$$

$$\begin{aligned} n_{deadhf} &= \text{Number of pregnant women who died during childbirth at health facility} \\ n_{deadnothf} &= \text{Number of pregnant women who died during childbirth outside of health facility} \\ n_{WRA} &= \text{Number of women of reproductive age} \end{aligned}$$

2. Time-series analysis of monthly NHIS data

Using the data frame objects `mProvince` and `mDistricts`, we can now produce time-series analysis of specific indicators specified above.

At least one antenatal care visit with a trained health worker

We first work with the province data.

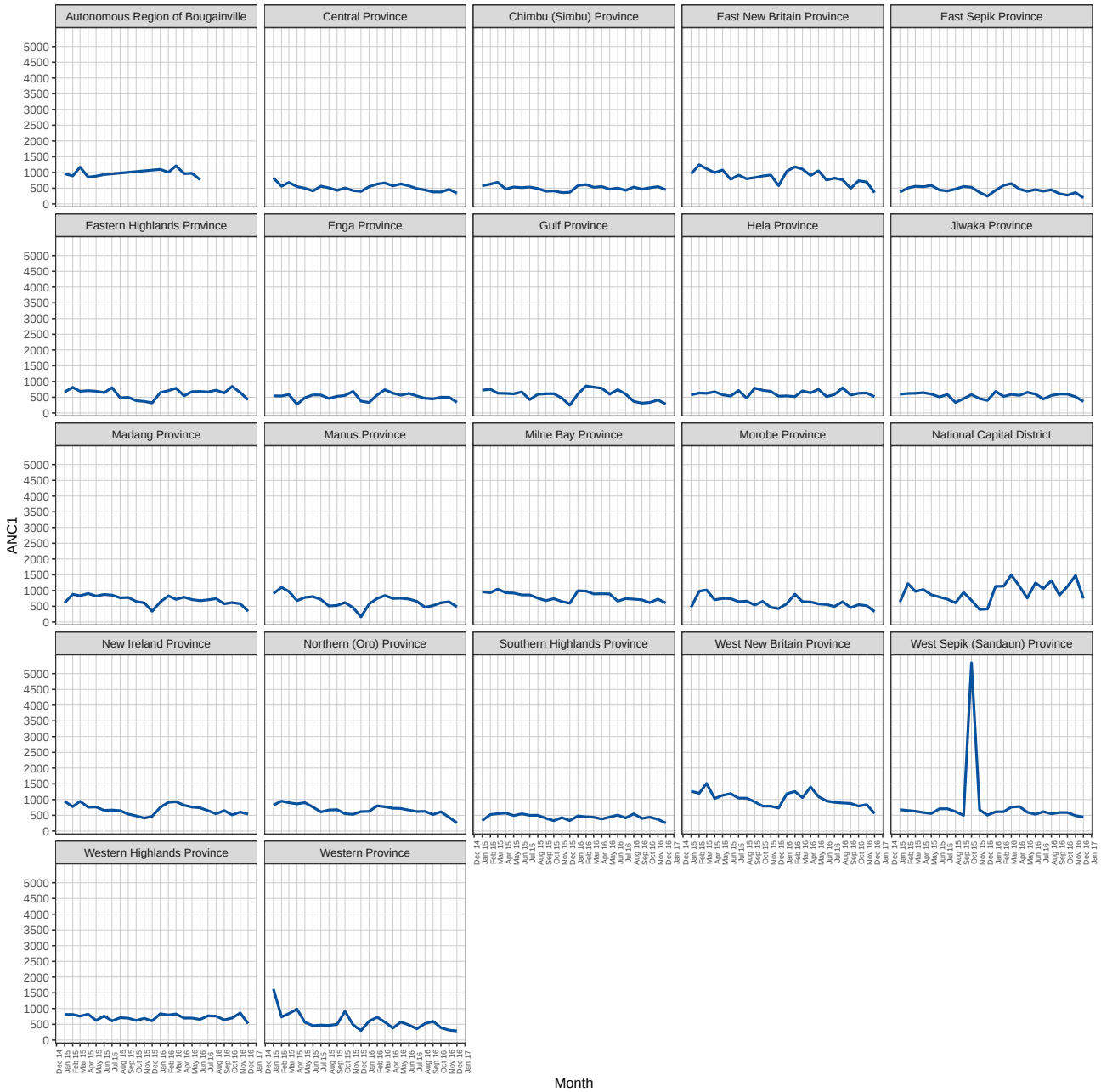
We will work with the data columns labelled `anc1` and `sf`

```
temp1 <- aggregate(anc1 ~ ADM1_PCODE + ADM1_EN + month + year,
                   data = mProvince,
                   FUN = sum)
temp2 <- aggregate(sf ~ ADM1_PCODE + ADM1_EN + month + year,
                   data = mProvince,
                   FUN = unique)

temp1$anc1Std <- temp1$anc1 / temp2$sf

temp1$month <- as.character(temp1$month)

temp1$month[temp1$month == "jan"] <- 1
temp1$month[temp1$month == "feb"] <- 2
temp1$month[temp1$month == "mar"] <- 3
temp1$month[temp1$month == "apr"] <- 4
temp1$month[temp1$month == "may"] <- 5
temp1$month[temp1$month == "jun"] <- 6
temp1$month[temp1$month == "jul"] <- 7
temp1$month[temp1$month == "aug"] <- 8
temp1$month[temp1$month == "sep"] <- 9
temp1$month[temp1$month == "oct"] <- 10
temp1$month[temp1$month == "nov"] <- 11
temp1$month[temp1$month == "dec"] <- 12
```

```r
temp1$date <- paste(temp1$year, temp1$month, sep = "-")

temp1$date <- zoo::as.yearmon(temp1$date)

temp1 <- temp1[order(temp1$date), ]

temp1 <- temp1 %>%
  group_by(ADM1_EN) %>%
  mutate(anc1Sm = rollmean(x = anc1Std, k = 3, na.pad = TRUE))

temp1long <- gather(data = temp1,
                    key = "anc1",
                    value = "value",
                    anc1Std, anc1Sm,
                    factor_key = TRUE)
```

```r
themeSettings <- theme_bw() +
                  theme(panel.grid.major = element_line(linetype = 1,
                                                        size = 0.2,
                                                        colour = "gray80"),
                        panel.grid.minor = element_line(linetype = 0),
                        axis.text.x = element_text(size = 6, angle = 90),
                        legend.key = element_rect(linetype = 0),
                        legend.key.size = unit(1, "cm"),
                        legend.position = "top")
```

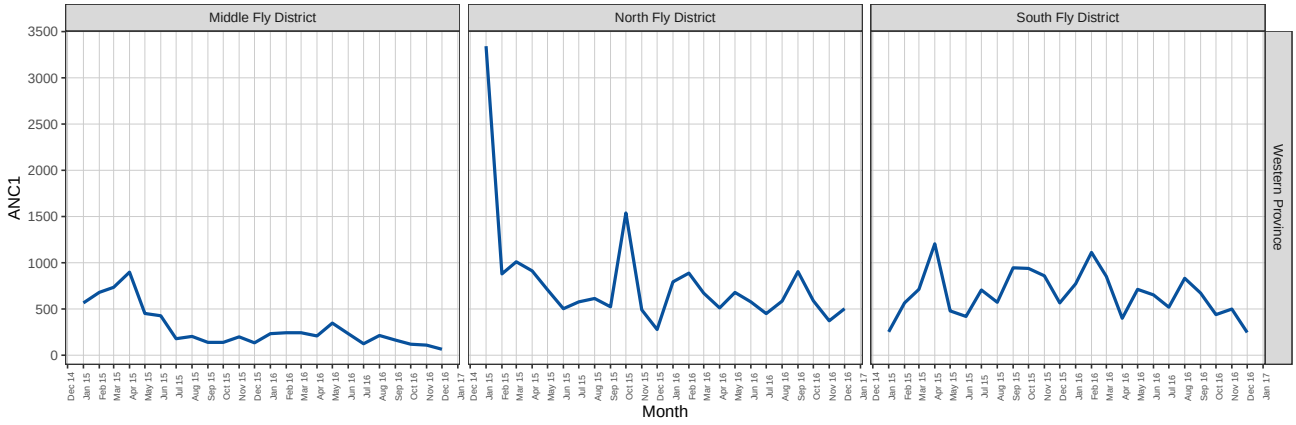
```
ggplot(temp1, aes(as.Date(date), anc1Std)) +
  geom_line(colour = "#08519c", size = 1) +
  scale_x_date(name = "Month",
               date_breaks = "1 month",
               date_labels = "%b %y") +
  scale_y_continuous(name = "ANC1",
                     breaks = seq(from = 0,
                                  to = max(temp1$anc1Std),
                                  by = 500)) +
  facet_wrap(vars(ADM1_EN)) +
  themeSettings
```



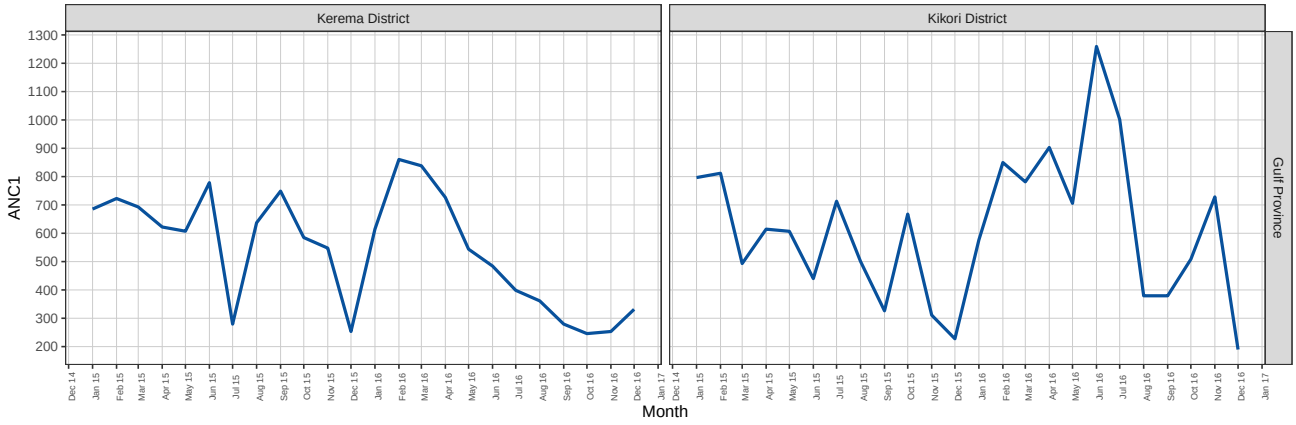
We now work with the district data.

```
dist1 <- aggregate(anc1 ~ ADM2_PCODE + ADM2_EN + ADM1_PCODE + ADM1_EN + month + year,
                   data = mDistrict,
                   FUN = sum)
dist2 <- aggregate(sf ~ ADM2_PCODE + ADM2_EN + ADM1_PCODE + ADM1_EN + month + year,
                   data = mDistrict,
                   FUN = unique)

dist1$anc1Std <- dist1$anc1 / dist2$sf

dist1$month <- as.character(dist1$month)

dist1$month[dist1$month == "jan"] <- 1
dist1$month[dist1$month == "feb"] <- 2
dist1$month[dist1$month == "mar"] <- 3
dist1$month[dist1$month == "apr"] <- 4
dist1$month[dist1$month == "may"] <- 5
dist1$month[dist1$month == "jun"] <- 6
dist1$month[dist1$month == "jul"] <- 7
dist1$month[dist1$month == "aug"] <- 8
dist1$month[dist1$month == "sep"] <- 9
dist1$month[dist1$month == "oct"] <- 10
dist1$month[dist1$month == "nov"] <- 11
dist1$month[dist1$month == "dec"] <- 12

dist1$date <- paste(dist1$year, dist1$month, sep = "-")

dist1$date <- zoo::as.yearmon(dist1$date)
```

```
ggplot(dist1[dist1$ADM1_PCODE == 1, ], aes(as.Date(date), anc1Std)) +
  geom_line(colour = "#08519c", size = 1) +
  scale_x_date(name = "Month", date_breaks = "1 month", date_labels = "%b %y") +
  scale_y_continuous(name = "ANC1",
                     breaks = seq(from = 0,
                                  to = max(dist1$anc1Std),
                                  by = 500)) +
  facet_grid(ADM1_EN ~ ADM2_EN) +
  themeSettings
```

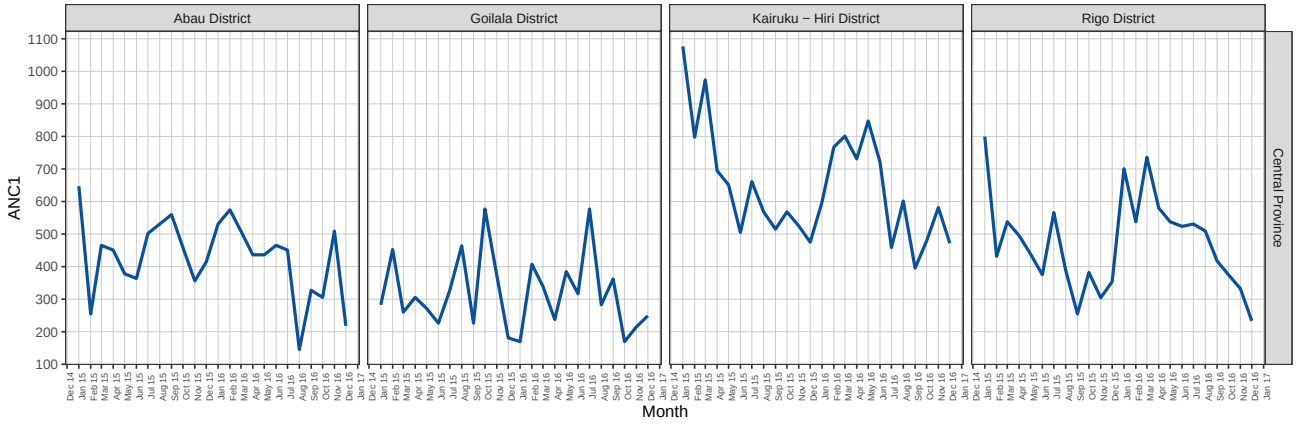



```
ggplot(dist1[dist1$ADM1_PCODE == 2, ], aes(as.Date(date), anc1Std)) +
  geom_line(colour = "#08519c", size = 1) +
  scale_x_date(name = "Month", date_breaks = "1 month", date_labels = "%b %y") +
  scale_y_continuous(name = "ANC1",
                     breaks = seq(from = 0,
                                  to = max(dist1$anc1Std),
                                  by = 100)) +
  facet_grid(ADM1_EN ~ ADM2_EN) +
  themeSettings
```

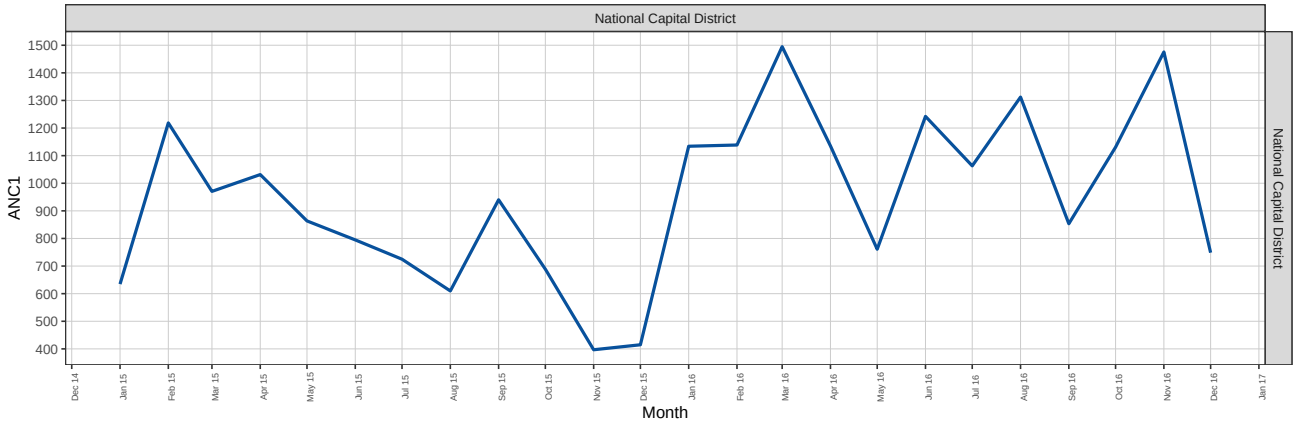



```
ggplot(dist1[dist1$ADM1_PCODE == 3, ], aes(as.Date(date), anc1Std)) +
  geom_line(colour = "#08519c", size = 1) +
  scale_x_date(name = "Month", date_breaks = "1 month", date_labels = "%b %y") +
  scale_y_continuous(name = "ANC1",
                     breaks = seq(from = 0,
                                  to = max(dist1$anc1Std),
                                  by = 100)) +
```

