fp-demand-optimization

July 25, 2025

1 Predicting Family Planning Demand and Optimizing Service Delivery in Kenya

1.1 Project Overview

This project aims to enhance family planning (FP) service delivery efficiency by leveraging data-driven approaches, specifically machine learning (ML) using the CRISP-DM methodology. The goal is to improve maternal and child health outcomes, reduce unmet need for family planning, and contribute to achieving national and global development goals related to reproductive health.

1.2 Problem Statement

Kenya faces significant strides in increasing access to family planning services, yet a substantial unmet need for family planning remains. According to the 2022 Kenya Demographic and Health Survey (KDHS), the total unmet need for family planning is 15%, with 10% for spacing and 5% for limiting births. This indicates that a significant portion of the population desires to space or limit births but is not using any contraceptive method. Traditional methods often show imbalances, with a heavy reliance on short-acting methods, leading to unstable uptake of long-acting reversible contraceptives (LARCs) and permanent methods. This disparity can lead to higher discontinuation rates and continued unmet need. Supply chain inefficiencies, commodity stock-outs, inadequate healthcare worker training, and uneven distribution of resources exacerbate these issues, hindering effective service delivery.

1.3 Stakeholders

- **Government of Kenya:** Ministry of Health (MoH), especially the National Family Planning Coordinated Implementation Plan (NFPICIP) and Kenya Health Information System (KHIS) initiatives.
- **Policymakers and Donors:** Need evidence-based advocacy for resource mobilization and investment.
- **Healthcare Providers:** Frontline health workers providing FP services.
- **Women of Reproductive Age:** Direct beneficiaries of improved FP services.
- **Local Communities:** Impacted by and involved in FP service delivery.

1.4 Key Statistics

- **Total Unmet Need for Family Planning (2022 KDHS):** 15%
  - **Unmet Need for Spacing:** 10%
  - **Unmet Need for Limiting Births:** 5%

- **Married Women Aged 15-49 Rising to 57% in 2022 (DRS 2022):** Modern contraceptive prevalence rate (mCPR).
- **Number of new clients for FP method band and the continuation rate:** Key data points for predicting future demand.

1.5 Key Analytics Questions

- How many new clients are expected for injectables in a County next quarter?
- What is the projected demand for different family planning methods (injectables, pills, condoms, implants, IUD, sterilization) at various geographical (e.g., county) and temporal (e.g., quarterly, annual) granularities?
- How can we optimize resource allocation (commodities, equipment, staffing) to meet projected demand and minimize wastage?
- How can predictive analytics identify potential stock-outs or oversupply of specific FP commodities in different locations?
- Which regions or demographics are most underserved in terms of family planning access and uptake?

1.6 Objectives

- **Quantitatively forecast the demand for specific family planning methods:** This includes predicting the continuation rates of users for each method at defined geographical and temporal scales.
- **Enable proactive resource allocation:** This involves optimizing the distribution of commodities, equipment, and staffing to reduce stock-outs, minimize wastage, and improve targeted interventions.
- **Improve method continuation:** By understanding demand and improving service delivery, the project aims to reduce discontinuation rates and increase sustained use of FP methods.
- **Provide evidence-based insights:** Support policymakers and donors in making informed decisions regarding resource mobilization and investment in family planning.

1.7 Metrics of Importance to Focus On

- **Accuracy of Demand Forecasts:** Measured by comparing predicted demand with actual uptake for various FP methods at different geographical and temporal levels (e.g., Mean Absolute Error, Root Mean Squared Error).
- **Commodity Stock-out Rates:** Reduction in the number or duration of stock-outs for essential family planning commodities.
- **Resource Utilization Efficiency:** Metrics related to optimal allocation and reduced wastage of commodities, equipment, and human resources.
- **Method Continuation Rates:** Increase in the percentage of users who continue using a specific family planning method over a defined period (e.g., 12-month continuation rate).
- **Unmet Need for Family Planning:** Contribution to the reduction of the national unmet need for family planning.
- **Client Satisfaction:** Indirectly improved through better access and availability of preferred methods.
- **Healthcare Worker Productivity:** Optimized allocation of staff to meet demand efficiently.

2 Preliminaries

2.1 Importing Python Libraries

[198]:
```
#Import necessary libraries for data manipulation, visualization, and machine␣
 ↪learning
# Data handling and manipulation
import pandas as pd                  # For dataframes and data manipulation
import numpy as np                   # For numerical operations and arrays

# Visualization libraries
import matplotlib.pyplot as plt      # For basic plotting
import seaborn as sns                # For advanced statistical visualizations

# Suppress warning messages
import warnings                      # To filter out warnings during execution

# Model selection and evaluation
from sklearn.model_selection import train_test_split, cross_val_score,␣
 ↪TimeSeriesSplit
# train_test_split: splits data into training and test sets
# cross_val_score: performs cross-validation
# TimeSeriesSplit: cross-validation for time series data such as this FP data
from sklearn.model_selection import GridSearchCV

# Data preprocessing
from sklearn.preprocessing import StandardScaler, MinMaxScaler, OneHotEncoder
# StandardScaler/MinMaxScaler: scale numerical features
# OneHotEncoder: encode categorical variables

# Metrics for model evaluation
from sklearn.metrics import mean_absolute_error, mean_squared_error, r2_score
# MAE, MSE, R²: performance metrics for regression models

# Combine preprocessing steps
from sklearn.compose import ColumnTransformer  # Apply different preprocessing␣
 ↪to columns

# Build machine learning workflows
from sklearn.pipeline import Pipeline          # Chain preprocessing and␣
 ↪modeling steps

# Handle missing data
from sklearn.impute import SimpleImputer       # Fill missing values

# Regression models
```

```
from sklearn.linear_model import LinearRegression, Ridge                    #␣
 ↪Linear regression model
from sklearn.ensemble import RandomForestRegressor, GradientBoostingRegressor
from sklearn.multioutput import MultiOutputRegressor
from xgboost import XGBRegressor


# RandomForestRegressor: ensemble method using decision trees
# GradientBoostingRegressor: boosting method for better accuracy
```

2.2 Data Loading

[2]:
```
# from google.colab import drive
# drive.mount('/content/drive')  # Mount Google Drive


# base_path = "/content/drive/MyDrive/data/"

# # File paths
# population_data_path = base_path + "ke_fp_population_data.csv"
# service_data_path = base_path + "ke_fp_service_data.csv"
# benchmarks_data_path = base_path + "ke_fp_benchmarks_data.csv"
# commodity_data_path = base_path + "ke_fp_commodity_data.csv"

# # Attempt to read with 'latin1' encoding
# df_population = pd.read_csv(population_data_path, encoding='latin1')
# df_service = pd.read_csv(service_data_path, encoding='latin1')
# df_benchmarks = pd.read_csv(benchmarks_data_path, encoding='latin1')
# df_commodity = pd.read_csv(commodity_data_path, encoding='latin1')
```

[3]:
```
# Data loading

try:
    # Define paths
    data_dir = "data/"
    benchmarks_dir = "data/benchmarks/"

    population_data_path = f"{data_dir}ke_fp_population_data.csv"
    service_data_path = f"{data_dir}ke_fp_service_data.csv"
    commodity_data_path = f"{data_dir}ke_fp_commodity_data.csv"

    benchmarks_core_health_workforce_data_path =␣
 ↪f"{benchmarks_dir}ke_fp_benchmarks_core_health_workforce.csv"
    benchmarks_demand_satisfied_data_path =␣
 ↪f"{benchmarks_dir}ke_fp_benchmarks_Demand_Satisfied.csv"
    benchmarks_mCPR_data_path = f"{benchmarks_dir}ke_fp_benchmarks_mCPR.csv"
```

```
    benchmarks_teen_pregnancy_data_path =␣
↪f"{benchmarks_dir}ke_fp_benchmarks_Teenage_Pregnancy_rate.csv"
    benchmarks_unmet_need_data_path =␣
↪f"{benchmarks_dir}ke_fp_benchmarks_Total_Unmet_Need_MW.csv"

    # Load CSVs with fallback encoding
    df_population = pd.read_csv(population_data_path, encoding='latin1')
    df_service = pd.read_csv(service_data_path, encoding='latin1')
    df_commodity = pd.read_csv(commodity_data_path, encoding='latin1')

    # Load benchmark-specific CSVs
    df_core_health_workforce = pd.
↪read_csv(benchmarks_core_health_workforce_data_path, encoding='latin1')
    df_demand_satisfied = pd.read_csv(benchmarks_demand_satisfied_data_path,␣
↪encoding='latin1')
    df_mcpr = pd.read_csv(benchmarks_mCPR_data_path, encoding='latin1')
    df_teenage_pregnancy = pd.read_csv(benchmarks_teen_pregnancy_data_path,␣
↪encoding='latin1')
    df_unmet_need = pd.read_csv(benchmarks_unmet_need_data_path,␣
↪encoding='latin1')

    # Success logs
    print("Datasets loaded successfully:")
    print(f"{population_data_path} shape: {df_population.shape}")
    print(f"{service_data_path} shape: {df_service.shape}")
    print(f"{commodity_data_path} shape: {df_commodity.shape}")
    print(f"{benchmarks_core_health_workforce_data_path} shape:␣
↪{df_core_health_workforce.shape}")
    print(f"{benchmarks_demand_satisfied_data_path} shape: {df_demand_satisfied.
↪shape}")
    print(f"{benchmarks_mCPR_data_path} shape: {df_mcpr.shape}")
    print(f"{benchmarks_teen_pregnancy_data_path} shape: {df_teenage_pregnancy.
↪shape}")
    print(f"{benchmarks_unmet_need_data_path} shape: {df_unmet_need.shape}")

except FileNotFoundError as e:
    print("  Error: One or more CSV files were not found.")
    print("  Please ensure all expected files are in their respective folders.")
    print(e)
except Exception as e:
    print("  An unexpected error occurred while loading the datasets:")
    print(e)
```

```
Datasets loaded successfully:
data/ke_fp_population_data.csv shape: (517, 19)
data/ke_fp_service_data.csv shape: (6204, 60)
data/ke_fp_commodity_data.csv shape: (2480, 50)
```

```
data/benchmarks/ke_fp_benchmarks_core_health_workforce.csv shape: (47, 8)
data/benchmarks/ke_fp_benchmarks_Demand_Satisfied.csv shape: (47, 8)
data/benchmarks/ke_fp_benchmarks_mCPR.csv shape: (47, 8)
data/benchmarks/ke_fp_benchmarks_Teenage_Pregnancy_rate.csv shape: (47, 8)
data/benchmarks/ke_fp_benchmarks_Total_Unmet_Need_MW.csv shape: (47, 8)
```