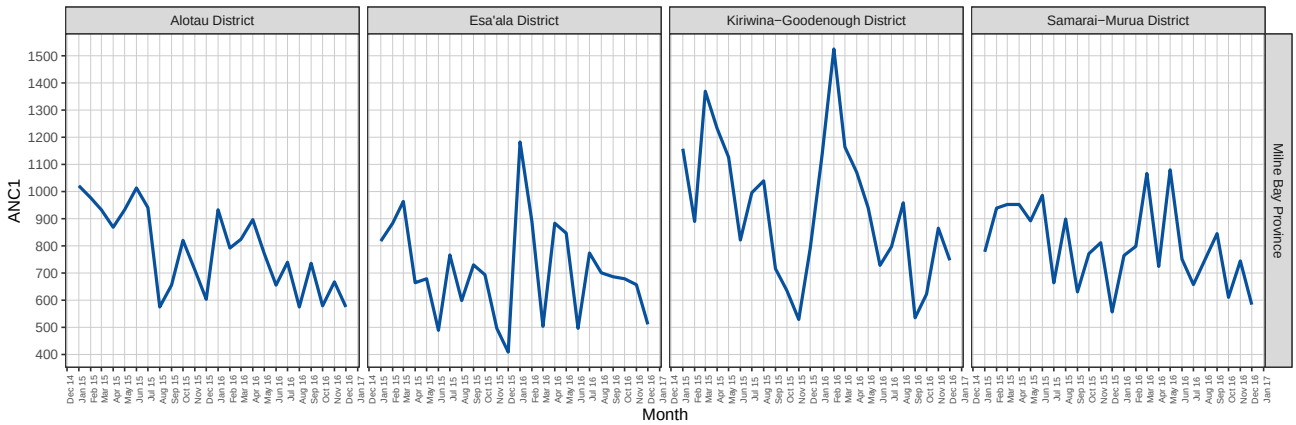
```
  facet_grid(ADM1_EN ~ ADM2_EN) +
  themeSettings
```



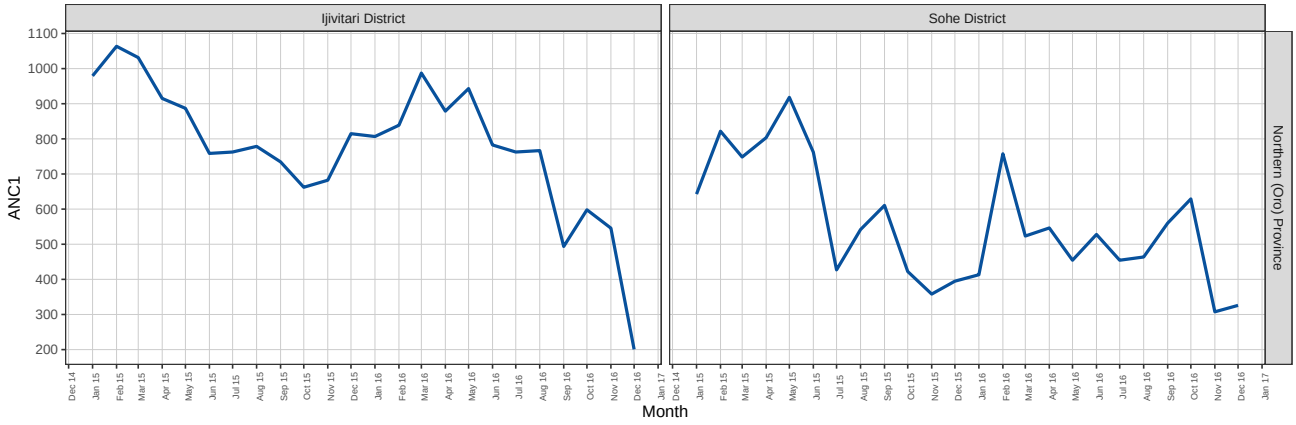

```
ggplot(dist1[dist1$ADM1_PCODE == 4, ], aes(as.Date(date), anc1Std)) +
  geom_line(colour = "#08519c", size = 1) +
  scale_x_date(name = "Month", date_breaks = "1 month", date_labels = "%b %y") +
  scale_y_continuous(name = "ANC1",
                     breaks = seq(from = 0,
                                  to = max(dist1$anc1Std),
                                  by = 100)) +
  facet_grid(ADM1_EN ~ ADM2_EN) +
  themeSettings
```



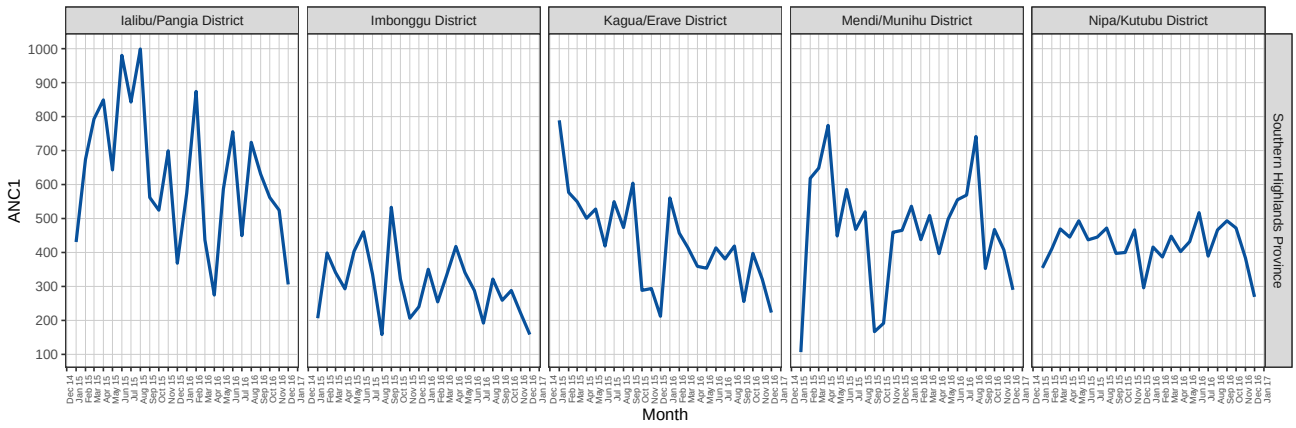

```
ggplot(dist1[dist1$ADM1_PCODE == 5, ], aes(as.Date(date), anc1Std)) +
  geom_line(colour = "#08519c", size = 1) +
  scale_x_date(name = "Month", date_breaks = "1 month", date_labels = "%b %y") +
  scale_y_continuous(name = "ANC1",
                     breaks = seq(from = 0,
                                  to = max(dist1$anc1Std),
                                  by = 100)) +
  facet_grid(ADM1_EN ~ ADM2_EN) +
  themeSettings
```



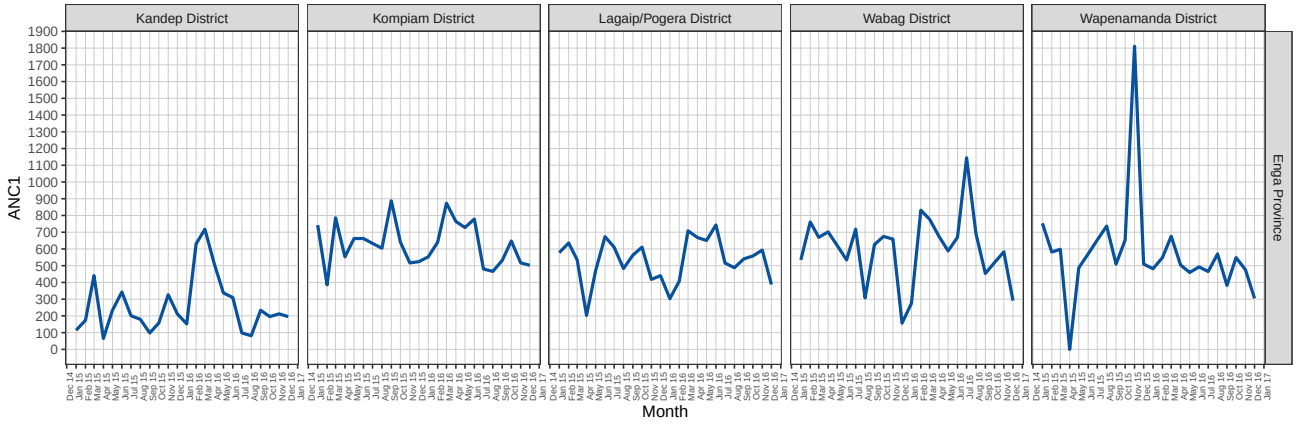

```
ggplot(dist1[dist1$ADM1_PCODE == 6, ], aes(as.Date(date), anc1Std)) +
  geom_line(colour = "#08519c", size = 1) +
  scale_x_date(name = "Month", date_breaks = "1 month", date_labels = "%b %y") +
  scale_y_continuous(name = "ANC1",
                     breaks = seq(from = 0,
                                  to = max(dist1$anc1Std),
                                  by = 100)) +
  facet_grid(ADM1_EN ~ ADM2_EN) +
  themeSettings
```



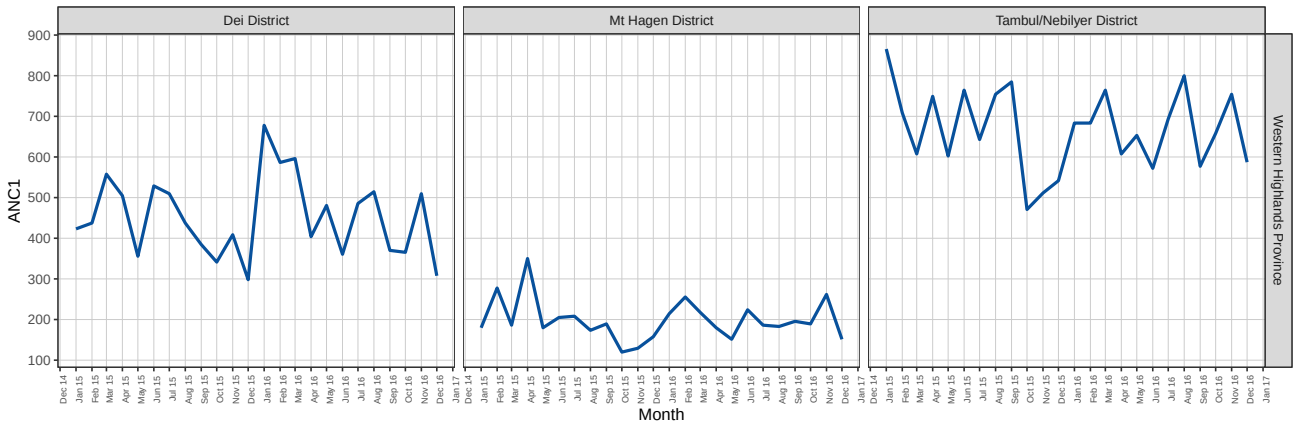

```
ggplot(dist1[dist1$ADM1_PCODE == 7, ], aes(as.Date(date), anc1Std)) +
  geom_line(colour = "#08519c", size = 1) +
  scale_x_date(name = "Month", date_breaks = "1 month", date_labels = "%b %y") +
  scale_y_continuous(name = "ANC1",
                     breaks = seq(from = 0,
                                  to = max(dist1$anc1Std),
                                  by = 100)) +
  facet_grid(ADM1_EN ~ ADM2_EN) +
  themeSettings
```



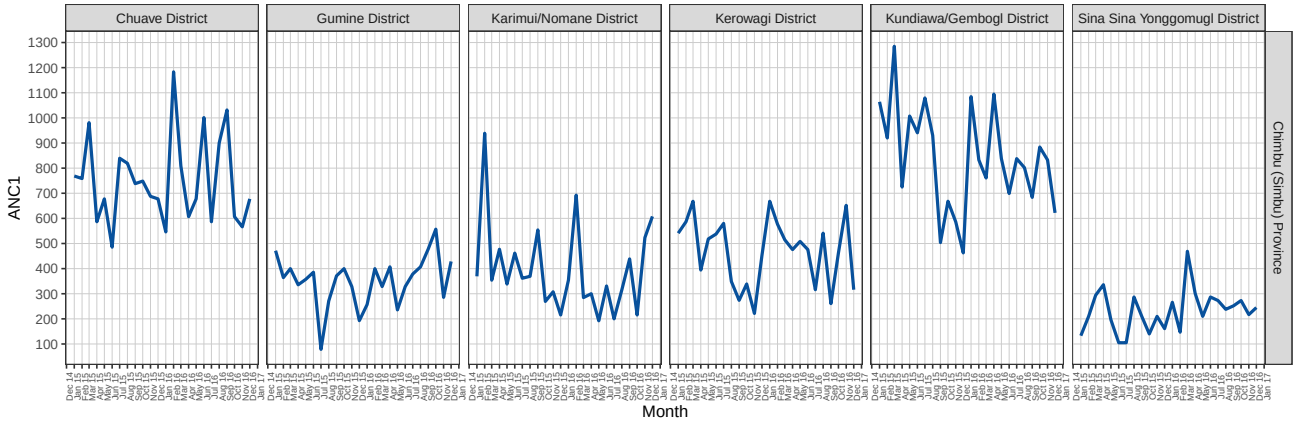

```
ggplot(dist1[dist1$ADM1_PCODE == 8, ], aes(as.Date(date), anc1Std)) +
  geom_line(colour = "#08519c", size = 1) +
  scale_x_date(name = "Month", date_breaks = "1 month", date_labels = "%b %y") +
  scale_y_continuous(name = "ANC1",
                     breaks = seq(from = 0,
                                  to = max(dist1$anc1Std),
                                  by = 100)) +
  facet_grid(ADM1_EN ~ ADM2_EN) +
  themeSettings
```



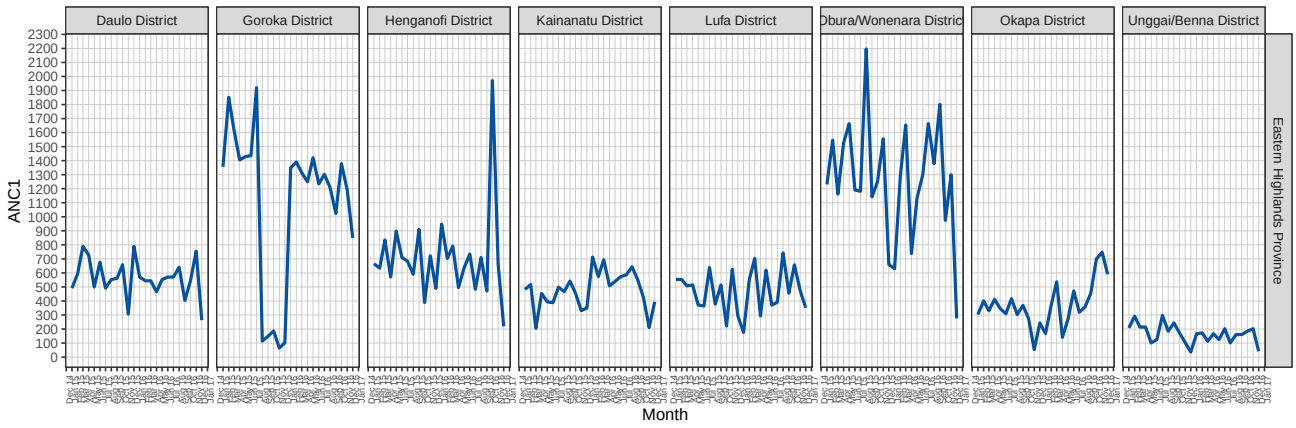

```
ggplot(dist1[dist1$ADM1_PCODE == 9, ], aes(as.Date(date), anc1Std)) +
  geom_line(colour = "#08519c", size = 1) +
  scale_x_date(name = "Month", date_breaks = "1 month", date_labels = "%b %y") +
  scale_y_continuous(name = "ANC1",
                     breaks = seq(from = 0,
                                  to = max(dist1$anc1Std),
                                  by = 100)) +
  facet_grid(ADM1_EN ~ ADM2_EN) +
  themeSettings
```



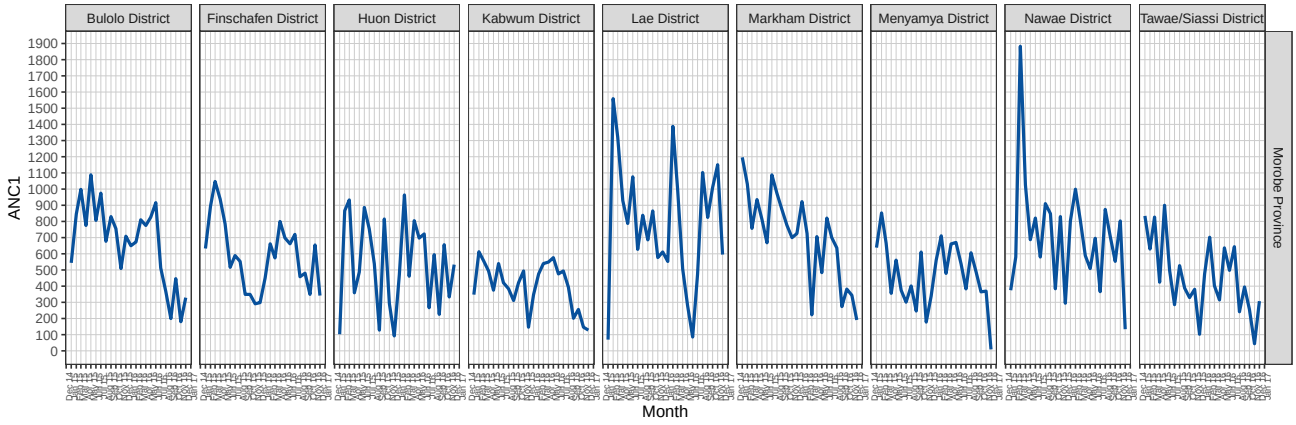

```
ggplot(dist1[dist1$ADM1_PCODE == 10, ], aes(as.Date(date), anc1Std)) +
  geom_line(colour = "#08519c", size = 1) +
  scale_x_date(name = "Month", date_breaks = "1 month", date_labels = "%b %y") +
  scale_y_continuous(name = "ANC1",
                     breaks = seq(from = 0,
                                  to = max(dist1$anc1Std),
                                  by = 100)) +
  facet_grid(ADM1_EN ~ ADM2_EN) +
  themeSettings
```



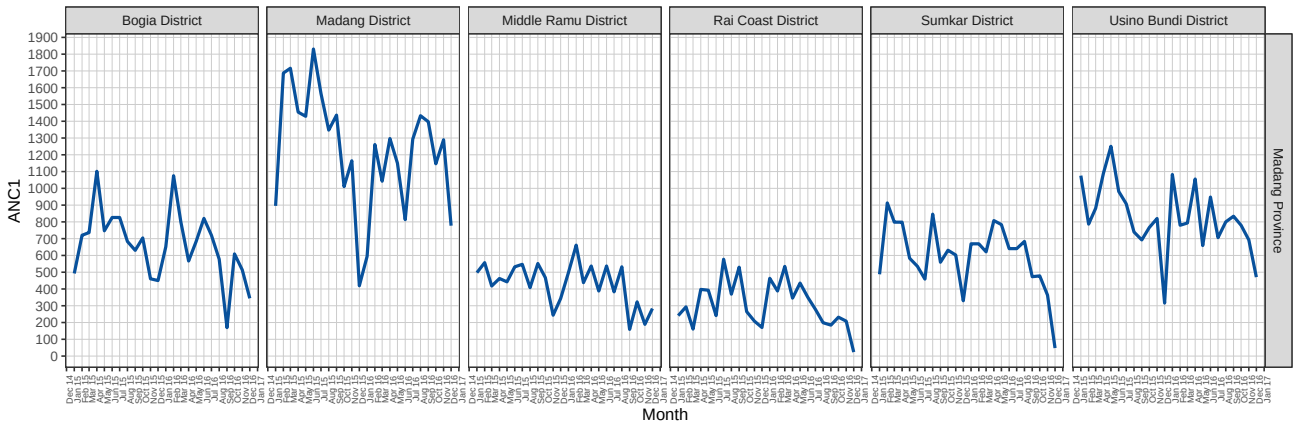

```
ggplot(dist1[dist1$ADM1_PCODE == 11, ], aes(as.Date(date), anc1Std)) +
  geom_line(colour = "#08519c", size = 1) +
  scale_x_date(name = "Month", date_breaks = "1 month", date_labels = "%b %y") +
  scale_y_continuous(name = "ANC1",
                     breaks = seq(from = 0,
                                  to = max(dist1$anc1Std),
                                  by = 100)) +
  facet_grid(ADM1_EN ~ ADM2_EN) +
  themeSettings
```



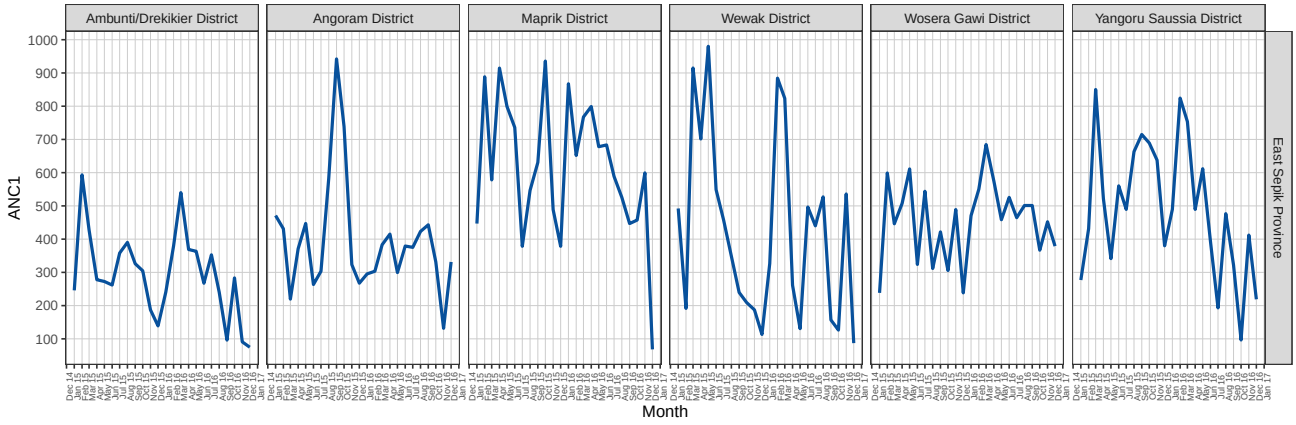

```
ggplot(dist1[dist1$ADM1_PCODE == 12, ], aes(as.Date(date), anc1Std)) +
  geom_line(colour = "#08519c", size = 1) +
  scale_x_date(name = "Month", date_breaks = "1 month", date_labels = "%b %y") +
  scale_y_continuous(name = "ANC1",
                     breaks = seq(from = 0,
                                  to = max(dist1$anc1Std),
                                  by = 100)) +
  facet_grid(ADM1_EN ~ ADM2_EN) +
  themeSettings
```



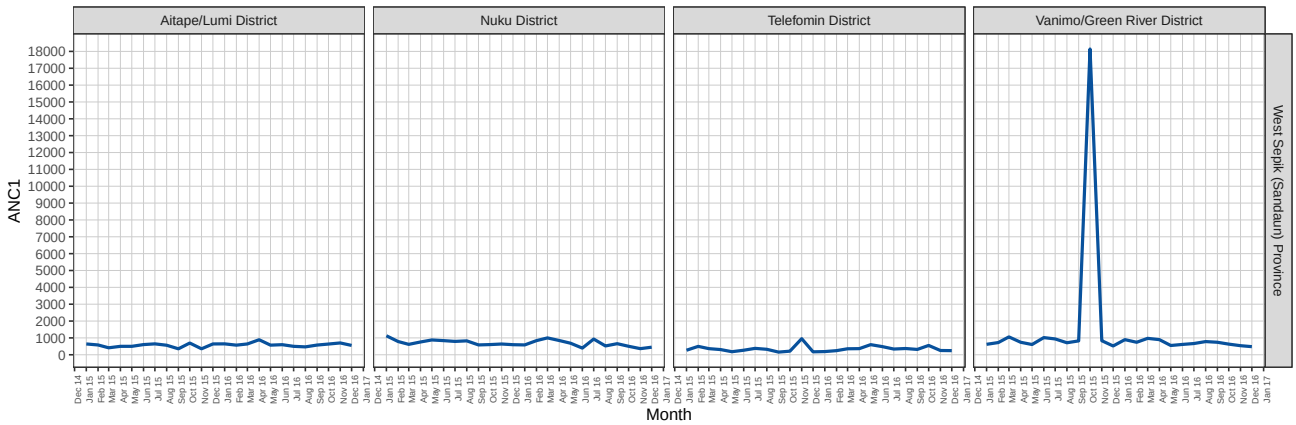

```
ggplot(dist1[dist1$ADM1_PCODE == 13, ], aes(as.Date(date), anc1Std)) +
  geom_line(colour = "#08519c", size = 1) +
  scale_x_date(name = "Month", date_breaks = "1 month", date_labels = "%b %y") +
  scale_y_continuous(name = "ANC1",
                     breaks = seq(from = 0,
                                  to = max(dist1$anc1Std),
                                  by = 100)) +
  facet_grid(ADM1_EN ~ ADM2_EN) +
  themeSettings
```



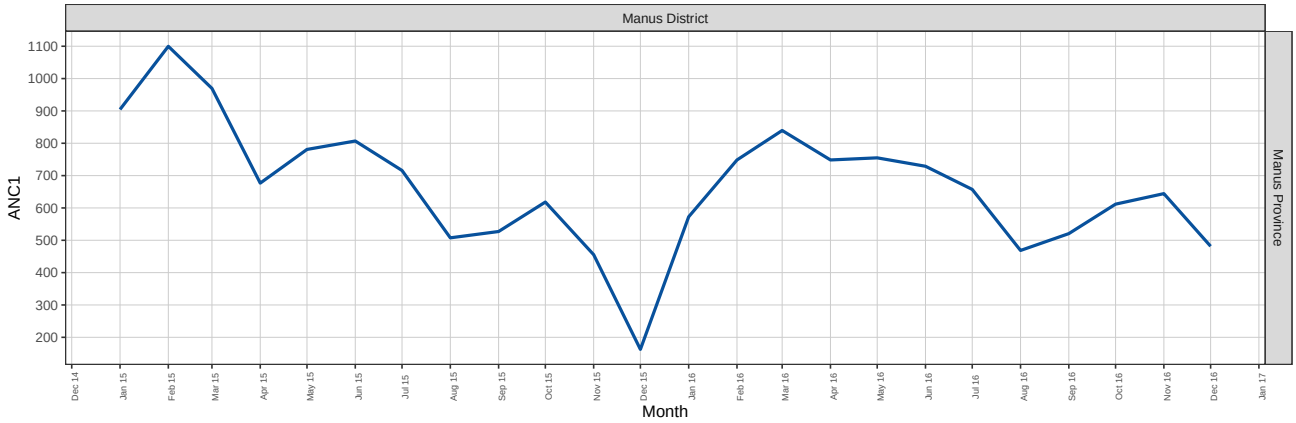

```
ggplot(dist1[dist1$ADM1_PCODE == 14, ], aes(as.Date(date), anc1Std)) +
  geom_line(colour = "#08519c", size = 1) +
  scale_x_date(name = "Month", date_breaks = "1 month", date_labels = "%b %y") +
  scale_y_continuous(name = "ANC1",
                     breaks = seq(from = 0,
                                  to = max(dist1$anc1Std),
                                  by = 100)) +
  facet_grid(ADM1_EN ~ ADM2_EN) +
  themeSettings
```



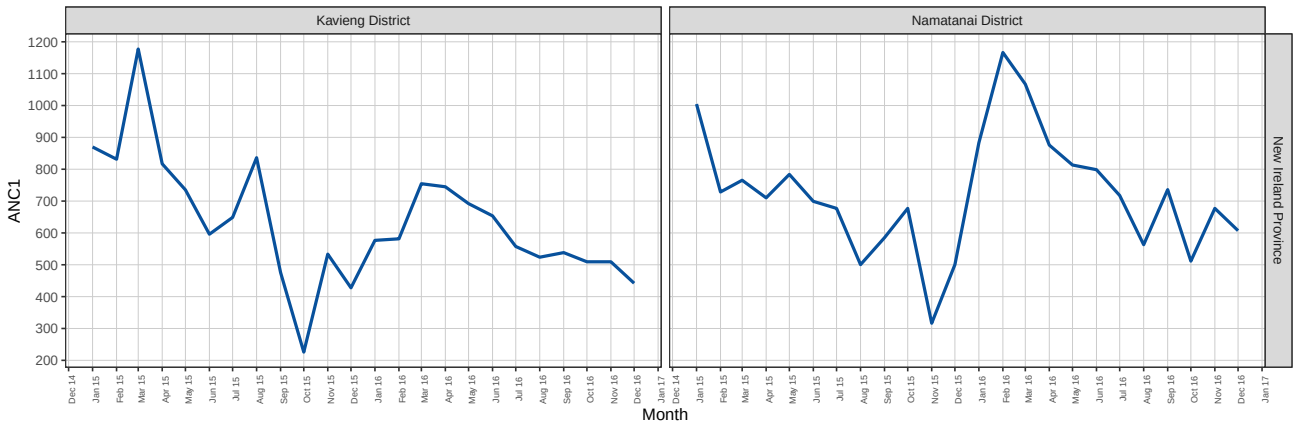

```
ggplot(dist1[dist1$ADM1_PCODE == 15, ], aes(as.Date(date), anc1Std)) +
  geom_line(colour = "#08519c", size = 1) +
  scale_x_date(name = "Month", date_breaks = "1 month", date_labels = "%b %y") +
  scale_y_continuous(name = "ANC1",
                     breaks = seq(from = 0,
                                  to = max(dist1$anc1Std),
                                  by = 1000)) +
  facet_grid(ADM1_EN ~ ADM2_EN) +
  themeSettings
```



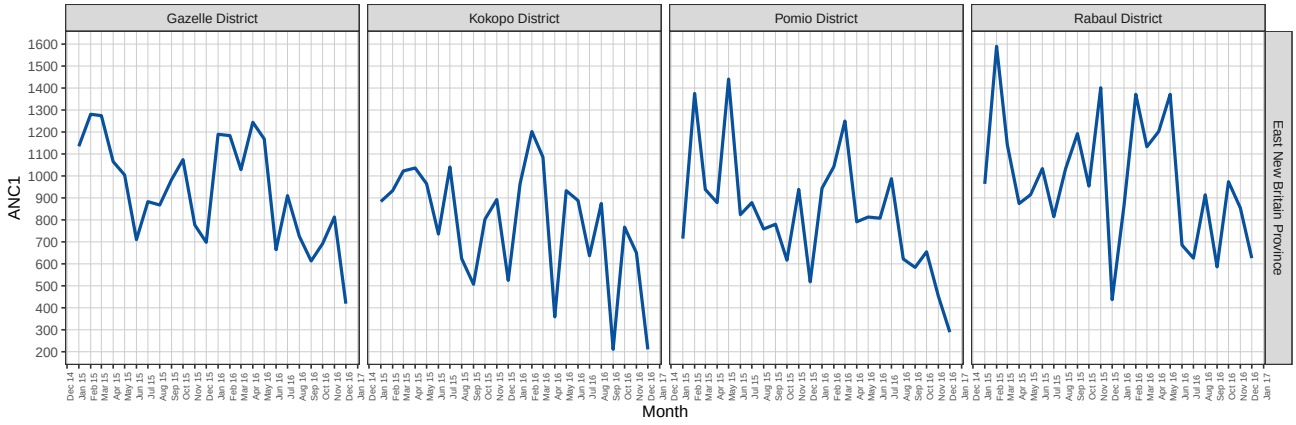

```
ggplot(dist1[dist1$ADM1_PCODE == 16, ], aes(as.Date(date), anc1Std)) +
  geom_line(colour = "#08519c", size = 1) +
  scale_x_date(name = "Month", date_breaks = "1 month", date_labels = "%b %y") +
  scale_y_continuous(name = "ANC1",
                     breaks = seq(from = 0,
                                  to = max(dist1$anc1Std),
                                  by = 100)) +
  facet_grid(ADM1_EN ~ ADM2_EN) +
  themeSettings
```