3 1. Data Understanding

3.1 *a) Data Cleaning*

This involved; * Standardization of the column names * Renaming the columns * Dropping empty and unwanted columns * Handling missing values, duplicates and outliers

3.1.1 1. ke_fp_service_data.csv

[4]:
```
# Make a copy of the data
df_service1=df_service.copy()
```

[5]:
```
# from google.colab import drive
# drive.mount('/content/drive')
```

[6]:
```
# Preview the data
df_service1.head()
```

[6]:
```
   periodid  periodname  periodcode  perioddescription orgunitlevel1  \
0    201404  April 2014      201404                NaN         Kenya
1    201404  April 2014      201404                NaN         Kenya
2    201404  April 2014      201404                NaN         Kenya
3    201404  April 2014      201404                NaN         Kenya
4    201404  April 2014      201404                NaN         Kenya

       orgunitlevel2 organisationunitid organisationunitname  \
0     Turkana County        kphDeKClFch       Turkana County
1       Nandi County        t0J75eHKxz5         Nandi County
2  West Pokot County        XWALbfAPa6n    West Pokot County
3       Bomet County        HMNARUV2CW4         Bomet County
4     Nairobi County        jkG3zaihdSs       Nairobi County

  organisationunitcode  organisationunitdescription  …  \
0         KE_County_23                          NaN  …
1         KE_County_29                          NaN  …
2         KE_County_24                          NaN  …
3         KE_County_36                          NaN  …
4         KE_County_47                          NaN  …

   MOH 711 Rev 2020_Post parturm FP 4weeks to 6weeks Re-visits  \
0                                                  NaN
```

```
1                                                   NaN
2                                                   NaN
3                                                   NaN
4                                                   NaN

   MOH 711 Rev 2020_Post parturm FP within 48 Hours New clients  \
0                                                   NaN
1                                                   NaN
2                                                   NaN
3                                                   NaN
4                                                   NaN

   MOH 711 Rev 2020_Post parturm FP within 48 Hours Re-visits  \
0                                                   NaN
1                                                   NaN
2                                                   NaN
3                                                   NaN
4                                                   NaN

   MOH 711 Rev 2020_Voluntary Surgical Contraception Vasectomy Ist Time
Insertion  \
0                                                   NaN
1                                                   NaN
2                                                   NaN
3                                                   NaN
4                                                   NaN

   MOH 711 Rev 2020_Voluntary Surgical Contraception Vasectomy Re-insertion  \
0                                                   NaN
1                                                   NaN
2                                                   NaN
3                                                   NaN
4                                                   NaN

   MOH 711 Rev 2020_Voluntary surgical contraception BTL Ist Time Insertion  \
0                                                   NaN
1                                                   NaN
2                                                   NaN
3                                                   NaN
4                                                   NaN

   MOH 711 Rev 2020_Voluntary surgical contraception BTL Re-insertion  \
0                                                   NaN
1                                                   NaN
2                                                   NaN
3                                                   NaN
4                                                   NaN
```

```
   Population Growth Rate  Total Population  \
0                    3.16          999367.0
1                    3.02          938866.0
2                    3.10          597313.0
3                 1568.96          834381.7
4                    4.02         3894186.0

   Women of childbearing age (15â 49yrs)
0                                225176.0
1                                223505.0
2                                144549.0
3                                237820.0
4                                981191.0

[5 rows x 60 columns]
```

[7]:
```
# Explore the data
df_service1.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 6204 entries, 0 to 6203
Data columns (total 60 columns):
 #   Column
Non-Null Count  Dtype
---  ------
--------------  -----
 0   periodid
6204 non-null   int64
 1   periodname
6204 non-null   object
 2   periodcode
6204 non-null   int64
 3   perioddescription
0 non-null      float64
 4   orgunitlevel1
6204 non-null   object
 5   orgunitlevel2
6204 non-null   object
 6   organisationunitid
6204 non-null   object
 7   organisationunitname
6204 non-null   object
 8   organisationunitcode
6204 non-null   object
 9   organisationunitdescription
0 non-null      float64
```

```
 10  Estimated Number of Pregnant Women
6192 non-null   float64
 11  FP Attendance New clients
6204 non-null   float64
 12  FP Attendance Re-visits
6204 non-null   float64
 13  MOH 711 Adolescent 10-14 yrs Receiving FP Services New clients
4095 non-null   float64
 14  MOH 711 Adolescent 10-14 yrs Receiving FP Services Re-visits
3327 non-null   float64
 15  MOH 711 Adolescent 15-19 Yrs Receiving FP Services New clients
4980 non-null   float64
 16  MOH 711 Adolescent 15-19 Yrs Receiving FP Services Re-visits
4956 non-null   float64
 17  MOH 711 Adolescent 20-24 Yrs Receiving FP Services New clients
4972 non-null   float64
 18  MOH 711 Adolescent 20-24 Yrs Receiving FP Services Re-visits
4964 non-null   float64
 19  MOH 711 Client receiving Male condoms New clients
6204 non-null   int64
 20  MOH 711 Client receiving Male condoms Re-visits
6004 non-null   float64
 21  MOH 711 Clients Counselled Natural Family Planning New clients
5459 non-null   float64
 22  MOH 711 Clients Counselled Natural Family Planning Re-visits
3309 non-null   float64
 23  MOH 711 Clients receiving Female Condoms New clients
4141 non-null   float64
 24  MOH 711 Clients receiving Female Condoms Re-visits
2826 non-null   float64
 25  MOH 711 Emergency contraceptive pill New clients
4837 non-null   float64
 26  MOH 711 Emergency contraceptive pill Re-visits
3402 non-null   float64
 27  MOH 711 Pills Combined oral contraceptive New clients
6201 non-null   float64
 28  MOH 711 Pills Combined oral contraceptive Re-visits
6194 non-null   float64
 29  MOH 711 Pills progestin only New clients
6193 non-null   float64
 30  MOH 711 Pills progestin only Re-visits
6165 non-null   float64
 31  MOH 711 Rev 2020_Adults 25+ receiving FP Services New clients
2415 non-null   float64
 32  MOH 711 Rev 2020_Adults 25+ receiving FP Services Re-visits
2408 non-null   float64
 33  MOH 711 Rev 2020_Clients given cycle beads New clients
1188 non-null   float64
```

```
 34  MOH 711 Rev 2020_Clients given cycle beads Re-visits
84 non-null     float64
 35  MOH 711 Rev 2020_Clients receiving post abortion FP New clients
2007 non-null   float64
 36  MOH 711 Rev 2020_Clients receiving post abortion FP Re-visits
425 non-null    float64
 37  MOH 711 Rev 2020_FP Injections DMPA- IM New clients
2465 non-null   float64
 38  MOH 711 Rev 2020_FP Injections DMPA- IM Re-visits
2469 non-null   float64
 39  MOH 711 Rev 2020_FP Injections DMPA- SC New clients
2133 non-null   float64
 40  MOH 711 Rev 2020_FP Injections DMPA- SC Re-visits
2108 non-null   float64
 41  MOH 711 Rev 2020_IUCD Insertion Hormonal Ist Time Insertion
2015 non-null   float64
 42  MOH 711 Rev 2020_IUCD Insertion Hormonal Re-insertion
1561 non-null   float64
 43  MOH 711 Rev 2020_IUCD Insertion Non Hormonal Ist Time Insertion
2332 non-null   float64
 44  MOH 711 Rev 2020_IUCD Insertion Non Hormonal Re-insertion
2094 non-null   float64
 45  MOH 711 Rev 2020_Implants insertion 1 Rod Ist Time Insertion
2438 non-null   float64
 46  MOH 711 Rev 2020_Implants insertion 1 Rod Re-insertion
2389 non-null   float64
 47  MOH 711 Rev 2020_Implants insertion 2 Rod Ist Time Insertion
2434 non-null   float64
 48  MOH 711 Rev 2020_Implants insertion 2 Rod Re-insertion
2402 non-null   float64
 49  MOH 711 Rev 2020_Post parturm FP 4weeks to 6weeks New clients
2350 non-null   float64
 50  MOH 711 Rev 2020_Post parturm FP 4weeks to 6weeks Re-visits
1428 non-null   float64
 51  MOH 711 Rev 2020_Post parturm FP within 48 Hours New clients
2208 non-null   float64
 52  MOH 711 Rev 2020_Post parturm FP within 48 Hours Re-visits
1199 non-null   float64
 53  MOH 711 Rev 2020_Voluntary Surgical Contraception Vasectomy Ist Time
Insertion  300 non-null    float64
 54  MOH 711 Rev 2020_Voluntary Surgical Contraception Vasectomy Re-insertion
5 non-null      float64
 55  MOH 711 Rev 2020_Voluntary surgical contraception BTL Ist Time Insertion
1585 non-null   float64
 56  MOH 711 Rev 2020_Voluntary surgical contraception BTL Re-insertion
32 non-null     float64
 57  Population Growth Rate
5352 non-null   float64
```

```
 58  Total Population
6204 non-null   float64
 59  Women of childbearing age (15â 49yrs)
6204 non-null   float64
dtypes: float64(51), int64(3), object(6)
memory usage: 2.8+ MB
```