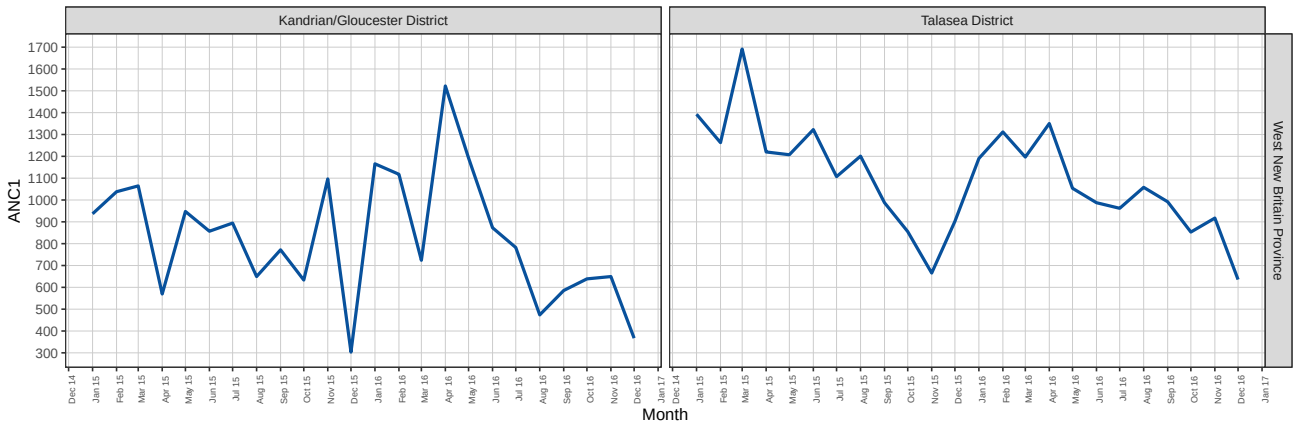

```
ggplot(dist1[dist1$ADM1_PCODE == 17, ], aes(as.Date(date), anc1Std)) +
  geom_line(colour = "#08519c", size = 1) +
  scale_x_date(name = "Month", date_breaks = "1 month", date_labels = "%b %y") +
  scale_y_continuous(name = "ANC1",
                     breaks = seq(from = 0,
                                  to = max(dist1$anc1Std),
                                  by = 100)) +
  facet_grid(ADM1_EN ~ ADM2_EN) +
  themeSettings
```



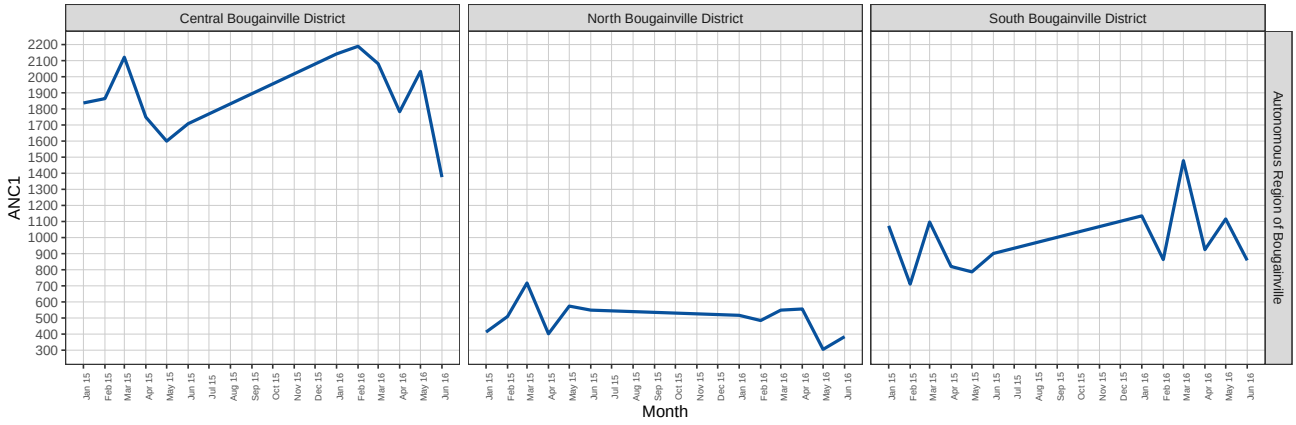

```
ggplot(dist1[dist1$ADM1_PCODE == 18, ], aes(as.Date(date), anc1Std)) +
  geom_line(colour = "#08519c", size = 1) +
  scale_x_date(name = "Month", date_breaks = "1 month", date_labels = "%b %y") +
  scale_y_continuous(name = "ANC1",
                     breaks = seq(from = 0,
                                  to = max(dist1$anc1Std),
                                  by = 100)) +
  facet_grid(ADM1_EN ~ ADM2_EN) +
  themeSettings
```



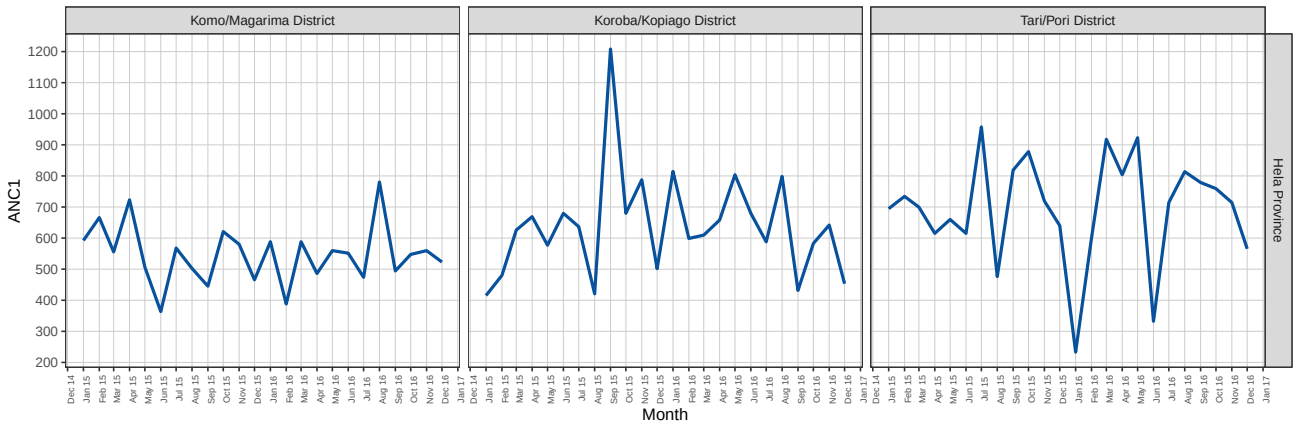

```
ggplot(dist1[dist1$ADM1_PCODE == 19, ], aes(as.Date(date), anc1Std)) +
  geom_line(colour = "#08519c", size = 1) +
  scale_x_date(name = "Month", date_breaks = "1 month", date_labels = "%b %y") +
  scale_y_continuous(name = "ANC1",
                     breaks = seq(from = 0,
                                  to = max(dist1$anc1Std),
                                  by = 100)) +
  facet_grid(ADM1_EN ~ ADM2_EN) +
  themeSettings
```



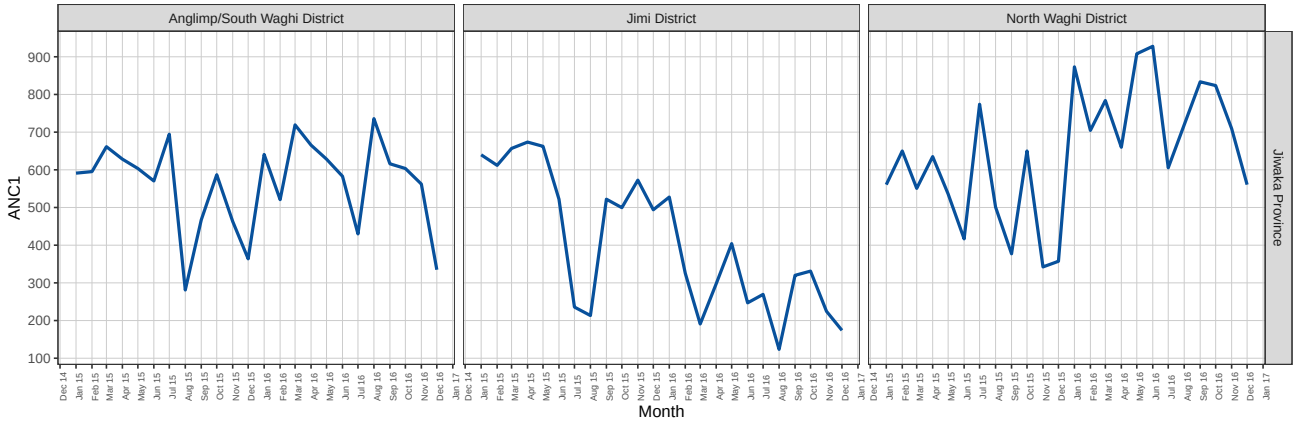

```
ggplot(dist1[dist1$ADM1_PCODE == 20, ], aes(as.Date(date), anc1Std)) +
  geom_line(colour = "#08519c", size = 1) +
  scale_x_date(name = "Month", date_breaks = "1 month", date_labels = "%b %y") +
  scale_y_continuous(name = "ANC1",
                     breaks = seq(from = 0,
                                  to = max(dist1$anc1Std),
                                  by = 100)) +
  facet_grid(ADM1_EN ~ ADM2_EN) +
  themeSettings
```




```
ggplot(dist1[dist1$ADM1_PCODE == 21, ], aes(as.Date(date), anc1Std)) +
  geom_line(colour = "#08519c", size = 1) +
  scale_x_date(name = "Month", date_breaks = "1 month", date_labels = "%b %y") +
  scale_y_continuous(name = "ANC1",
                     breaks = seq(from = 0,
                                  to = max(dist1$anc1Std),
                                  by = 100)) +
  facet_grid(ADM1_EN ~ ADM2_EN) +
  themeSettings
```




```
ggplot(dist1[dist1$ADM1_PCODE == 22, ], aes(as.Date(date), anc1Std)) +
  geom_line(colour = "#08519c", size = 1) +
  scale_x_date(name = "Month", date_breaks = "1 month", date_labels = "%b %y") +
  scale_y_continuous(name = "ANC1",
                     breaks = seq(from = 0,
                                  to = max(dist1$anc1Std),
                                  by = 100)) +
  facet_grid(ADM1_EN ~ ADM2_EN) +
  themeSettings
```



Smoothing time-series data

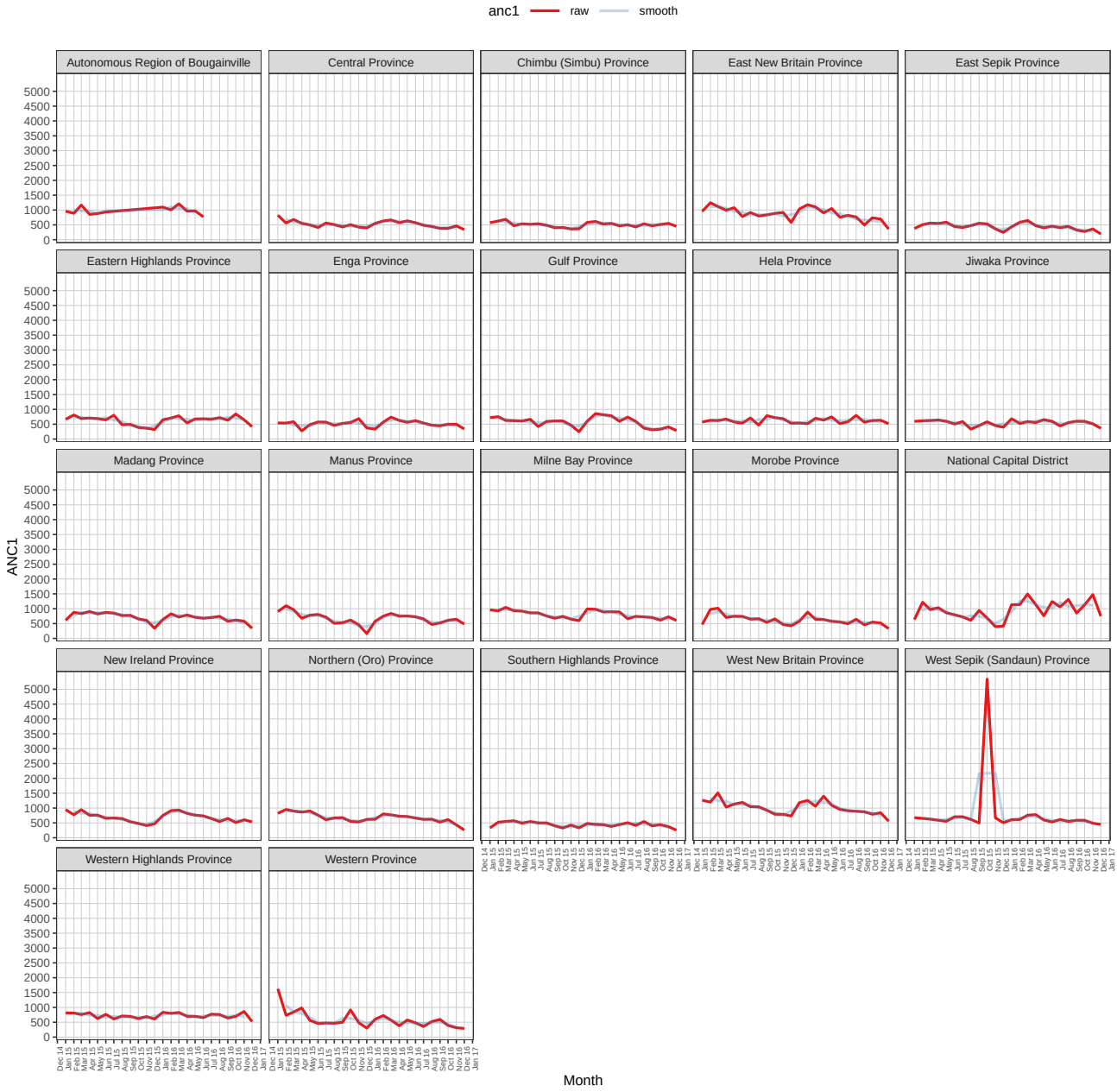
In the line charts above, we will notice that it is not very easy to see the trend of the indicators over time. Smoothing the time-series data is usually done to address this. Smoothing is usually performed using a rolling/running averages. This can be done in R using the function `rollmean()` from the `zoo` package and is implemented as shown below:

```
temp1 <- temp1[order(temp1$date), ]

temp1 <- temp1 %>%
  group_by(ADM1_EN) %>%
  mutate(anc1Sm = rollmean(x = anc1Std, k = 3, na.pad = TRUE))

temp1long <- gather(data = temp1,
                    key = "anc1",
```

```
                    value = "value",
                    anc1Std, anc1Sm,
                    factor_key = TRUE)
```

The smoothed data can then be plotted alongside the raw data as follows (for province data):

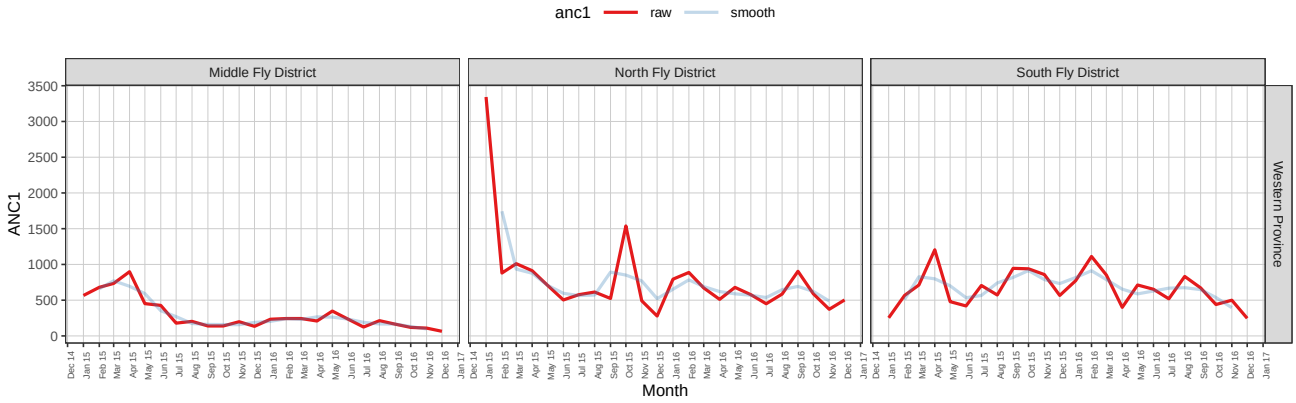
```
ggplot(temp1long, aes(as.Date(date), value, colour = anc1)) +
  geom_line(size = 1) +
  scale_colour_manual(labels = c("raw", "smooth"),
                      values = c("#e41a1c", alpha("#377eb8", 0.3))) +
  scale_x_date(name = "Month",
               date_breaks = "1 month",
               date_labels = "%b %y") +
  scale_y_continuous(name = "ANC1",
                     breaks = seq(from = 0,
                                  to = max(temp1$anc1Std),
                                  by = 500)) +
  facet_wrap(vars(ADM1_EN)) +
  themeSettings
```



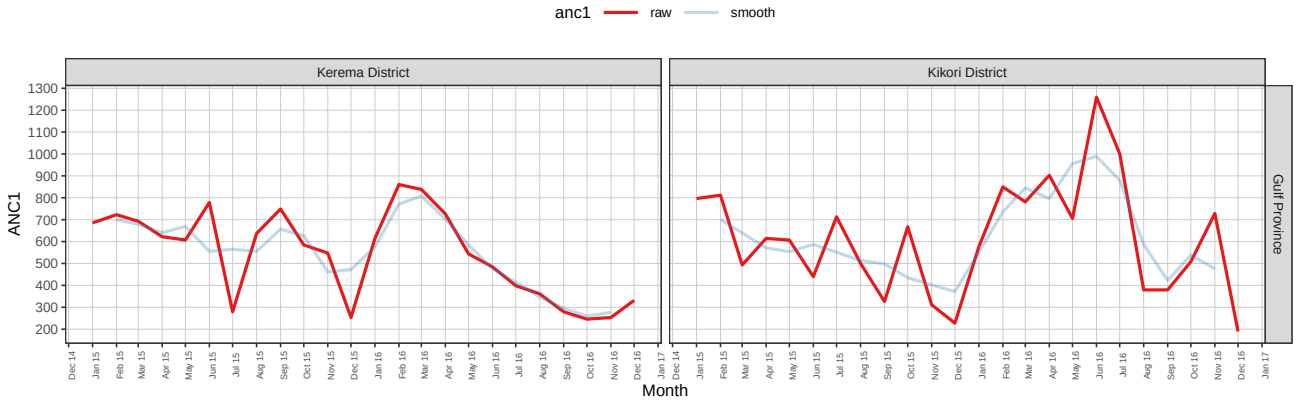
We can do the same for the district data.

```
dist1 <- dist1[order(dist1$date), ]

dist1 <- dist1 %>%
  group_by(ADM2_EN) %>%
  mutate(anc1Sm = rollmean(x = anc1Std, k = 3, na.pad = TRUE))

dist1long <- gather(data = dist1,
                    key = "anc1",
                    value = "value",
                    anc1Std, anc1Sm,
                    factor_key = TRUE)
```

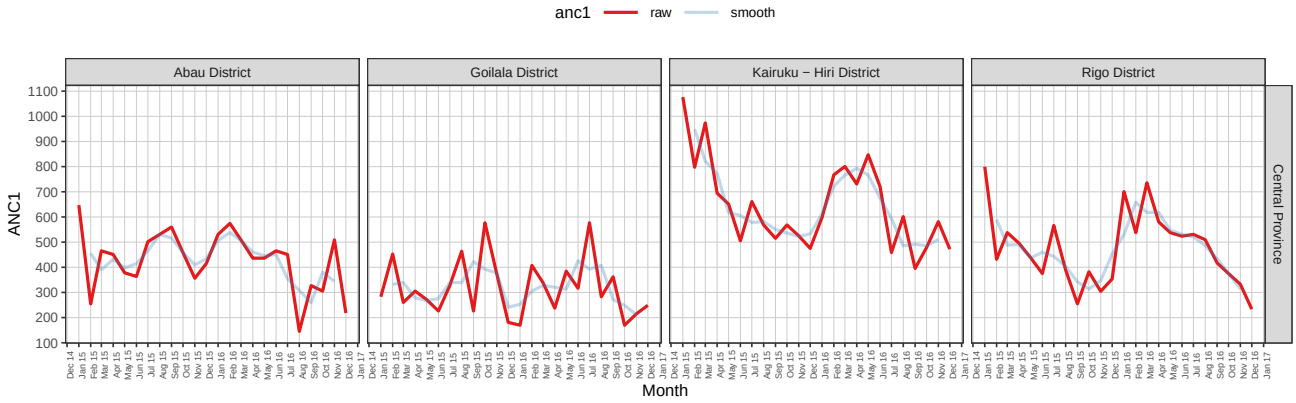
```
ggplot(dist1long[dist1long$ADM1_PCODE == 1, ],
       aes(as.Date(date), value, colour = anc1)) +
  geom_line(size = 1) +
  scale_colour_manual(labels = c("raw", "smooth"),
                      values = c("#e41a1c", alpha("#377eb8", 0.3))) +
  scale_x_date(name = "Month",
               date_breaks = "1 month",
               date_labels = "%b %y") +
  scale_y_continuous(name = "ANC1",
                     breaks = seq(from = 0,
                                  to = max(dist1$anc1Std),
                                  by = 500)) +
  facet_grid(ADM1_EN ~ ADM2_EN) +
  themeSettings
```



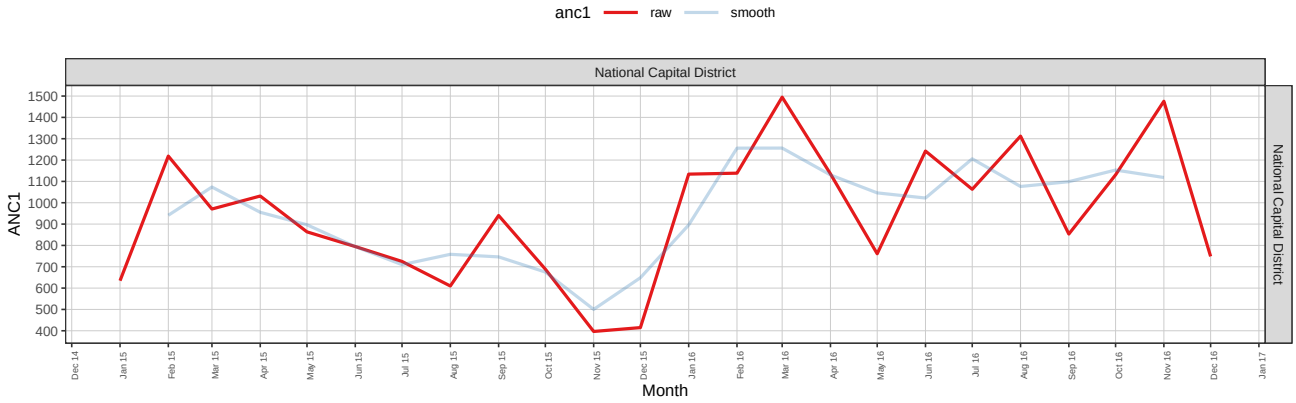

```
ggplot(dist1long[dist1long$ADM1_PCODE == 2, ],
       aes(as.Date(date), value, colour = anc1)) +
  geom_line(size = 1) +
  scale_colour_manual(labels = c("raw", "smooth"),
                      values = c("#e41a1c", alpha("#377eb8", 0.3))) +
  scale_x_date(name = "Month",
               date_breaks = "1 month",
               date_labels = "%b %y") +
  scale_y_continuous(name = "ANC1",
                     breaks = seq(from = 0,
                                  to = max(dist1$anc1Std),
                                  by = 100)) +
  facet_grid(ADM1_EN ~ ADM2_EN) +
  themeSettings
```



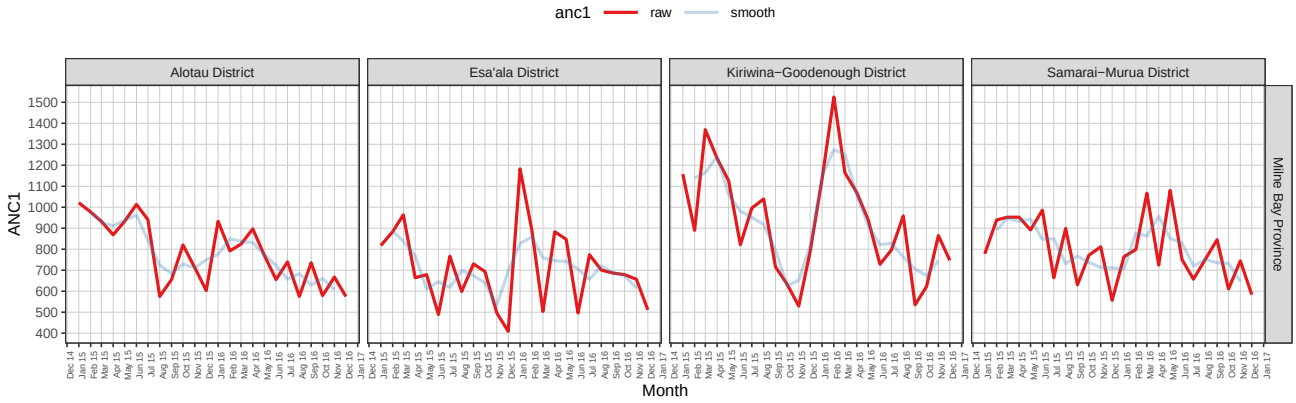

```
ggplot(dist1long[dist1long$ADM1_PCODE == 3, ],
       aes(as.Date(date), value, colour = anc1)) +
  geom_line(size = 1) +
  scale_colour_manual(labels = c("raw", "smooth"),
                      values = c("#e41a1c", alpha("#377eb8", 0.3))) +
  scale_x_date(name = "Month",
               date_breaks = "1 month",
               date_labels = "%b %y") +
  scale_y_continuous(name = "ANC1",
                     breaks = seq(from = 0,
                                  to = max(dist1$anc1Std),
                                  by = 100)) +
  facet_grid(ADM1_EN ~ ADM2_EN) +
  themeSettings
```



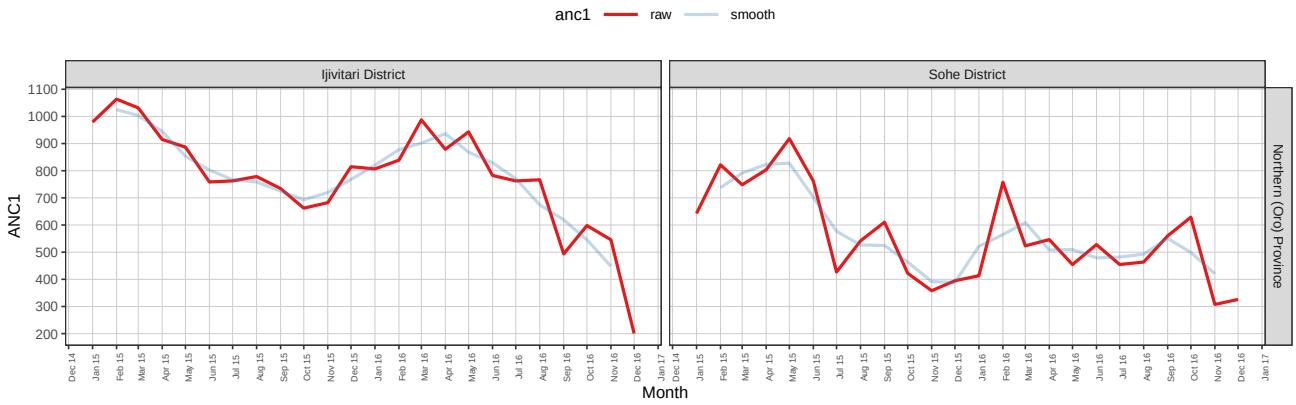

```
ggplot(dist1long[dist1long$ADM1_PCODE == 4, ],
       aes(as.Date(date), value, colour = anc1)) +
  geom_line(size = 1) +
  scale_colour_manual(labels = c("raw", "smooth"),
                      values = c("#e41a1c", alpha("#377eb8", 0.3))) +
  scale_x_date(name = "Month",
               date_breaks = "1 month",
               date_labels = "%b %y") +
  scale_y_continuous(name = "ANC1",
                     breaks = seq(from = 0,
                                  to = max(dist1$anc1Std),
                                  by = 100)) +
  facet_grid(ADM1_EN ~ ADM2_EN) +
  themeSettings
```



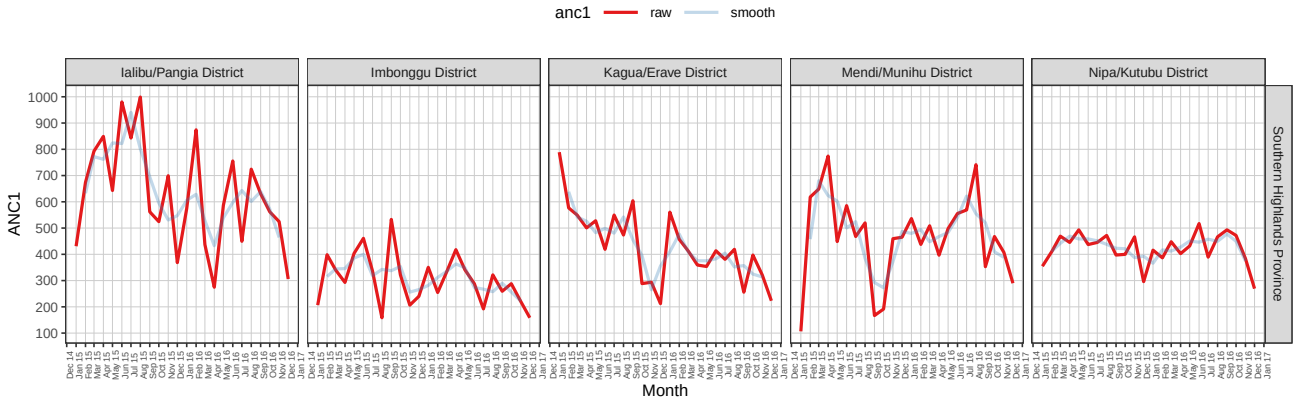

```
ggplot(dist1long[dist1long$ADM1_PCODE == 5, ],
       aes(as.Date(date), value, colour = anc1)) +
  geom_line(size = 1) +
  scale_colour_manual(labels = c("raw", "smooth"),
                      values = c("#e41a1c", alpha("#377eb8", 0.3))) +
  scale_x_date(name = "Month",
               date_breaks = "1 month",
               date_labels = "%b %y") +
  scale_y_continuous(name = "ANC1",
                     breaks = seq(from = 0,
                                  to = max(dist1$anc1Std),
                                  by = 100)) +
  facet_grid(ADM1_EN ~ ADM2_EN) +
  themeSettings
```