[8]:
```python
# Standardize the column names

def standardize_col_labels(df):
    def clean_column(col):
        # Remove redundant prefixes
        col = col.replace('MOH 711 Rev ', '')
        col = col.replace('MOH 711 ', '')

        # Formatting
        col = col.strip().lower()           # Convert to lowercase
        col = col.replace(' ', '_')      # Replace spaces with underscores
        col = col.replace('-', '_')  # Replace hyphen with underscores
        col = col.replace('â€"', '_')
        col = col.replace('â ', '_')
        return col

    df.columns = [clean_column(col) for col in df.columns]
    return df

df_service1 = standardize_col_labels(df_service1)
df_service1.columns
```

[8]:
```
Index(['periodid', 'periodname', 'periodcode', 'perioddescription',
       'orgunitlevel1', 'orgunitlevel2', 'organisationunitid',
       'organisationunitname', 'organisationunitcode',
       'organisationunitdescription', 'estimated_number_of_pregnant_women',
       'fp_attendance_new_clients', 'fp_attendance_re_visits',
       'adolescent_10_14_yrs_receiving_fp_services_new_clients',
       'adolescent_10_14_yrs_receiving_fp_services_re_visits',
       'adolescent_15_19_yrs_receiving_fp_services_new_clients',
       'adolescent_15_19_yrs_receiving_fp_services_re_visits',
       'adolescent_20_24_yrs_receiving_fp_services_new_clients',
       'adolescent_20_24_yrs_receiving_fp_services_re_visits',
       'client_receiving_male_condoms_new_clients',
       'client_receiving_male_condoms_re_visits',
       'clients_counselled_natural_family_planning_new_clients',
       'clients_counselled_natural_family_planning_re_visits',
       'clients_receiving_female_condoms_new_clients',
       'clients_receiving_female_condoms_re_visits',
       'emergency_contraceptive_pill_new_clients',
```

```
       'emergency_contraceptive_pill_re_visits',
       'pills_combined_oral_contraceptive_new_clients',
       'pills_combined_oral_contraceptive_re_visits',
       'pills_progestin_only_new_clients', 'pills_progestin_only_re_visits',
       '2020_adults_25+_receiving_fp_services_new_clients',
       '2020_adults_25+_receiving_fp_services_re_visits',
       '2020_clients_given_cycle_beads_new_clients',
       '2020_clients_given_cycle_beads_re_visits',
       '2020_clients_receiving_post_abortion_fp_new_clients',
       '2020_clients_receiving_post_abortion_fp_re_visits',
       '2020_fp_injections_dmpa__im_new_clients',
       '2020_fp_injections_dmpa__im_re_visits',
       '2020_fp_injections_dmpa__sc_new_clients',
       '2020_fp_injections_dmpa__sc_re_visits',
       '2020_iucd_insertion_hormonal_ist_time_insertion',
       '2020_iucd_insertion_hormonal_re_insertion',
       '2020_iucd_insertion_non_hormonal_ist_time_insertion',
       '2020_iucd_insertion_non_hormonal_re_insertion',
       '2020_implants_insertion_1_rod_ist_time_insertion',
       '2020_implants_insertion_1_rod_re_insertion',
       '2020_implants_insertion_2_rod_ist_time_insertion',
       '2020_implants_insertion_2_rod_re_insertion',
       '2020_post_parturm_fp_4weeks_to_6weeks_new_clients',
       '2020_post_parturm_fp_4weeks_to_6weeks_re_visits',
       '2020_post_parturm_fp_within_48_hours_new_clients',
       '2020_post_parturm_fp_within_48_hours_re_visits',
       '2020_voluntary_surgical_contraception_vasectomy_ist_time_insertion',
       '2020_voluntary_surgical_contraception_vasectomy_re_insertion',
       '2020_voluntary_surgical_contraception_btl_ist_time_insertion',
       '2020_voluntary_surgical_contraception_btl_re_insertion',
       'population_growth_rate', 'total_population',
       'women_of_childbearing_age_(15_49yrs)'],
      dtype='object')
```

[9]:
```
# Rename column names

name_map = {
    'periodcode': 'year_month',
    'orgunitlevel1': 'country',
    'orgunitlevel2': 'county',
    'organisationunitid': 'uid',
    'organisationunitcode':'county_code',
    'county_cou':'county_code',
    'dataname':'population_indicator'
}
df_service1 = df_service1.rename(columns=name_map)
df_service1
```

[9]:

	periodid	periodname	year_month	perioddescription	country	\
0	201404	April 2014	201404	NaN	Kenya	
1	201404	April 2014	201404	NaN	Kenya	
2	201404	April 2014	201404	NaN	Kenya	
3	201404	April 2014	201404	NaN	Kenya	
4	201404	April 2014	201404	NaN	Kenya	
…	…	…	…	…	…	
6199	202409	September 2024	202409	NaN	Kenya	
6200	202409	September 2024	202409	NaN	Kenya	
6201	202409	September 2024	202409	NaN	Kenya	
6202	202409	September 2024	202409	NaN	Kenya	
6203	202409	September 2024	202409	NaN	Kenya	

	county	uid	organisationunitname	county_code	\
0	Turkana County	kphDeKClFch	Turkana County	KE_County_23	
1	Nandi County	t0J75eHKxz5	Nandi County	KE_County_29	
2	West Pokot County	XWALbfAPa6n	West Pokot County	KE_County_24	
3	Bomet County	HMNARUV2CW4	Bomet County	KE_County_36	
4	Nairobi County	jkG3zaihdSs	Nairobi County	KE_County_47	
…	…	…	…	…	
6199	Isiolo County	bzOfj0iwfDH	Isiolo County	KE_County_11	
6200	Trans Nzoia County	mThvosEflAU	Trans Nzoia County	KE_County_26	
6201	Nakuru County	ob6SxuRcqU4	Nakuru County	KE_County_32	
6202	Tharaka Nithi County	T4urHM47nlm	Tharaka Nithi County	KE_County_13	
6203	Nyeri County	ptWVfaCIdVx	Nyeri County	KE_County_19	

	organisationunitdescription	…	\
0	NaN	…	
1	NaN	…	
2	NaN	…	
3	NaN	…	
4	NaN	…	
…	…	…	
6199	NaN	…	
6200	NaN	…	
6201	NaN	…	
6202	NaN	…	
6203	NaN	…	

	2020_post_parturm_fp_4weeks_to_6weeks_re_visits	\
0	NaN	
1	NaN	
2	NaN	
3	NaN	
4	NaN	
…	…	
6199	53.0	

```
6200                                                 3.0
6201                                                41.0
6202                                                 NaN
6203                                                21.0

      2020_post_parturm_fp_within_48_hours_new_clients  \
0                                                    NaN
1                                                    NaN
2                                                    NaN
3                                                    NaN
4                                                    NaN
…                                                    …
6199                                                17.0
6200                                                75.0
6201                                               191.0
6202                                                 NaN
6203                                                 9.0

      2020_post_parturm_fp_within_48_hours_re_visits  \
0                                                  NaN
1                                                  NaN
2                                                  NaN
3                                                  NaN
4                                                  NaN
…                                                  …
6199                                               NaN
6200                                              54.0
6201                                              34.0
6202                                               NaN
6203                                               8.0

      2020_voluntary_surgical_contraception_vasectomy_ist_time_insertion  \
0                                                    NaN
1                                                    NaN
2                                                    NaN
3                                                    NaN
4                                                    NaN
…                                                    …
6199                                                 NaN
6200                                                 NaN
6201                                                 3.0
6202                                                 NaN
6203                                                 NaN

      2020_voluntary_surgical_contraception_vasectomy_re_insertion  \
0                                                    NaN
1                                                    NaN
```

```
2                                                    NaN
3                                                    NaN
4                                                    NaN
…                                                    …
6199                                                 NaN
6200                                                 NaN
6201                                                 NaN
6202                                                 NaN
6203                                                 NaN

      2020_voluntary_surgical_contraception_btl_ist_time_insertion  \
0                                                    NaN
1                                                    NaN
2                                                    NaN
3                                                    NaN
4                                                    NaN
…                                                    …
6199                                                 1.0
6200                                                 1.0
6201                                                15.0
6202                                                 NaN
6203                                                10.0

      2020_voluntary_surgical_contraception_btl_re_insertion  \
0                                                    NaN
1                                                    NaN
2                                                    NaN
3                                                    NaN
4                                                    NaN
…                                                    …
6199                                                 NaN
6200                                                 NaN
6201                                                 NaN
6202                                                 NaN
6203                                                 NaN

      population_growth_rate  total_population  \
0                       3.16         999367.00
1                       3.02         938866.00
2                       3.10         597313.00
3                    1568.96         834381.70
4                       4.02        3894186.00
…                          …                …
6199                    2.32         296179.23
6200                    2.94        1153812.49
6201                    2.90        2480137.33
6202                    2.67         451552.75
```

```
6203                    NaN         849272.42

      women_of_childbearing_age_(15_49yrs)
0                                225176.00
1                                223505.00
2                                144549.00
3                                237820.00
4                                981191.00
…                                      …
6199                              67863.42
6200                             277655.62
6201                             651943.27
6202                             113879.15
6203                             213275.72

[6204 rows x 60 columns]
```