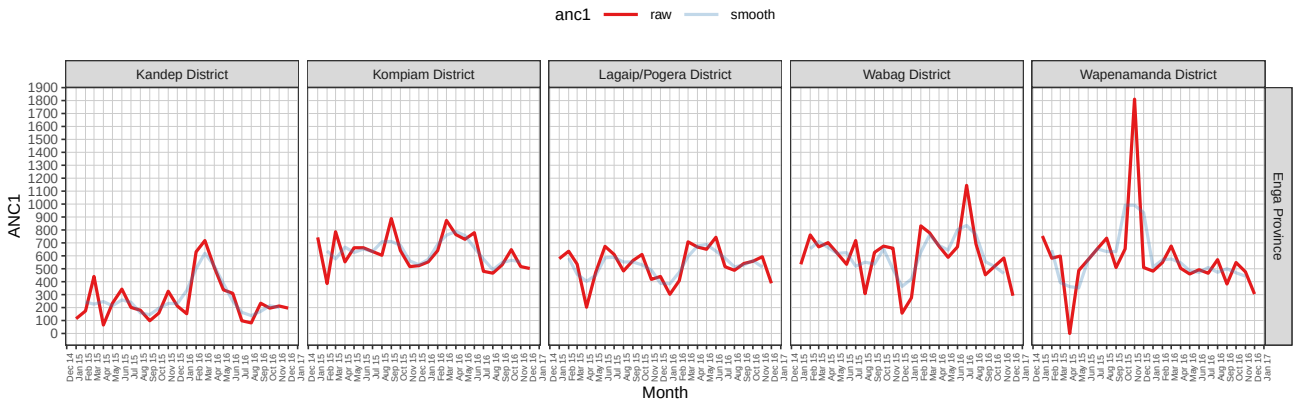

```
ggplot(dist1long[dist1long$ADM1_PCODE == 6, ],
       aes(as.Date(date), value, colour = anc1)) +
  geom_line(size = 1) +
  scale_colour_manual(labels = c("raw", "smooth"),
                      values = c("#e41a1c", alpha("#377eb8", 0.3))) +
  scale_x_date(name = "Month",
               date_breaks = "1 month",
               date_labels = "%b %y") +
  scale_y_continuous(name = "ANC1",
                     breaks = seq(from = 0,
                                  to = max(dist1$anc1Std),
                                  by = 100)) +
  facet_grid(ADM1_EN ~ ADM2_EN) +
  themeSettings
```



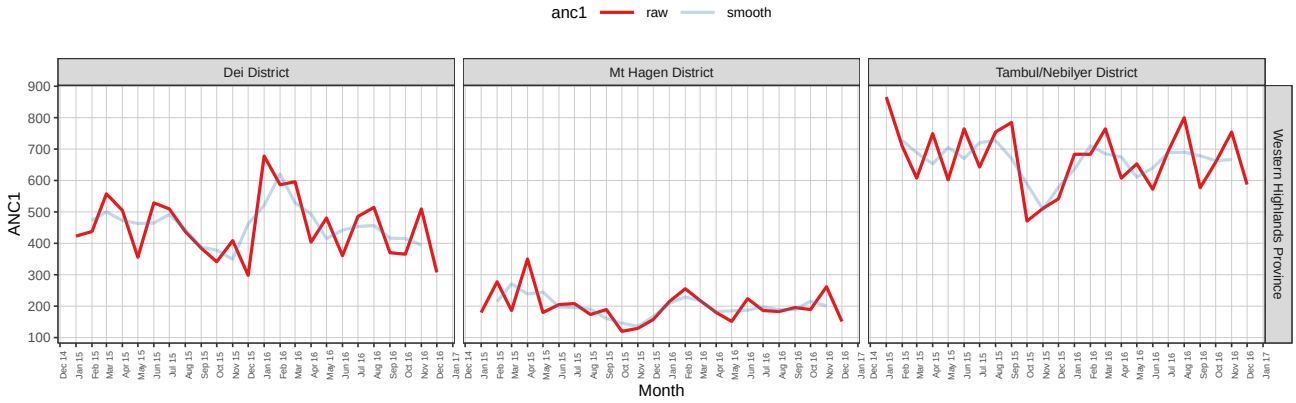

```
ggplot(dist1long[dist1long$ADM1_PCODE == 7, ],
       aes(as.Date(date), value, colour = anc1)) +
  geom_line(size = 1) +
  scale_colour_manual(labels = c("raw", "smooth"),
                      values = c("#e41a1c", alpha("#377eb8", 0.3))) +
  scale_x_date(name = "Month",
               date_breaks = "1 month",
               date_labels = "%b %y") +
  scale_y_continuous(name = "ANC1",
                     breaks = seq(from = 0,
                                  to = max(dist1$anc1Std),
                                  by = 100)) +
  facet_grid(ADM1_EN ~ ADM2_EN) +
  themeSettings
```



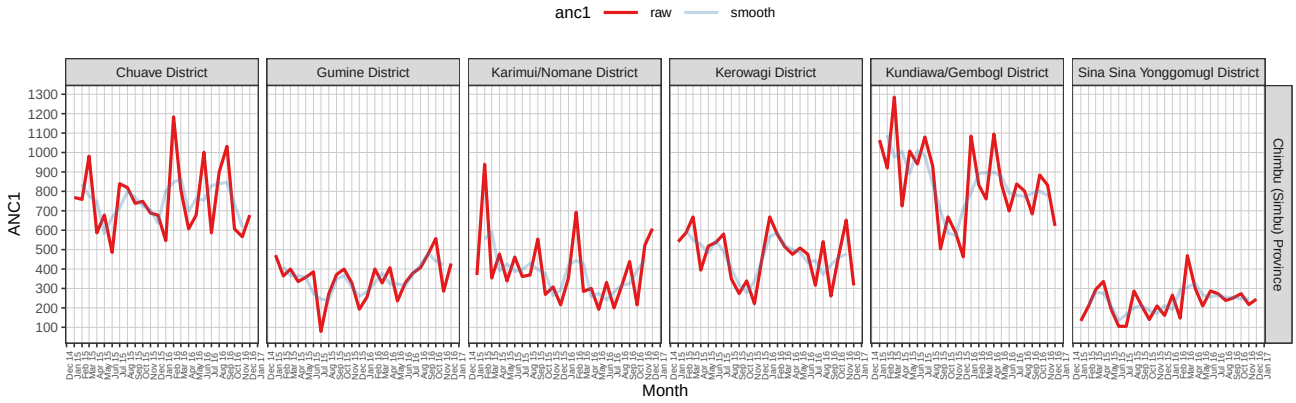

```
ggplot(dist1long[dist1long$ADM1_PCODE == 8, ],
       aes(as.Date(date), value, colour = anc1)) +
  geom_line(size = 1) +
  scale_colour_manual(labels = c("raw", "smooth"),
                      values = c("#e41a1c", alpha("#377eb8", 0.3))) +
  scale_x_date(name = "Month",
               date_breaks = "1 month",
               date_labels = "%b %y") +
  scale_y_continuous(name = "ANC1",
                     breaks = seq(from = 0,
                                  to = max(dist1$anc1Std),
                                  by = 100)) +
  facet_grid(ADM1_EN ~ ADM2_EN) +
  themeSettings
```



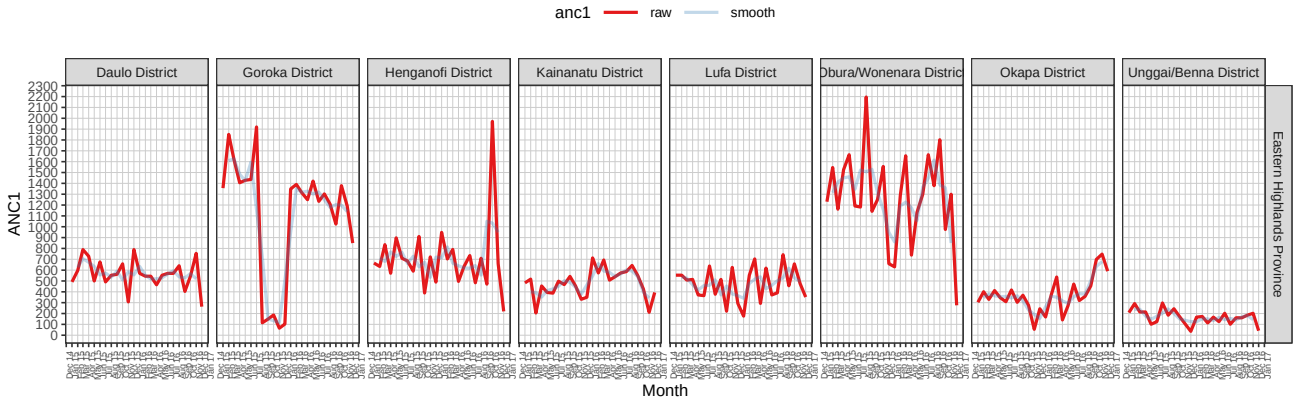

```
ggplot(dist1long[dist1long$ADM1_PCODE == 9, ],
       aes(as.Date(date), value, colour = anc1)) +
  geom_line(size = 1) +
  scale_colour_manual(labels = c("raw", "smooth"),
                      values = c("#e41a1c", alpha("#377eb8", 0.3))) +
  scale_x_date(name = "Month",
               date_breaks = "1 month",
               date_labels = "%b %y") +
  scale_y_continuous(name = "ANC1",
                     breaks = seq(from = 0,
                                  to = max(dist1$anc1Std),
                                  by = 100)) +
  facet_grid(ADM1_EN ~ ADM2_EN) +
  themeSettings
```



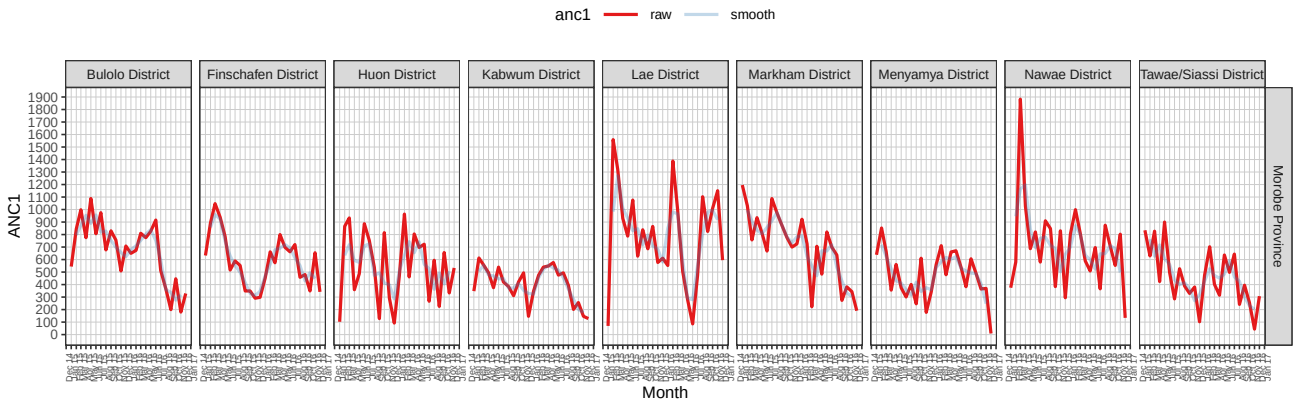

```
ggplot(dist1long[dist1long$ADM1_PCODE == 10, ],
       aes(as.Date(date), value, colour = anc1)) +
  geom_line(size = 1) +
  scale_colour_manual(labels = c("raw", "smooth"),
                      values = c("#e41a1c", alpha("#377eb8", 0.3))) +
  scale_x_date(name = "Month",
               date_breaks = "1 month",
               date_labels = "%b %y") +
  scale_y_continuous(name = "ANC1",
                     breaks = seq(from = 0,
                                  to = max(dist1$anc1Std),
                                  by = 100)) +
  facet_grid(ADM1_EN ~ ADM2_EN) +
  themeSettings
```



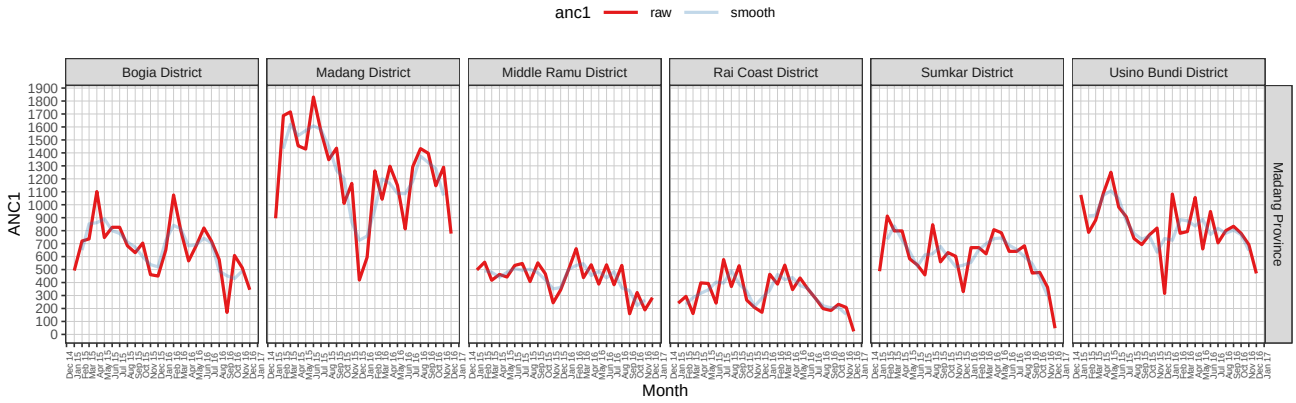

```
ggplot(dist1long[dist1long$ADM1_PCODE == 11, ],
       aes(as.Date(date), value, colour = anc1)) +
  geom_line(size = 1) +
  scale_colour_manual(labels = c("raw", "smooth"),
                      values = c("#e41a1c", alpha("#377eb8", 0.3))) +
  scale_x_date(name = "Month",
               date_breaks = "1 month",
               date_labels = "%b %y") +
  scale_y_continuous(name = "ANC1",
                     breaks = seq(from = 0,
                                  to = max(dist1$anc1Std),
                                  by = 100)) +
  facet_grid(ADM1_EN ~ ADM2_EN) +
  themeSettings
```



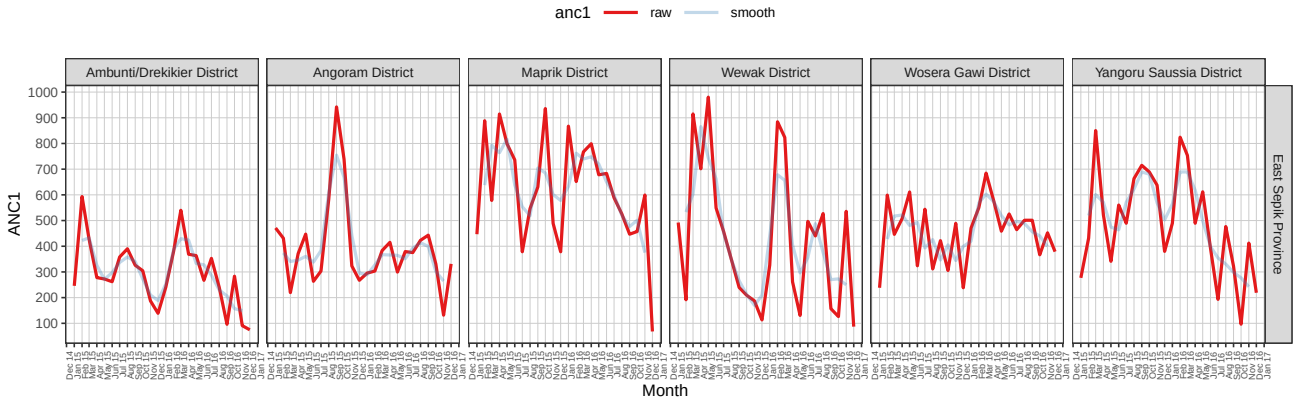

```
ggplot(dist1long[dist1long$ADM1_PCODE == 12, ],
       aes(as.Date(date), value, colour = anc1)) +
  geom_line(size = 1) +
  scale_colour_manual(labels = c("raw", "smooth"),
                      values = c("#e41a1c", alpha("#377eb8", 0.3))) +
  scale_x_date(name = "Month",
               date_breaks = "1 month",
               date_labels = "%b %y") +
  scale_y_continuous(name = "ANC1",
                     breaks = seq(from = 0,
                                  to = max(dist1$anc1Std),
                                  by = 100)) +
  facet_grid(ADM1_EN ~ ADM2_EN) +
  themeSettings
```