[10]:
```
# Drop columns where all values are null
df_service1=df_service1.dropna(axis=1, how='all')
df_service1
```

[10]:
```
      periodid      periodname  year_month country                county  \
0       201404      April 2014      201404   Kenya        Turkana County
1       201404      April 2014      201404   Kenya          Nandi County
2       201404      April 2014      201404   Kenya     West Pokot County
3       201404      April 2014      201404   Kenya          Bomet County
4       201404      April 2014      201404   Kenya        Nairobi County
…          …               …           …       …                     …
6199    202409  September 2024      202409   Kenya         Isiolo County
6200    202409  September 2024      202409   Kenya    Trans Nzoia County
6201    202409  September 2024      202409   Kenya         Nakuru County
6202    202409  September 2024      202409   Kenya  Tharaka Nithi County
6203    202409  September 2024      202409   Kenya          Nyeri County

              uid  organisationunitname   county_code  \
0     kphDeKClFch        Turkana County  KE_County_23
1     t0J75eHKxz5          Nandi County  KE_County_29
2     XWALbfAPa6n     West Pokot County  KE_County_24
3     HMNARUV2CW4          Bomet County  KE_County_36
4     jkG3zaihdSs        Nairobi County  KE_County_47
…           …                  …           …
6199  bzOfj0iwfDH         Isiolo County  KE_County_11
6200  mThvosEflAU    Trans Nzoia County  KE_County_26
6201  ob6SxuRcqU4         Nakuru County  KE_County_32
6202  T4urHM47nlm  Tharaka Nithi County  KE_County_13
6203  ptWVfaCIdVx          Nyeri County  KE_County_19
```

```
      estimated_number_of_pregnant_women  fp_attendance_new_clients  …  \
0                                24517.00                      440.0  …
1                                43784.00                     3572.0  …
2                                21198.00                      745.0  …
3                                39762.00                     2521.0  …
4                               158875.00                    11356.0  …
…                                     …                          …  …
6199                             7422.28                       240.0  …
6200                            35675.47                      2805.0  …
6201                            78676.96                     10801.0  …
6202                            13004.53                      1061.0  …
6203                            19362.90                      1516.0  …

      2020_post_parturm_fp_4weeks_to_6weeks_re_visits  \
0                                                 NaN
1                                                 NaN
2                                                 NaN
3                                                 NaN
4                                                 NaN
…                                                 …
6199                                             53.0
6200                                              3.0
6201                                             41.0
6202                                              NaN
6203                                             21.0

      2020_post_parturm_fp_within_48_hours_new_clients  \
0                                                  NaN
1                                                  NaN
2                                                  NaN
3                                                  NaN
4                                                  NaN
…                                                  …
6199                                              17.0
6200                                              75.0
6201                                             191.0
6202                                               NaN
6203                                               9.0

      2020_post_parturm_fp_within_48_hours_re_visits  \
0                                                 NaN
1                                                 NaN
2                                                 NaN
3                                                 NaN
4                                                 NaN
…                                                 …
6199                                              NaN
```

```
6200                                                54.0
6201                                                34.0
6202                                                 NaN
6203                                                 8.0

      2020_voluntary_surgical_contraception_vasectomy_ist_time_insertion  \
0                                                     NaN
1                                                     NaN
2                                                     NaN
3                                                     NaN
4                                                     NaN
…                                                     …
6199                                                  NaN
6200                                                  NaN
6201                                                  3.0
6202                                                  NaN
6203                                                  NaN

      2020_voluntary_surgical_contraception_vasectomy_re_insertion  \
0                                                     NaN
1                                                     NaN
2                                                     NaN
3                                                     NaN
4                                                     NaN
…                                                     …
6199                                                  NaN
6200                                                  NaN
6201                                                  NaN
6202                                                  NaN
6203                                                  NaN

      2020_voluntary_surgical_contraception_btl_ist_time_insertion  \
0                                                     NaN
1                                                     NaN
2                                                     NaN
3                                                     NaN
4                                                     NaN
…                                                     …
6199                                                  1.0
6200                                                  1.0
6201                                                 15.0
6202                                                  NaN
6203                                                 10.0

      2020_voluntary_surgical_contraception_btl_re_insertion  \
0                                                     NaN
1                                                     NaN
```

```
2                                                    NaN
3                                                    NaN
4                                                    NaN
…                                                    …
6199                                                 NaN
6200                                                 NaN
6201                                                 NaN
6202                                                 NaN
6203                                                 NaN

      population_growth_rate  total_population  \
0                       3.16         999367.00
1                       3.02         938866.00
2                       3.10         597313.00
3                    1568.96         834381.70
4                       4.02        3894186.00
…                         …                …
6199                    2.32         296179.23
6200                    2.94        1153812.49
6201                    2.90        2480137.33
6202                    2.67         451552.75
6203                     NaN         849272.42

      women_of_childbearing_age_(15_49yrs)
0                                225176.00
1                                223505.00
2                                144549.00
3                                237820.00
4                                981191.00
…                                      …
6199                              67863.42
6200                             277655.62
6201                             651943.27
6202                             113879.15
6203                             213275.72

[6204 rows x 58 columns]
```

[11]:
```
# Drop unwanted columns
df_service1=df_service1.drop(columns=['periodid','organisationunitname',␣
 ↪'periodname','population_growth_rate',
                                      ␣
 ↪'total_population','women_of_childbearing_age_(15_49yrs)'
                                       ], axis=1)
```

[12]:
```
# Check for missing values
df_service1.isna().sum().sort_values(ascending=False)
```

[12]:

2020_voluntary_surgical_contraception_vasectomy_re_insertion	6199
2020_voluntary_surgical_contraception_btl_re_insertion	6172
2020_clients_given_cycle_beads_re_visits	6120
2020_voluntary_surgical_contraception_vasectomy_ist_time_insertion	5904
2020_clients_receiving_post_abortion_fp_re_visits	5779
2020_clients_given_cycle_beads_new_clients	5016
2020_post_parturm_fp_within_48_hours_re_visits	5005
2020_post_parturm_fp_4weeks_to_6weeks_re_visits	4776
2020_iucd_insertion_hormonal_re_insertion	4643
2020_voluntary_surgical_contraception_btl_ist_time_insertion	4619
2020_clients_receiving_post_abortion_fp_new_clients	4197
2020_iucd_insertion_hormonal_ist_time_insertion	4189
2020_iucd_insertion_non_hormonal_re_insertion	4110
2020_fp_injections_dmpa__sc_re_visits	4096
2020_fp_injections_dmpa__sc_new_clients	4071
2020_post_parturm_fp_within_48_hours_new_clients	3996
2020_iucd_insertion_non_hormonal_ist_time_insertion	3872
2020_post_parturm_fp_4weeks_to_6weeks_new_clients	3854
2020_implants_insertion_1_rod_re_insertion	3815
2020_implants_insertion_2_rod_re_insertion	3802
2020_adults_25+_receiving_fp_services_re_visits	3796
2020_adults_25+_receiving_fp_services_new_clients	3789
2020_implants_insertion_2_rod_ist_time_insertion	3770
2020_implants_insertion_1_rod_ist_time_insertion	3766
2020_fp_injections_dmpa__im_new_clients	3739
2020_fp_injections_dmpa__im_re_visits	3735
clients_receiving_female_condoms_re_visits	3378
clients_counselled_natural_family_planning_re_visits	2895
adolescent_10_14_yrs_receiving_fp_services_re_visits	2877
emergency_contraceptive_pill_re_visits	2802
adolescent_10_14_yrs_receiving_fp_services_new_clients	2109
clients_receiving_female_condoms_new_clients	2063
emergency_contraceptive_pill_new_clients	1367
adolescent_15_19_yrs_receiving_fp_services_re_visits	1248
adolescent_20_24_yrs_receiving_fp_services_re_visits	1240
adolescent_20_24_yrs_receiving_fp_services_new_clients	1232
adolescent_15_19_yrs_receiving_fp_services_new_clients	1224
clients_counselled_natural_family_planning_new_clients	745
client_receiving_male_condoms_re_visits	200
pills_progestin_only_re_visits	39
estimated_number_of_pregnant_women	12
pills_progestin_only_new_clients	11
pills_combined_oral_contraceptive_re_visits	10
pills_combined_oral_contraceptive_new_clients	3
client_receiving_male_condoms_new_clients	0
fp_attendance_re_visits	0
fp_attendance_new_clients	0

```
county_code                                                    0
uid                                                            0
county                                                         0
country                                                        0
year_month                                                     0
dtype: int64
```

Missing values were interpreted as 'no service was provided or dataset missing for the organization unit' and filled with 0

[13]:
```
# Fill the missing values with zeros
df_service1 = df_service1.fillna(0)
```

[14]:
```
# Extract year from 'year_month'
df_service1['year'] = df_service1['year_month'].astype(str).str[:4].astype(int)
df_service1
```

[14]:
```
      year_month country                county          uid   county_code  \
0         201404   Kenya        Turkana County  kphDeKClFch  KE_County_23
1         201404   Kenya          Nandi County  t0J75eHKxz5  KE_County_29
2         201404   Kenya     West Pokot County  XWALbfAPa6n  KE_County_24
3         201404   Kenya          Bomet County  HMNARUV2CW4  KE_County_36
4         201404   Kenya        Nairobi County  jkG3zaihdSs  KE_County_47
…          …     …                    …          …           …
6199      202409   Kenya         Isiolo County  bzOfj0iwfDH  KE_County_11
6200      202409   Kenya    Trans Nzoia County  mThvosEflAU  KE_County_26
6201      202409   Kenya         Nakuru County  ob6SxuRcqU4  KE_County_32
6202      202409   Kenya  Tharaka Nithi County  T4urHM47nlm  KE_County_13
6203      202409   Kenya          Nyeri County  ptWVfaCIdVx  KE_County_19

      estimated_number_of_pregnant_women  fp_attendance_new_clients  \
0                                24517.00                      440.0
1                                43784.00                     3572.0
2                                21198.00                      745.0
3                                39762.00                     2521.0
4                               158875.00                    11356.0
…                                     …                     …
6199                              7422.28                      240.0
6200                             35675.47                     2805.0
6201                             78676.96                    10801.0
6202                             13004.53                     1061.0
6203                             19362.90                     1516.0

      fp_attendance_re_visits  \
0                       896.0
1                      7044.0
2                       738.0
```

```
3                      4411.0
4                     26382.0
…                       …
6199                   683.0
6200                  7968.0
6201                 25114.0
6202                  4490.0
6203                  6719.0

      adolescent_10_14_yrs_receiving_fp_services_new_clients  \
0                                                       0.0
1                                                       0.0
2                                                       0.0
3                                                       0.0
4                                                       0.0
…                                                       …
6199                                                    1.0
6200                                                    1.0
6201                                                    8.0
6202                                                    1.0
6203                                                    5.0

      adolescent_10_14_yrs_receiving_fp_services_re_visits  …  \
0                                                       0.0  …
1                                                       0.0  …
2                                                       0.0  …
3                                                       0.0  …
4                                                       0.0  …
…                                                       …    …
6199                                                    0.0  …
6200                                                    1.0  …
6201                                                    5.0  …
6202                                                    1.0  …
6203                                                    0.0  …

      2020_implants_insertion_2_rod_re_insertion  \
0                                            0.0
1                                            0.0
2                                            0.0
3                                            0.0
4                                            0.0
…                                            …
6199                                        71.0
6200                                       491.0
6201                                      1004.0
6202                                       142.0
6203                                       198.0
```

```
      2020_post_parturm_fp_4weeks_to_6weeks_new_clients  \
0                                                   0.0
1                                                   0.0
2                                                   0.0
3                                                   0.0
4                                                   0.0
…                                                   …
6199                                               36.0
6200                                              424.0
6201                                             1214.0
6202                                               64.0
6203                                              382.0

      2020_post_parturm_fp_4weeks_to_6weeks_re_visits  \
0                                                   0.0
1                                                   0.0
2                                                   0.0
3                                                   0.0
4                                                   0.0
…                                                   …
6199                                               53.0
6200                                                3.0
6201                                               41.0
6202                                                0.0
6203                                               21.0

      2020_post_parturm_fp_within_48_hours_new_clients  \
0                                                   0.0
1                                                   0.0
2                                                   0.0
3                                                   0.0
4                                                   0.0
…                                                   …
6199                                               17.0
6200                                               75.0
6201                                              191.0
6202                                                0.0
6203                                                9.0

      2020_post_parturm_fp_within_48_hours_re_visits  \
0                                                  0.0
1                                                  0.0
2                                                  0.0
3                                                  0.0
4                                                  0.0
…                                                  …
```

```
6199                                                 0.0
6200                                                54.0
6201                                                34.0
6202                                                 0.0
6203                                                 8.0

      2020_voluntary_surgical_contraception_vasectomy_ist_time_insertion  \
0                                                     0.0
1                                                     0.0
2                                                     0.0
3                                                     0.0
4                                                     0.0
…                                                     …
6199                                                  0.0
6200                                                  0.0
6201                                                  3.0
6202                                                  0.0
6203                                                  0.0

      2020_voluntary_surgical_contraception_vasectomy_re_insertion  \
0                                                     0.0
1                                                     0.0
2                                                     0.0
3                                                     0.0
4                                                     0.0
…                                                     …
6199                                                  0.0
6200                                                  0.0
6201                                                  0.0
6202                                                  0.0
6203                                                  0.0

      2020_voluntary_surgical_contraception_btl_ist_time_insertion  \
0                                                     0.0
1                                                     0.0
2                                                     0.0
3                                                     0.0
4                                                     0.0
…                                                     …
6199                                                  1.0
6200                                                  1.0
6201                                                 15.0
6202                                                  0.0
6203                                                 10.0

      2020_voluntary_surgical_contraception_btl_re_insertion  year
0                                                     0.0       2014
```

```
1                                                    0.0       2014
2                                                    0.0       2014
3                                                    0.0       2014
4                                                    0.0       2014
…                                                    …         …
6199                                                 0.0       2024
6200                                                 0.0       2024
6201                                                 0.0       2024
6202                                                 0.0       2024
6203                                                 0.0       2024

[6204 rows x 53 columns]
```

[15]:
```
# Create a new column (uid_code)
df_service1['uid_code'] = df_service1[
    ['year_month','uid' ]].astype(str).agg('_'.join, axis=1)

df_service1.head()
```

[15]:
```
   year_month country             county          uid   county_code  \
0      201404   Kenya     Turkana County  kphDeKClFch  KE_County_23
1      201404   Kenya       Nandi County  t0J75eHKxz5  KE_County_29
2      201404   Kenya  West Pokot County  XWALbfAPa6n  KE_County_24
3      201404   Kenya       Bomet County  HMNARUV2CW4  KE_County_36
4      201404   Kenya     Nairobi County  jkG3zaihdSs  KE_County_47

   estimated_number_of_pregnant_women  fp_attendance_new_clients  \
0                             24517.0                      440.0
1                             43784.0                     3572.0
2                             21198.0                      745.0
3                             39762.0                     2521.0
4                            158875.0                    11356.0

   fp_attendance_re_visits  \
0                    896.0
1                   7044.0
2                    738.0
3                   4411.0
4                  26382.0

   adolescent_10_14_yrs_receiving_fp_services_new_clients  \
0                                                0.0
1                                                0.0
2                                                0.0
3                                                0.0
4                                                0.0
```

```
   adolescent_10_14_yrs_receiving_fp_services_re_visits  …  \
0                                                   0.0     …
1                                                   0.0     …
2                                                   0.0     …
3                                                   0.0     …
4                                                   0.0     …

   2020_post_parturm_fp_4weeks_to_6weeks_new_clients  \
0                                                0.0
1                                                0.0
2                                                0.0
3                                                0.0
4                                                0.0

   2020_post_parturm_fp_4weeks_to_6weeks_re_visits  \
0                                              0.0
1                                              0.0
2                                              0.0
3                                              0.0
4                                              0.0

   2020_post_parturm_fp_within_48_hours_new_clients  \
0                                               0.0
1                                               0.0
2                                               0.0
3                                               0.0
4                                               0.0

   2020_post_parturm_fp_within_48_hours_re_visits  \
0                                             0.0
1                                             0.0
2                                             0.0
3                                             0.0
4                                             0.0

   2020_voluntary_surgical_contraception_vasectomy_ist_time_insertion  \
0                                                0.0
1                                                0.0
2                                                0.0
3                                                0.0
4                                                0.0

   2020_voluntary_surgical_contraception_vasectomy_re_insertion  \
0                                                0.0
1                                                0.0
2                                                0.0
3                                                0.0
```

```
4                                                 0.0

   2020_voluntary_surgical_contraception_btl_ist_time_insertion  \
0                                                 0.0
1                                                 0.0
2                                                 0.0
3                                                 0.0
4                                                 0.0

   2020_voluntary_surgical_contraception_btl_re_insertion  year  \
0                                                 0.0       2014
1                                                 0.0       2014
2                                                 0.0       2014
3                                                 0.0       2014
4                                                 0.0       2014

            uid_code
0  201404_kphDeKClFch
1  201404_t0J75eHKxz5
2  201404_XWALbfAPa6n
3  201404_HMNARUV2CW4
4  201404_jkG3zaihdSs

[5 rows x 54 columns]
```

[16]:
```
# Create a new column (uid_year)
df_service1['uid_year'] = df_service1[
    ['year','uid' ]].astype(str).agg('_'.join, axis=1)

df_service1.head()
```

[16]:
```
   year_month country             county          uid   county_code  \
0      201404   Kenya     Turkana County  kphDeKClFch  KE_County_23
1      201404   Kenya       Nandi County  t0J75eHKxz5  KE_County_29
2      201404   Kenya  West Pokot County  XWALbfAPa6n  KE_County_24
3      201404   Kenya       Bomet County  HMNARUV2CW4  KE_County_36
4      201404   Kenya     Nairobi County  jkG3zaihdSs  KE_County_47

   estimated_number_of_pregnant_women  fp_attendance_new_clients  \
0                             24517.0                      440.0
1                             43784.0                     3572.0
2                             21198.0                      745.0
3                             39762.0                     2521.0
4                            158875.0                    11356.0

   fp_attendance_re_visits  \
0                    896.0
```

```
1                   7044.0
2                    738.0
3                   4411.0
4                  26382.0

   adolescent_10_14_yrs_receiving_fp_services_new_clients  \
0                                                  0.0
1                                                  0.0
2                                                  0.0
3                                                  0.0
4                                                  0.0

   adolescent_10_14_yrs_receiving_fp_services_re_visits  …  \
0                                                  0.0     …
1                                                  0.0     …
2                                                  0.0     …
3                                                  0.0     …
4                                                  0.0     …

   2020_post_parturm_fp_4weeks_to_6weeks_re_visits  \
0                                              0.0
1                                              0.0
2                                              0.0
3                                              0.0
4                                              0.0

   2020_post_parturm_fp_within_48_hours_new_clients  \
0                                               0.0
1                                               0.0
2                                               0.0
3                                               0.0
4                                               0.0

   2020_post_parturm_fp_within_48_hours_re_visits  \
0                                             0.0
1                                             0.0
2                                             0.0
3                                             0.0
4                                             0.0

   2020_voluntary_surgical_contraception_vasectomy_ist_time_insertion  \
0                                                  0.0
1                                                  0.0
2                                                  0.0
3                                                  0.0
4                                                  0.0
```

```
   2020_voluntary_surgical_contraception_vasectomy_re_insertion  \
0                                                        0.0
1                                                        0.0
2                                                        0.0
3                                                        0.0
4                                                        0.0

   2020_voluntary_surgical_contraception_btl_ist_time_insertion  \
0                                                        0.0
1                                                        0.0
2                                                        0.0
3                                                        0.0
4                                                        0.0

   2020_voluntary_surgical_contraception_btl_re_insertion  year  \
0                                                        0.0       2014
1                                                        0.0       2014
2                                                        0.0       2014
3                                                        0.0       2014
4                                                        0.0       2014

             uid_code          uid_year
0  201404_kphDeKClFch  2014_kphDeKClFch
1  201404_t0J75eHKxz5  2014_t0J75eHKxz5
2  201404_XWALbfAPa6n  2014_XWALbfAPa6n
3  201404_HMNARUV2CW4  2014_HMNARUV2CW4
4  201404_jkG3zaihdSs  2014_jkG3zaihdSs

[5 rows x 55 columns]
```