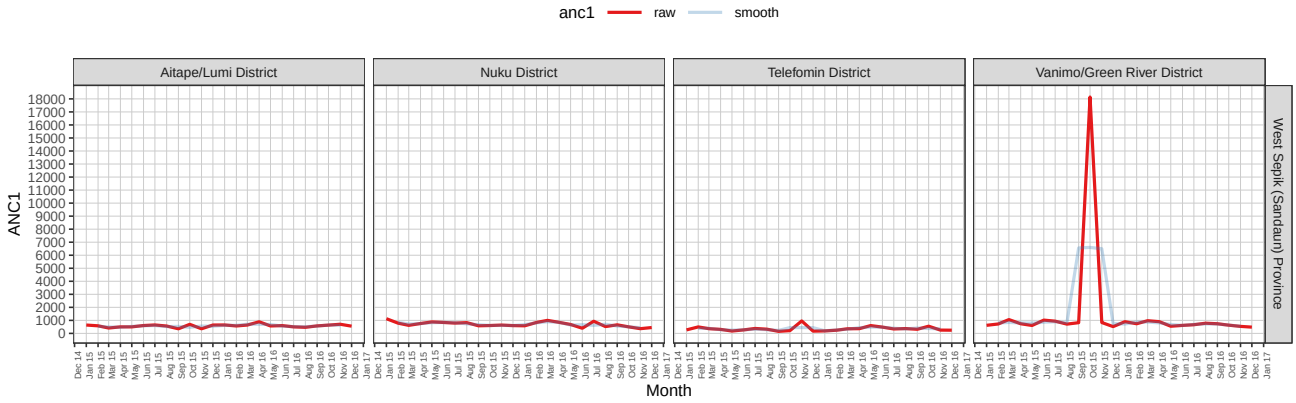

```
ggplot(dist1long[dist1long$ADM1_PCODE == 13, ],
       aes(as.Date(date), value, colour = anc1)) +
  geom_line(size = 1) +
  scale_colour_manual(labels = c("raw", "smooth"),
                      values = c("#e41a1c", alpha("#377eb8", 0.3))) +
  scale_x_date(name = "Month",
               date_breaks = "1 month",
               date_labels = "%b %y") +
  scale_y_continuous(name = "ANC1",
                     breaks = seq(from = 0,
                                  to = max(dist1$anc1Std),
                                  by = 100)) +
  facet_grid(ADM1_EN ~ ADM2_EN) +
  themeSettings
```



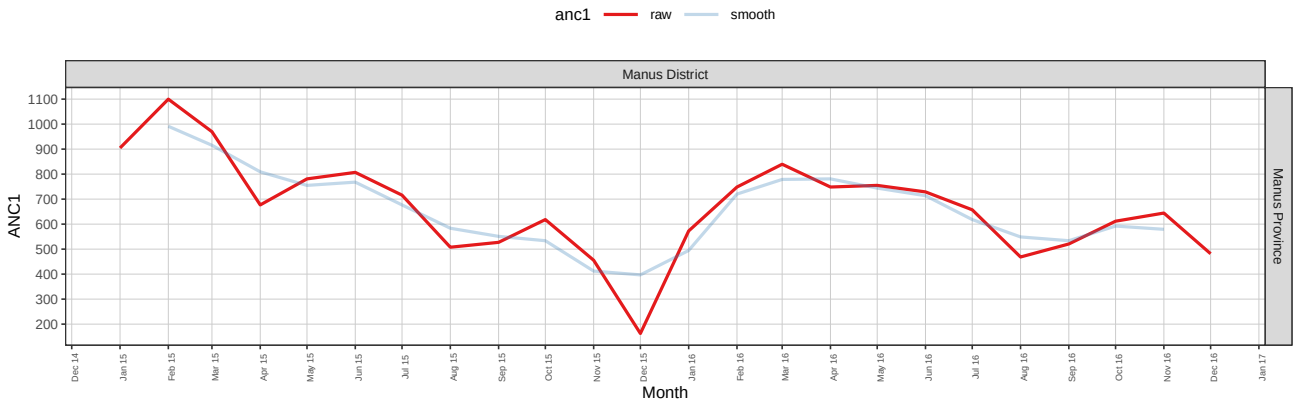

```
ggplot(dist1long[dist1long$ADM1_PCODE == 14, ],
       aes(as.Date(date), value, colour = anc1)) +
  geom_line(size = 1) +
  scale_colour_manual(labels = c("raw", "smooth"),
                      values = c("#e41a1c", alpha("#377eb8", 0.3))) +
  scale_x_date(name = "Month",
               date_breaks = "1 month",
               date_labels = "%b %y") +
  scale_y_continuous(name = "ANC1",
                     breaks = seq(from = 0,
                                  to = max(dist1$anc1Std),
                                  by = 100)) +
  facet_grid(ADM1_EN ~ ADM2_EN) +
  themeSettings
```



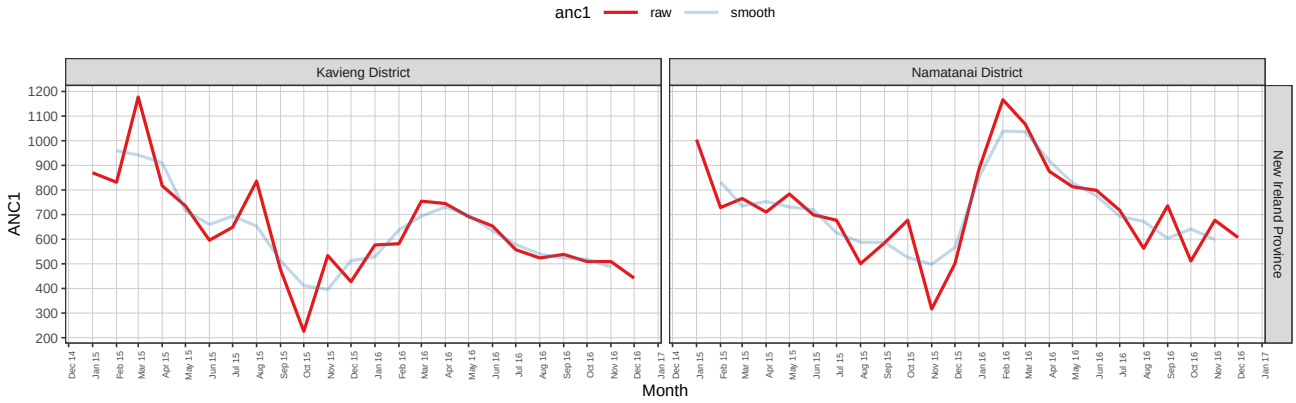

```
ggplot(dist1long[dist1long$ADM1_PCODE == 15, ],
       aes(as.Date(date), value, colour = anc1)) +
  geom_line(size = 1) +
  scale_colour_manual(labels = c("raw", "smooth"),
                      values = c("#e41a1c", alpha("#377eb8", 0.3))) +
  scale_x_date(name = "Month",
               date_breaks = "1 month",
               date_labels = "%b %y") +
  scale_y_continuous(name = "ANC1",
                     breaks = seq(from = 0,
                                  to = max(dist1$anc1Std),
                                  by = 1000)) +
  facet_grid(ADM1_EN ~ ADM2_EN) +
  themeSettings
```



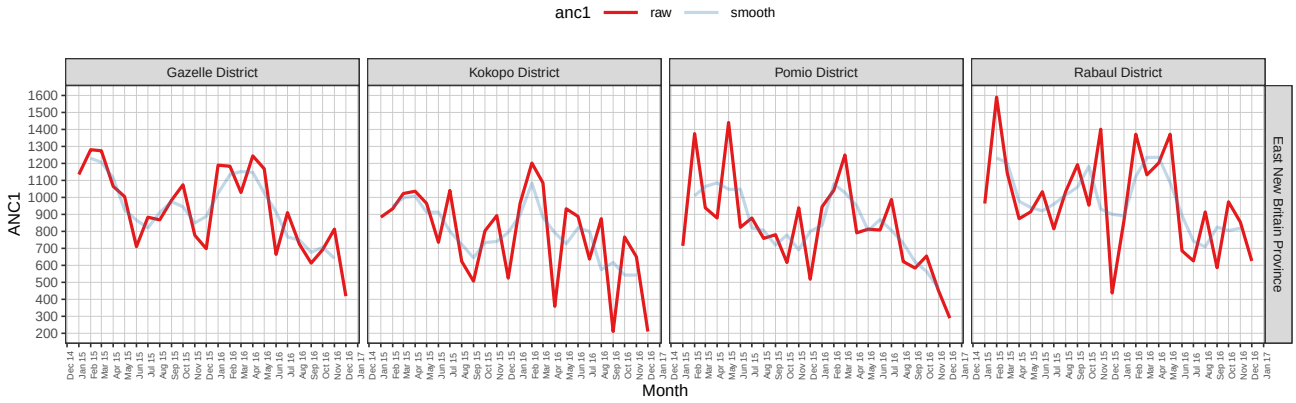

```
ggplot(dist1long[dist1long$ADM1_PCODE == 16, ],
       aes(as.Date(date), value, colour = anc1)) +
  geom_line(size = 1) +
  scale_colour_manual(labels = c("raw", "smooth"),
                      values = c("#e41a1c", alpha("#377eb8", 0.3))) +
  scale_x_date(name = "Month",
               date_breaks = "1 month",
               date_labels = "%b %y") +
  scale_y_continuous(name = "ANC1",
                     breaks = seq(from = 0,
                                  to = max(dist1$anc1Std),
                                  by = 100)) +
  facet_grid(ADM1_EN ~ ADM2_EN) +
  themeSettings
```



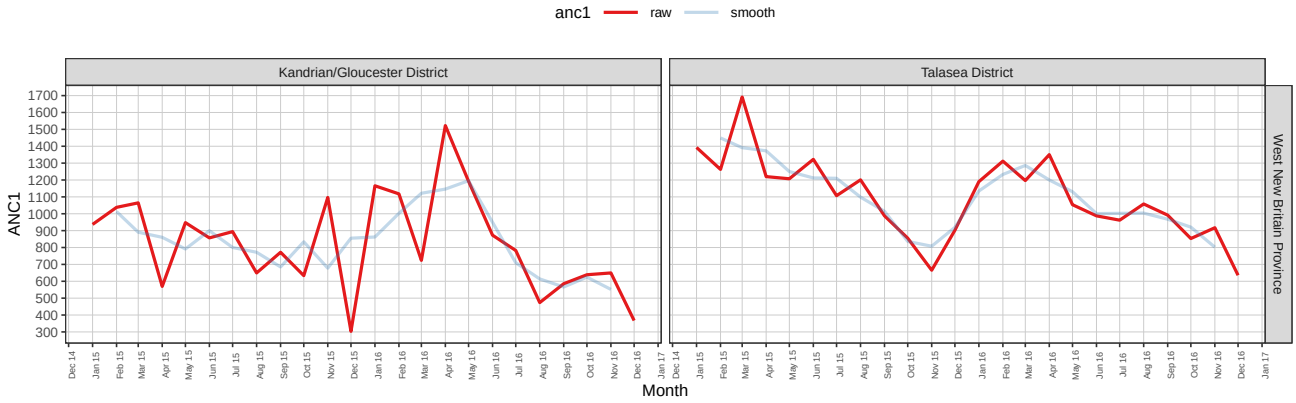

```
ggplot(dist1long[dist1long$ADM1_PCODE == 17, ],
       aes(as.Date(date), value, colour = anc1)) +
  geom_line(size = 1) +
  scale_colour_manual(labels = c("raw", "smooth"),
                      values = c("#e41a1c", alpha("#377eb8", 0.3))) +
  scale_x_date(name = "Month",
               date_breaks = "1 month",
               date_labels = "%b %y") +
  scale_y_continuous(name = "ANC1",
                     breaks = seq(from = 0,
                                  to = max(dist1$anc1Std),
                                  by = 100)) +
  facet_grid(ADM1_EN ~ ADM2_EN) +
  themeSettings
```



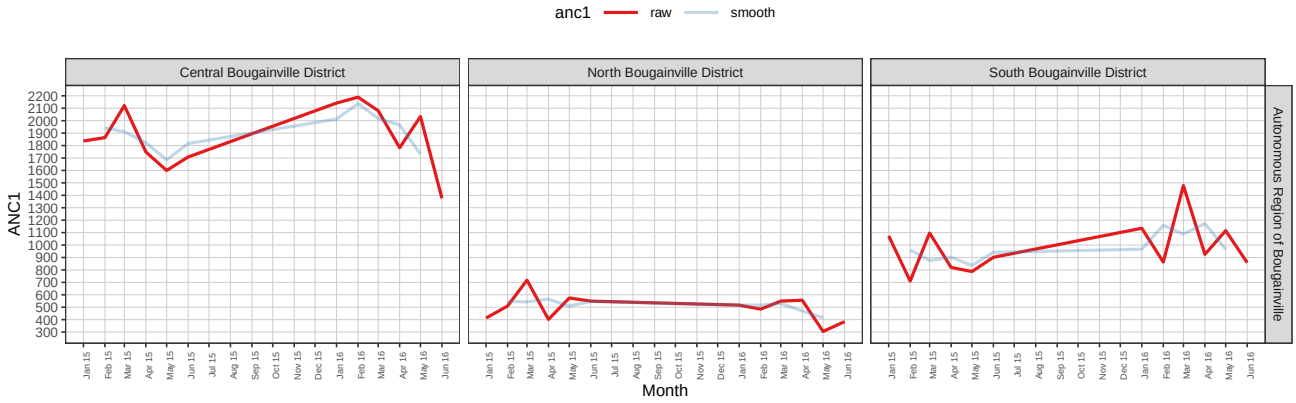

```
ggplot(dist1long[dist1long$ADM1_PCODE == 18, ],
       aes(as.Date(date), value, colour = anc1)) +
  geom_line(size = 1) +
  scale_colour_manual(labels = c("raw", "smooth"),
                      values = c("#e41a1c", alpha("#377eb8", 0.3))) +
  scale_x_date(name = "Month",
               date_breaks = "1 month",
               date_labels = "%b %y") +
  scale_y_continuous(name = "ANC1",
                     breaks = seq(from = 0,
                                  to = max(dist1$anc1Std),
                                  by = 100)) +
  facet_grid(ADM1_EN ~ ADM2_EN) +
  themeSettings
```



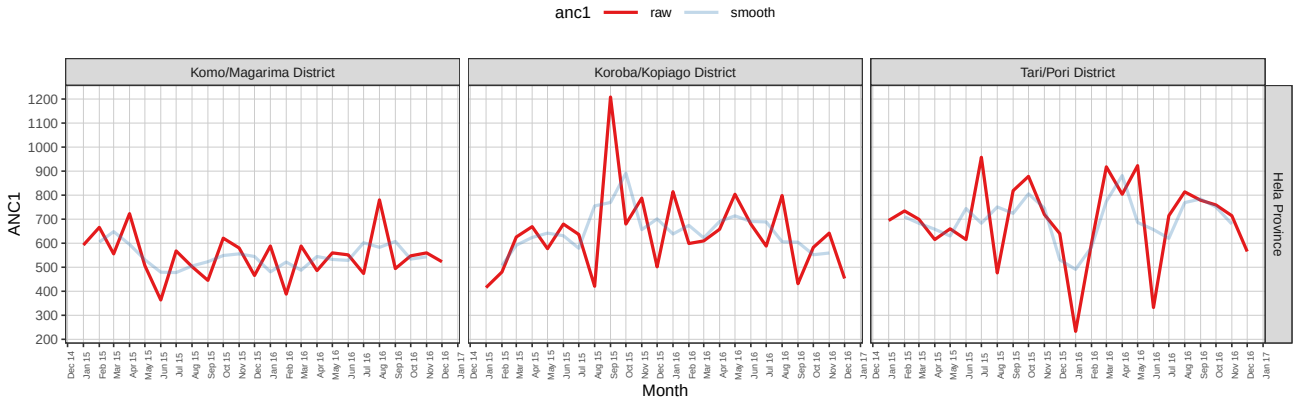

```
ggplot(dist1long[dist1long$ADM1_PCODE == 19, ],
       aes(as.Date(date), value, colour = anc1)) +
  geom_line(size = 1) +
  scale_colour_manual(labels = c("raw", "smooth"),
                      values = c("#e41a1c", alpha("#377eb8", 0.3))) +
  scale_x_date(name = "Month",
               date_breaks = "1 month",
               date_labels = "%b %y") +
  scale_y_continuous(name = "ANC1",
                     breaks = seq(from = 0,
                                  to = max(dist1$anc1Std),
                                  by = 100)) +
  facet_grid(ADM1_EN ~ ADM2_EN) +
  themeSettings
```