[17]:
```
df_service1.columns
```

[17]:
```
Index(['year_month', 'country', 'county', 'uid', 'county_code',
       'estimated_number_of_pregnant_women', 'fp_attendance_new_clients',
       'fp_attendance_re_visits',
       'adolescent_10_14_yrs_receiving_fp_services_new_clients',
       'adolescent_10_14_yrs_receiving_fp_services_re_visits',
       'adolescent_15_19_yrs_receiving_fp_services_new_clients',
       'adolescent_15_19_yrs_receiving_fp_services_re_visits',
       'adolescent_20_24_yrs_receiving_fp_services_new_clients',
       'adolescent_20_24_yrs_receiving_fp_services_re_visits',
       'client_receiving_male_condoms_new_clients',
       'client_receiving_male_condoms_re_visits',
       'clients_counselled_natural_family_planning_new_clients',
       'clients_counselled_natural_family_planning_re_visits',
       'clients_receiving_female_condoms_new_clients',
       'clients_receiving_female_condoms_re_visits',
```

```
       'emergency_contraceptive_pill_new_clients',
       'emergency_contraceptive_pill_re_visits',
       'pills_combined_oral_contraceptive_new_clients',
       'pills_combined_oral_contraceptive_re_visits',
       'pills_progestin_only_new_clients', 'pills_progestin_only_re_visits',
       '2020_adults_25+_receiving_fp_services_new_clients',
       '2020_adults_25+_receiving_fp_services_re_visits',
       '2020_clients_given_cycle_beads_new_clients',
       '2020_clients_given_cycle_beads_re_visits',
       '2020_clients_receiving_post_abortion_fp_new_clients',
       '2020_clients_receiving_post_abortion_fp_re_visits',
       '2020_fp_injections_dmpa__im_new_clients',
       '2020_fp_injections_dmpa__im_re_visits',
       '2020_fp_injections_dmpa__sc_new_clients',
       '2020_fp_injections_dmpa__sc_re_visits',
       '2020_iucd_insertion_hormonal_ist_time_insertion',
       '2020_iucd_insertion_hormonal_re_insertion',
       '2020_iucd_insertion_non_hormonal_ist_time_insertion',
       '2020_iucd_insertion_non_hormonal_re_insertion',
       '2020_implants_insertion_1_rod_ist_time_insertion',
       '2020_implants_insertion_1_rod_re_insertion',
       '2020_implants_insertion_2_rod_ist_time_insertion',
       '2020_implants_insertion_2_rod_re_insertion',
       '2020_post_parturm_fp_4weeks_to_6weeks_new_clients',
       '2020_post_parturm_fp_4weeks_to_6weeks_re_visits',
       '2020_post_parturm_fp_within_48_hours_new_clients',
       '2020_post_parturm_fp_within_48_hours_re_visits',
       '2020_voluntary_surgical_contraception_vasectomy_ist_time_insertion',
       '2020_voluntary_surgical_contraception_vasectomy_re_insertion',
       '2020_voluntary_surgical_contraception_btl_ist_time_insertion',
       '2020_voluntary_surgical_contraception_btl_re_insertion', 'year',
       'uid_code', 'uid_year'],
      dtype='object')
```

[18]:
```
# Check columns with float dtypes
float_cols = df_service1.select_dtypes(include=['float', 'float64']).columns
float_cols
```

[18]:
```
Index(['estimated_number_of_pregnant_women', 'fp_attendance_new_clients',
       'fp_attendance_re_visits',
       'adolescent_10_14_yrs_receiving_fp_services_new_clients',
       'adolescent_10_14_yrs_receiving_fp_services_re_visits',
       'adolescent_15_19_yrs_receiving_fp_services_new_clients',
       'adolescent_15_19_yrs_receiving_fp_services_re_visits',
       'adolescent_20_24_yrs_receiving_fp_services_new_clients',
       'adolescent_20_24_yrs_receiving_fp_services_re_visits',
       'client_receiving_male_condoms_re_visits',
```

```
       'clients_counselled_natural_family_planning_new_clients',
       'clients_counselled_natural_family_planning_re_visits',
       'clients_receiving_female_condoms_new_clients',
       'clients_receiving_female_condoms_re_visits',
       'emergency_contraceptive_pill_new_clients',
       'emergency_contraceptive_pill_re_visits',
       'pills_combined_oral_contraceptive_new_clients',
       'pills_combined_oral_contraceptive_re_visits',
       'pills_progestin_only_new_clients', 'pills_progestin_only_re_visits',
       '2020_adults_25+_receiving_fp_services_new_clients',
       '2020_adults_25+_receiving_fp_services_re_visits',
       '2020_clients_given_cycle_beads_new_clients',
       '2020_clients_given_cycle_beads_re_visits',
       '2020_clients_receiving_post_abortion_fp_new_clients',
       '2020_clients_receiving_post_abortion_fp_re_visits',
       '2020_fp_injections_dmpa__im_new_clients',
       '2020_fp_injections_dmpa__im_re_visits',
       '2020_fp_injections_dmpa__sc_new_clients',
       '2020_fp_injections_dmpa__sc_re_visits',
       '2020_iucd_insertion_hormonal_ist_time_insertion',
       '2020_iucd_insertion_hormonal_re_insertion',
       '2020_iucd_insertion_non_hormonal_ist_time_insertion',
       '2020_iucd_insertion_non_hormonal_re_insertion',
       '2020_implants_insertion_1_rod_ist_time_insertion',
       '2020_implants_insertion_1_rod_re_insertion',
       '2020_implants_insertion_2_rod_ist_time_insertion',
       '2020_implants_insertion_2_rod_re_insertion',
       '2020_post_parturm_fp_4weeks_to_6weeks_new_clients',
       '2020_post_parturm_fp_4weeks_to_6weeks_re_visits',
       '2020_post_parturm_fp_within_48_hours_new_clients',
       '2020_post_parturm_fp_within_48_hours_re_visits',
       '2020_voluntary_surgical_contraception_vasectomy_ist_time_insertion',
       '2020_voluntary_surgical_contraception_vasectomy_re_insertion',
       '2020_voluntary_surgical_contraception_btl_ist_time_insertion',
       '2020_voluntary_surgical_contraception_btl_re_insertion'],
      dtype='object')
```

[19]:
```
# Convert float columns to int64
df_service1[float_cols] = df_service1[float_cols].astype('int64')
```

[20]:
```
df_service1.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 6204 entries, 0 to 6203
Data columns (total 55 columns):
 #   Column                                                          Non-
Null Count  Dtype
```

```
---  ------
--------------  -----
 0   year_month                                                6204
non-null   int64
 1   country                                                   6204
non-null   object
 2   county                                                    6204
non-null   object
 3   uid                                                       6204
non-null   object
 4   county_code                                               6204
non-null   object
 5   estimated_number_of_pregnant_women                        6204
non-null   int64
 6   fp_attendance_new_clients                                 6204
non-null   int64
 7   fp_attendance_re_visits                                   6204
non-null   int64
 8   adolescent_10_14_yrs_receiving_fp_services_new_clients    6204
non-null   int64
 9   adolescent_10_14_yrs_receiving_fp_services_re_visits      6204
non-null   int64
 10  adolescent_15_19_yrs_receiving_fp_services_new_clients    6204
non-null   int64
 11  adolescent_15_19_yrs_receiving_fp_services_re_visits      6204
non-null   int64
 12  adolescent_20_24_yrs_receiving_fp_services_new_clients    6204
non-null   int64
 13  adolescent_20_24_yrs_receiving_fp_services_re_visits      6204
non-null   int64
 14  client_receiving_male_condoms_new_clients                 6204
non-null   int64
 15  client_receiving_male_condoms_re_visits                   6204
non-null   int64
 16  clients_counselled_natural_family_planning_new_clients    6204
non-null   int64
 17  clients_counselled_natural_family_planning_re_visits      6204
non-null   int64
 18  clients_receiving_female_condoms_new_clients              6204
non-null   int64
 19  clients_receiving_female_condoms_re_visits                6204
non-null   int64
 20  emergency_contraceptive_pill_new_clients                  6204
non-null   int64
 21  emergency_contraceptive_pill_re_visits                    6204
non-null   int64
 22  pills_combined_oral_contraceptive_new_clients             6204
non-null   int64
```

```
 23  pills_combined_oral_contraceptive_re_visits                    6204
non-null   int64
 24  pills_progestin_only_new_clients                               6204
non-null   int64
 25  pills_progestin_only_re_visits                                 6204
non-null   int64
 26  2020_adults_25+_receiving_fp_services_new_clients              6204
non-null   int64
 27  2020_adults_25+_receiving_fp_services_re_visits                6204
non-null   int64
 28  2020_clients_given_cycle_beads_new_clients                     6204
non-null   int64
 29  2020_clients_given_cycle_beads_re_visits                       6204
non-null   int64
 30  2020_clients_receiving_post_abortion_fp_new_clients            6204
non-null   int64
 31  2020_clients_receiving_post_abortion_fp_re_visits              6204
non-null   int64
 32  2020_fp_injections_dmpa__im_new_clients                        6204
non-null   int64
 33  2020_fp_injections_dmpa__im_re_visits                          6204
non-null   int64
 34  2020_fp_injections_dmpa__sc_new_clients                        6204
non-null   int64
 35  2020_fp_injections_dmpa__sc_re_visits                          6204
non-null   int64
 36  2020_iucd_insertion_hormonal_ist_time_insertion                6204
non-null   int64
 37  2020_iucd_insertion_hormonal_re_insertion                      6204
non-null   int64
 38  2020_iucd_insertion_non_hormonal_ist_time_insertion            6204
non-null   int64
 39  2020_iucd_insertion_non_hormonal_re_insertion                  6204
non-null   int64
 40  2020_implants_insertion_1_rod_ist_time_insertion               6204
non-null   int64
 41  2020_implants_insertion_1_rod_re_insertion                     6204
non-null   int64
 42  2020_implants_insertion_2_rod_ist_time_insertion               6204
non-null   int64
 43  2020_implants_insertion_2_rod_re_insertion                     6204
non-null   int64
 44  2020_post_parturm_fp_4weeks_to_6weeks_new_clients              6204
non-null   int64
 45  2020_post_parturm_fp_4weeks_to_6weeks_re_visits                6204
non-null   int64
 46  2020_post_parturm_fp_within_48_hours_new_clients               6204
non-null   int64
```

```
 47  2020_post_parturm_fp_within_48_hours_re_visits                      6204
non-null   int64
 48  2020_voluntary_surgical_contraception_vasectomy_ist_time_insertion  6204
non-null   int64
 49  2020_voluntary_surgical_contraception_vasectomy_re_insertion        6204
non-null   int64
 50  2020_voluntary_surgical_contraception_btl_ist_time_insertion        6204
non-null   int64
 51  2020_voluntary_surgical_contraception_btl_re_insertion              6204
non-null   int64
 52  year                                                                6204
non-null   int32
 53  uid_code                                                            6204
non-null   object
 54  uid_year                                                            6204
non-null   object
dtypes: int32(1), int64(48), object(6)
memory usage: 2.6+ MB
```

3.1.2 2. ke_fp_commodity_data.csv

[21]:
```
# Make a copy of the data
df_commodity1 = df_commodity.copy()
```

[22]:
```
# Preview the data
df_commodity1.head()
```

[22]:

	periodid	periodname	periodcode	perioddescription	orgunitlevel1	orgunitlevel2	organisationunitid	organisationunitname	organisationunitcode	organisationunitdescription	…
0	201404	14-Apr	201404	NaN	Kenya	Kirinyaga County	Ulj33KBau7V	Kirinyaga County	KE_County_20	NaN	…
1	201404	14-Apr	201404	NaN	Kenya	Kisii County	sPkRcDvhGWA	Kisii County	KE_County_45	NaN	…
2	201404	14-Apr	201404	NaN	Kenya	Kisumu County	tAbBVBbueqD	Kisumu County	KE_County_42	NaN	…
3	201404	14-Apr	201404	NaN	Kenya	Makueni County	BoDytkJQ4Qi	Makueni County	KE_County_17	NaN	…
4	201404	14-Apr	201404	NaN	Kenya	Kwale County	N7YETT3A9r1	Kwale County	KE_County_2	NaN	…

```
   implants_stock_losses  implants_stock_dispensed  implants_stock_at_hand  \
0                      0                       223                    1670
1                      0                         6                      14
2                      1                       151                    1719
3                      0                        31                      89
4                      1                        94                    1224

   implants_stock_requested  implants_stock_received  iud_stock_losses  \
0                       245                       30                 1
1                        70                       20                 0
2                       100                        0                 0
3                        50                       40                 0
4                       250                       53                 1

   iud_stock_dispensed  iud_stock_at_hand  iud_stock_requested  \
0                  253               1445                  368
1                    0                  0                   20
2                   20                 78                  220
3                    2                289                   20
4                    7                444                   25

   iud_stock_received
0                  30
1                   0
2                   0
3                   0
4                   0

[5 rows x 50 columns]
```

[23]:
```
# Explore the data
df_commodity1.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 2480 entries, 0 to 2479
Data columns (total 50 columns):
 #   Column                                    Non-Null Count  Dtype
---  ------                                    --------------  -----
 0   periodid                                  2480 non-null   int64
 1   periodname                                2480 non-null   object
 2   periodcode                                2480 non-null   int64
 3   perioddescription                         0 non-null      float64
 4   orgunitlevel1                             2480 non-null   object
 5   orgunitlevel2                             2480 non-null   object
 6   organisationunitid                        2480 non-null   object
 7   organisationunitname                      2480 non-null   object
```

```
 8   organisationunitcode                                2480 non-null   object
 9   organisationunitdescription                         0 non-null      float64
 10  pills_combined_oral_contraceptive_stock_losses      2480 non-null   int64
 11  pills_combined_oral_contraceptive_stock_dispensed   2480 non-null   int64
 12  pills_combined_oral_contraceptive_stock_at_hand     2480 non-null   int64
 13  pills_combined_oral_contraceptive_stock_requested   2480 non-null   int64
 14  pills_combined_oral_contraceptive_stock_received    2480 non-null   int64
 15  pills_emergency_pill_stock_losses                   2480 non-null   int64
 16  pills_emergency_pill_stock_dispensed                2480 non-null   int64
 17  pills_emergency_pill_stock_at_hand                  2480 non-null   int64
 18  pills_emergency_pill_stock_requested                2480 non-null   int64
 19  pills_emergency_pill_stock_received                 2480 non-null   int64
 20  pills_progestin_only_pills_stock_losses             2480 non-null   int64
 21  pills_progestin_only_pills_stock_dispensed          2480 non-null   int64
 22  pills_progestin_only_pills_stock_at_hand            2480 non-null   int64
 23  pills_progestin_only_pills_stock_requested          2480 non-null   int64
 24  pills_progestin_only_pills_stock_received           2480 non-null   int64
 25  condoms_female_condom_stock_losses                  2480 non-null   int64
 26  condoms_female_condom_stock_dispensed               2480 non-null   int64
 27  condoms_female_condom_stock_at_hand                 2480 non-null   int64
 28  condoms_female_condom_stock_requested               2480 non-null   int64
 29  condoms_female_condom_stock_received                2480 non-null   int64
 30  condoms_male_condom_stock_losses                    2480 non-null   int64
 31  condoms_male_condom_stock_dispensed                 2480 non-null   int64
 32  condoms_male_condom_stock_at_hand                   2480 non-null   int64
 33  condoms_male_condom_stock_requested                 2480 non-null   int64
 34  condoms_male_condom_stock_received                  2480 non-null   int64
 35  injectables_stock_losses                            2480 non-null   int64
 36  injectables_stock_dispensed                         2480 non-null   int64
 37  injectables_stock_at_hand                           2480 non-null   int64
 38  injectables_stock_requested                         2480 non-null   int64
 39  injectables_stock_received                          2480 non-null   int64
 40  implants_stock_losses                               2480 non-null   int64
 41  implants_stock_dispensed                            2480 non-null   int64
 42  implants_stock_at_hand                              2480 non-null   int64
 43  implants_stock_requested                            2480 non-null   int64
 44  implants_stock_received                             2480 non-null   int64
 45  iud_stock_losses                                    2480 non-null   int64
 46  iud_stock_dispensed                                 2480 non-null   int64
 47  iud_stock_at_hand                                   2480 non-null   int64
 48  iud_stock_requested                                 2480 non-null   int64
 49  iud_stock_received                                  2480 non-null   int64
dtypes: float64(2), int64(42), object(6)
memory usage: 968.9+ KB
```

[24]:
```
# Standardize the column names
df_commodity1 = standardize_col_labels(df_commodity1)
```

```
df_commodity1.head()
```

[24]:

```
   periodid periodname  periodcode  perioddescription orgunitlevel1  \
0    201404     14-Apr      201404                NaN         Kenya
1    201404     14-Apr      201404                NaN         Kenya
2    201404     14-Apr      201404                NaN         Kenya
3    201404     14-Apr      201404                NaN         Kenya
4    201404     14-Apr      201404                NaN         Kenya

      orgunitlevel2 organisationunitid organisationunitname  \
0  Kirinyaga County        Ulj33KBau7V     Kirinyaga County
1      Kisii County        sPkRcDvhGWA         Kisii County
2     Kisumu County        tAbBVBbueqD        Kisumu County
3    Makueni County        BoDytkJQ4Qi       Makueni County
4      Kwale County        N7YETT3A9r1         Kwale County

  organisationunitcode  organisationunitdescription  …  \
0         KE_County_20                          NaN  …
1         KE_County_45                          NaN  …
2         KE_County_42                          NaN  …
3         KE_County_17                          NaN  …
4          KE_County_2                          NaN  …

   implants_stock_losses  implants_stock_dispensed  implants_stock_at_hand  \
0                      0                       223                    1670
1                      0                         6                      14
2                      1                       151                    1719
3                      0                        31                      89
4                      1                        94                    1224

   implants_stock_requested  implants_stock_received  iud_stock_losses  \
0                       245                       30                 1
1                        70                       20                 0
2                       100                        0                 0
3                        50                       40                 0
4                       250                       53                 1

   iud_stock_dispensed  iud_stock_at_hand  iud_stock_requested  \
0                  253               1445                  368
1                    0                  0                   20
2                   20                 78                  220
3                    2                289                   20
4                    7                444                   25

   iud_stock_received
0                  30
```

```
1                    0
2                    0
3                    0
4                    0

[5 rows x 50 columns]
```