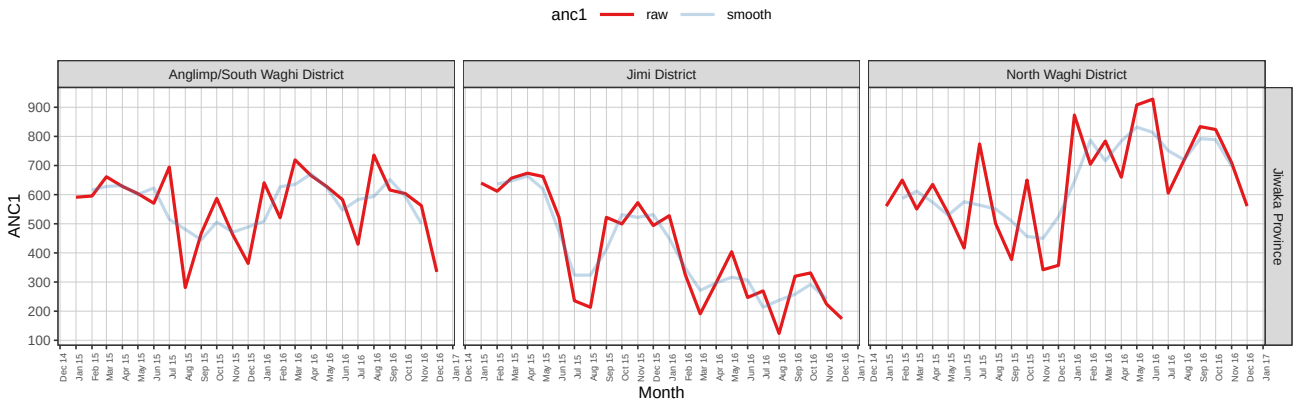

```
ggplot(dist1long[dist1long$ADM1_PCODE == 20, ],
       aes(as.Date(date), value, colour = anc1)) +
  geom_line(size = 1) +
  scale_colour_manual(labels = c("raw", "smooth"),
                      values = c("#e41a1c", alpha("#377eb8", 0.3))) +
  scale_x_date(name = "Month",
               date_breaks = "1 month",
               date_labels = "%b %y") +
  scale_y_continuous(name = "ANC1",
                     breaks = seq(from = 0,
                                  to = max(dist1$anc1Std),
                                  by = 100)) +
  facet_grid(ADM1_EN ~ ADM2_EN) +
  themeSettings
```




```
ggplot(dist1long[dist1long$ADM1_PCODE == 21, ],
       aes(as.Date(date), value, colour = anc1)) +
  geom_line(size = 1) +
  scale_colour_manual(labels = c("raw", "smooth"),
                      values = c("#e41a1c", alpha("#377eb8", 0.3))) +
  scale_x_date(name = "Month",
               date_breaks = "1 month",
               date_labels = "%b %y") +
  scale_y_continuous(name = "ANC1",
                     breaks = seq(from = 0,
                                  to = max(dist1$anc1Std),
                                  by = 100)) +
  facet_grid(ADM1_EN ~ ADM2_EN) +
  themeSettings
```




```
ggplot(dist1long[dist1long$ADM1_PCODE == 22, ],
       aes(as.Date(date), value, colour = anc1)) +
  geom_line(size = 1) +
  scale_colour_manual(labels = c("raw", "smooth"),
                      values = c("#e41a1c", alpha("#377eb8", 0.3))) +
  scale_x_date(name = "Month",
               date_breaks = "1 month",
               date_labels = "%b %y") +
  scale_y_continuous(name = "ANC1",
                     breaks = seq(from = 0,
                                  to = max(dist1$anc1Std),
                                  by = 100)) +
  facet_grid(ADM1_EN ~ ADM2_EN) +
  themeSettings
```



These approaches can be used for all the indicators.

3. Mapping of spatial distribution of indicators

The `provincedata` and the `districtdata` data frame objects are to be used for mapping. In addition, the `province` and `district` map data from the `papuanewguinea` package is for plotting the boundaries.

First, let us inspect the `province` and the `district` map objects.

	ADM1_EN	ADM1_PCODE	ADM0_EN	ADM0_PCODE
0	Autonomous Region of Bougainville	20	Papua New Guinea	PG
1	Central Province	03	Papua New Guinea	PG
2	Chimbu (Simbu) Province	10	Papua New Guinea	PG
3	East New Britain Province	18	Papua New Guinea	PG
4	East Sepik Province	14	Papua New Guinea	PG
5	Eastern Highlands Province	11	Papua New Guinea	PG
6	Enga Province	08	Papua New Guinea	PG
7	Gulf Province	02	Papua New Guinea	PG
8	Hela Province	21	Papua New Guinea	PG
9	Jiwaka Province	22	Papua New Guinea	PG
10	Madang Province	13	Papua New Guinea	PG
11	Manus Province	16	Papua New Guinea	PG
12	Milne Bay Province	05	Papua New Guinea	PG
13	Morobe Province	12	Papua New Guinea	PG
14	National Capital District	04	Papua New Guinea	PG
15	New Ireland Province	17	Papua New Guinea	PG
16	Northern (Oro) Province	06	Papua New Guinea	PG
17	Southern Highlands Province	07	Papua New Guinea	PG
18	West New Britain Province	19	Papua New Guinea	PG
19	West Sepik (Sandaun) Province	15	Papua New Guinea	PG
20	Western Highlands Province	09	Papua New Guinea	PG
21	Western Province	01	Papua New Guinea	PG

We notice that the order of the provinces are not sequential based on administrative code. We will need to re-order this in such a way that the admin codes are sequential. This can be done as follows:

```
province@data <- province@data[order(province@data$ADM1_PCODE), ]
```

We can now map the `provincedata`. For this, we will use `anc1` as our index indicator.

The first thing we need to do is to standardise the `anc1` indicator in the same way we did earlier in the time-series analysis. This can be done as follows:

```
anc1Province <- provincedata[ , c("ADM1_PCODE", "ADM1_EN", "WRA",
                                  "sf", "year", "anc1")]

anc1Province$anc1Std <- anc1Province$anc1 / anc1Province$sf
```

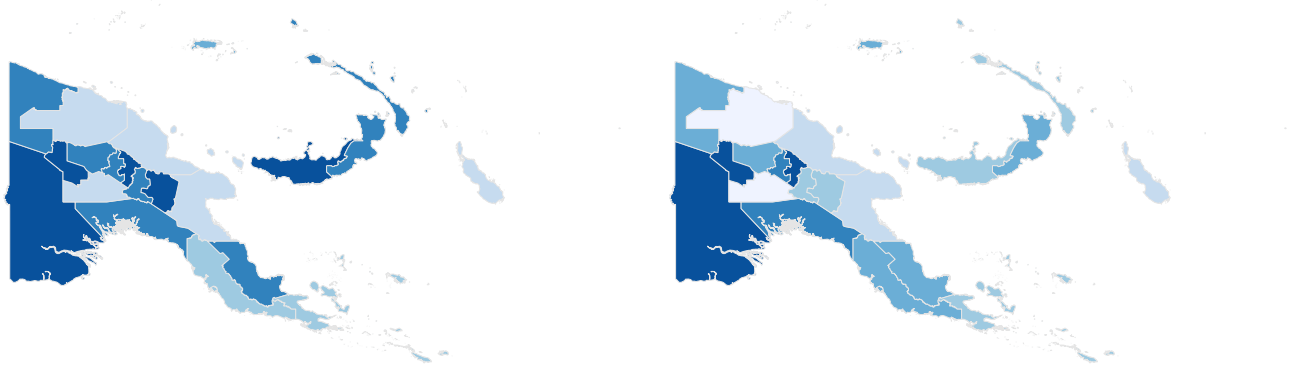
We then need to classify the standardised `anc1` values into groups/classes that will allow us to colour the province based on their `anc1` classification. We can use an approach in which the standardised `anc1` counts are grouped into meaningful classes. A useful approach will be using quantiles. For this, we can use the R package called `classInt` which has a function called `classIntervals()`. The `anc1` can be classified as follows:

```
anc1Province$class <- cut(x = anc1Province$anc1Std,
                          breaks = classIntervals(var = anc1Province$anc1Std,
                                                  n = 5,
                                                  style = "quantile")$brks,
                          labels = FALSE)

anc1Province$class <- ifelse(is.na(anc1Province$class), 0, anc1Province$class)
```

We can now map the `anc1` indicator for year 2015 and year 2016 as follows:

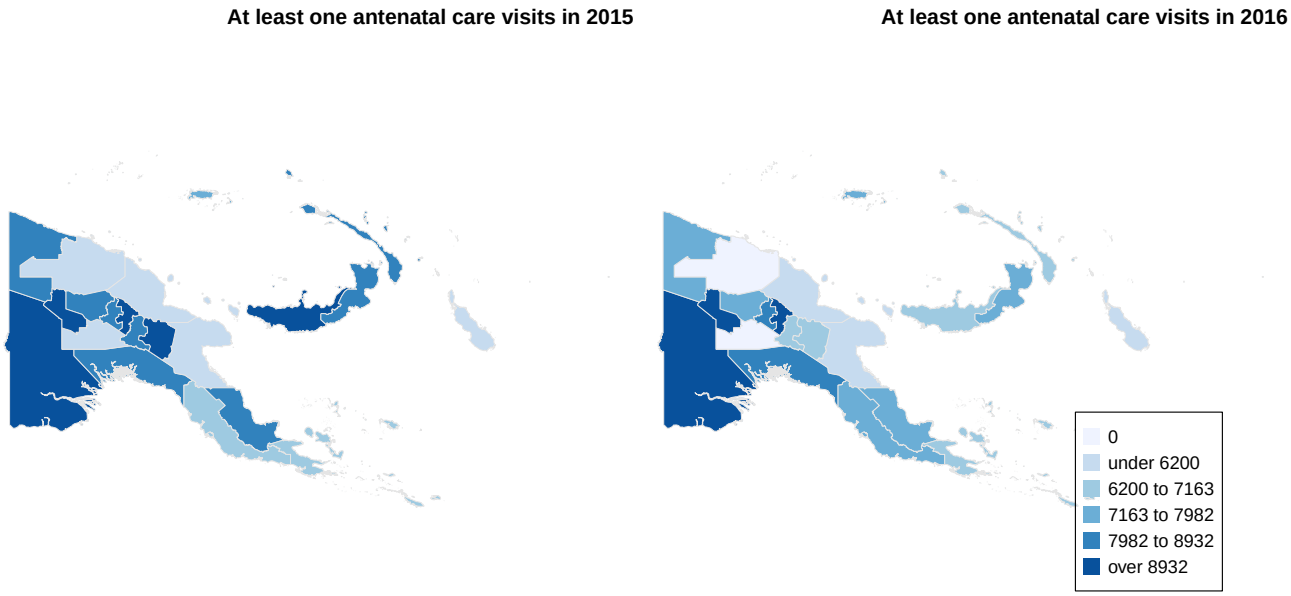
```
colourscheme <- c("#eff3ff", "#c6dbef", "#9ecae1",
                  "#6baed6", "#3182bd", "#08519c")

par(mar = c(0, 0, 0, 0), mfrow = c(1, 2))

plot(province,
     col = colourscheme[anc1Province$class[anc1Province$year == 2015] + 1],
     border = "gray90",
     lwd = 0.5)

plot(province,
```

```
     col = colourscheme[anc1Province$class[anc1Province$year == 2016] + 1],
     border = "gray90",
     lwd = 0.5)
```



Now, it will be useful to add a title to each plot to identify which map is for which year and to add a legend to show what the colours refer to. This can be done as follows:

```
par(mar = c(0, 0, 0, 0), mfrow = c(1, 2))

plot(province,
     col = colourscheme[anc1Province$class[anc1Province$year == 2015] + 1],
     border = "gray90",
     lwd = 0.5)
title(main = "At least one antenatal care visits in 2015", line = -1, adj = 1)

plot(province,
     col = colourscheme[anc1Province$class[anc1Province$year == 2016] + 1],
     border = "gray90",
     lwd = 0.5)
title(main = "At least one antenatal care visits in 2016", line = -1, adj = 1)
legend(x = "bottomright",
       inset = 0.1,
       y.intersp = 1.2,
       legend = c("0", names(print(classIntervals(anc1Province$anc1Std,
                                                  n = 5,
                                                  style = "quantile",
                                                  dataPrecision = 0),
                                   between = "to",
                                   cutlabels = FALSE))),
       pch = 15, pt.cex = 2,
       col = colourscheme)
```




```
## style: quantile
##   one of 12,650 possible partitions of this variable into 5 classes
##   under 6200 6200 to 7163 7163 to 7982 7982 to 8932    over 8932
##            5            5            5            5            6
```

We can now map the `districtdata`. For this, we will use `anc1` as our index indicator.

We will need to reorder the `district` map sequentially based on administrative code. This can be done as follows:

```
district@data <- district@data[order(district@data$ADM2_PCODE), ]
```

We now need to standardise the `anc1` indicator in the same way we did earlier in the time-series analysis. This can be done as follows:

```
anc1District <- districtdata[ , c("ADM1_PCODE", "ADM1_EN", "ADM2_PCODE", "ADM2_EN", "WRA
                                  "sf", "year", "anc1")]

anc1District$anc1Std <- anc1District$anc1 / anc1District$sf
```

We then need to classify the standardised `anc1` values into groups/classes that will allow us to colour the districts based on their `anc1` classification. We can use an approach in which the standardised `anc1` counts are grouped into meaningful classes. A useful approach will be using quantiles. For this, we can use the R package called `classInt` which has a function called `classIntervals()`. The `anc1` can be classified as follows:

```
anc1District$class <- cut(x = anc1District$anc1Std,
                          breaks = classIntervals(var = anc1District$anc1Std,
                                                  n = 5,
                                                  style = "quantile")$brks,
```

```
                            labels = FALSE)

anc1District$class <- ifelse(is.na(anc1District$class), 0, anc1District$class)
```

We can now do some final inspection of whether the districts in the map data correspond to the districts in `districdata`.

Checking the number of districts, we note that there is one district more in the map data compared to the `districtdata`. District with administrative code 0905 is not included in `districtdata`. To be able to map, we can create additional rows of data corresponding to this district and then just adding `NA` data. This can be done as follows:

```
rowdata <- anc1District[1:2, ]
rowdata$ADM2_PCODE <- c(905, 905)
rowdata$ADM2_EN <- c("Mul/Baiyer District", "Mul/Baiyer District")
rowdata$WRA <- rep(as.numeric(pop_adm2[pop_adm2$ADM2_PCODE == "PG0905", "WRA"]), 2)
rowdata$sf <- rowdata$WRA / 100000
rowdata$anc1 <- NA
rowdata$anc1Std <- NA
rowdata$class <- NA

anc1District <- data.frame(rbind(anc1District, rowdata))

anc1District <- anc1District[order(anc1District$ADM2_PCODE), ]
```

We can now map the `anc1` indicator for year 2015 and year 2016 as follows:

```
colourscheme <- c("#eff3ff", "#c6dbef", "#9ecae1",
                  "#6baed6", "#3182bd", "#08519c")

par(mar = c(0, 0, 0, 0), mfrow = c(1, 2))

plot(district,
     col = colourscheme[anc1District$class[anc1District$year == 2015] + 1],
     border = "gray90",
     lwd = 0.5)

plot(district,
     col = colourscheme[anc1District$class[anc1District$year == 2016] + 1],
     border = "gray90",
     lwd = 0.5)
```