[25]:
```
# Rename column names
df_commodity1 = df_commodity1.rename(columns=name_map)
df_commodity1
```

[25]:
```
      periodid periodname  year_month  perioddescription country  \
0       201404     14-Apr      201404                NaN   Kenya
1       201404     14-Apr      201404                NaN   Kenya
2       201404     14-Apr      201404                NaN   Kenya
3       201404     14-Apr      201404                NaN   Kenya
4       201404     14-Apr      201404                NaN   Kenya
…          …          …           …                  …      …
2475    202209     22-Sep      202209                NaN   Kenya
2476    202209     22-Sep      202209                NaN   Kenya
2477    202209     22-Sep      202209                NaN   Kenya
2478    202309     23-Sep      202309                NaN   Kenya
2479    202409     24-Sep      202409                NaN   Kenya

                county          uid organisationunitname   county_code  \
0     Kirinyaga County  Ulj33KBau7V     Kirinyaga County  KE_County_20
1         Kisii County  sPkRcDvhGWA         Kisii County  KE_County_45
2        Kisumu County  tAbBVBbueqD        Kisumu County  KE_County_42
3       Makueni County  BoDytkJQ4Qi       Makueni County  KE_County_17
4         Kwale County  N7YETT3A9r1         Kwale County   KE_County_2
…                  …           …                  …           …
2475    Kericho County  ihZsJ8alvtb       Kericho County  KE_County_35
2476      Nandi County  t0J75eHKxz5         Nandi County  KE_County_29
2477   Machakos County  yhCUgGcCcOo      Machakos County  KE_County_16
2478    Nairobi County  jkG3zaihdSs       Nairobi County  KE_County_47
2479    Nairobi County  jkG3zaihdSs       Nairobi County  KE_County_47

      organisationunitdescription  …  implants_stock_losses  \
0                             NaN  …                      0
1                             NaN  …                      0
2                             NaN  …                      1
3                             NaN  …                      0
4                             NaN  …                      1
…                             …  …                      …
2475                          NaN  …                      0
2476                          NaN  …                      0
2477                          NaN  …                      0
```

```
2478                          NaN  …                      0
2479                          NaN  …                      0

      implants_stock_dispensed  implants_stock_at_hand  \
0                          223                    1670
1                            6                      14
2                          151                    1719
3                           31                      89
4                           94                    1224
…                          …                      …
2475                         0                       0
2476                         0                       0
2477                         0                       0
2478                         0                       0
2479                         0                       6

      implants_stock_requested  implants_stock_received  iud_stock_losses  \
0                          245                       30                 1
1                           70                       20                 0
2                          100                        0                 0
3                           50                       40                 0
4                          250                       53                 1
…                          …                        …                  …
2475                       300                        0                 0
2476                       500                        0                 0
2477                         0                        0                 0
2478                         0                        0                 0
2479                         0                        6                 0

      iud_stock_dispensed  iud_stock_at_hand  iud_stock_requested  \
0                     253               1445                  368
1                       0                  0                   20
2                      20                 78                  220
3                       2                289                   20
4                       7                444                   25
…                     …                  …                     …
2475                    0                  0                    0
2476                    0                  0                    0
2477                    0                  0                    0
2478                    2                 21                    0
2479                    3                  7                    0

      iud_stock_received
0                     30
1                      0
2                      0
3                      0
```

```
4                       0
…                     …
2475                    0
2476                    0
2477                    0
2478                    0
2479                    0

[2480 rows x 50 columns]
```

[26]:
```
# Drop columns where all values are null
df_commodity1=df_commodity1.dropna(axis=1, how='all')
df_commodity1
```

[26]:
```
      periodid periodname  year_month country            county          uid  \
0       201404     14-Apr      201404   Kenya  Kirinyaga County  Ulj33KBau7V
1       201404     14-Apr      201404   Kenya      Kisii County  sPkRcDvhGWA
2       201404     14-Apr      201404   Kenya     Kisumu County  tAbBVBbueqD
3       201404     14-Apr      201404   Kenya    Makueni County  BoDytkJQ4Qi
4       201404     14-Apr      201404   Kenya      Kwale County  N7YETT3A9r1
…         …          …          …      …                 …           …
2475    202209     22-Sep      202209   Kenya    Kericho County  ihZsJ8alvtb
2476    202209     22-Sep      202209   Kenya      Nandi County  t0J75eHKxz5
2477    202209     22-Sep      202209   Kenya   Machakos County  yhCUgGcCcOo
2478    202309     23-Sep      202309   Kenya    Nairobi County  jkG3zaihdSs
2479    202409     24-Sep      202409   Kenya    Nairobi County  jkG3zaihdSs

     organisationunitname   county_code  \
0        Kirinyaga County  KE_County_20
1            Kisii County  KE_County_45
2           Kisumu County  KE_County_42
3          Makueni County  KE_County_17
4            Kwale County   KE_County_2
…                    …           …
2475       Kericho County  KE_County_35
2476         Nandi County  KE_County_29
2477      Machakos County  KE_County_16
2478       Nairobi County  KE_County_47
2479       Nairobi County  KE_County_47

      pills_combined_oral_contraceptive_stock_losses  \
0                                                  0
1                                                  0
2                                                 17
3                                                135
4                                                 13
…                                                 …
```

```
2475                                                  0
2476                                                  0
2477                                                  0
2478                                                  0
2479                                                  0

      pills_combined_oral_contraceptive_stock_dispensed  …  \
0                                                  5728  …
1                                                     8  …
2                                                   241  …
3                                                   149  …
4                                                   693  …
…                                                   …  …
2475                                                  0  …
2476                                                420  …
2477                                               3653  …
2478                                                  0  …
2479                                                 22  …

      implants_stock_losses  implants_stock_dispensed  implants_stock_at_hand  \
0                         0                       223                    1670
1                         0                         6                      14
2                         1                       151                    1719
3                         0                        31                      89
4                         1                        94                    1224
…                       …                         …                       …
2475                      0                         0                       0
2476                      0                         0                       0
2477                      0                         0                       0
2478                      0                         0                       0
2479                      0                         0                       6

      implants_stock_requested  implants_stock_received  iud_stock_losses  \
0                          245                       30                 1
1                           70                       20                 0
2                          100                        0                 0
3                           50                       40                 0
4                          250                       53                 1
…                          …                         …                  …
2475                       300                        0                 0
2476                       500                        0                 0
2477                         0                        0                 0
2478                         0                        0                 0
2479                         0                        6                 0

      iud_stock_dispensed  iud_stock_at_hand  iud_stock_requested  \
0                     253               1445                  368
```

```
1                       0                   0                   20
2                      20                  78                  220
3                       2                 289                   20
4                       7                 444                   25
…                     …                   …                   …
2475                    0                   0                    0
2476                    0                   0                    0
2477                    0                   0                    0
2478                    2                  21                    0
2479                    3                   7                    0

      iud_stock_received
0                     30
1                      0
2                      0
3                      0
4                      0
…                    …
2475                   0
2476                   0
2477                   0
2478                   0
2479                   0

[2480 rows x 48 columns]
```

[27]:
```
# Drop unwanted columns
df_commodity1.drop(columns='organisationunitname', inplace=True)
df_commodity1
```

```
c:\Users\User\anaconda3\envs\learn-env\lib\site-
packages\pandas\core\frame.py:4163: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame

See the caveats in the documentation: https://pandas.pydata.org/pandas-
docs/stable/user_guide/indexing.html#returning-a-view-versus-a-copy
  return super().drop(
```

[27]:
```
      periodid periodname  year_month country            county          uid  \
0       201404     14-Apr      201404   Kenya  Kirinyaga County  Ulj33KBau7V
1       201404     14-Apr      201404   Kenya      Kisii County  sPkRcDvhGWA
2       201404     14-Apr      201404   Kenya     Kisumu County  tAbBVBbueqD
3       201404     14-Apr      201404   Kenya    Makueni County  BoDytkJQ4Qi
4       201404     14-Apr      201404   Kenya      Kwale County  N7YETT3A9r1
…          …          …           …       …                 …           …
2475    202209     22-Sep      202209   Kenya    Kericho County  ihZsJ8alvtb
2476    202209     22-Sep      202209   Kenya      Nandi County  t0J75eHKxz5
```

```
2477    202209     22-Sep      202209   Kenya   Machakos County  yhCUgGcCcOo
2478    202309     23-Sep      202309   Kenya    Nairobi County  jkG3zaihdSs
2479    202409     24-Sep      202409   Kenya    Nairobi County  jkG3zaihdSs

       county_code  pills_combined_oral_contraceptive_stock_losses  \
0     KE_County_20                                                0
1     KE_County_45                                                0
2     KE_County_42                                               17
3     KE_County_17                                              135
4      KE_County_2                                               13
…            …                                                  …
2475  KE_County_35                                                0
2476  KE_County_29                                                0
2477  KE_County_16                                                0
2478  KE_County_47                                                0
2479  KE_County_47                                                0

      pills_combined_oral_contraceptive_stock_dispensed  \
0                                                  5728
1                                                     8
2                                                   241
3                                                   149
4                                                   693
…                                                   …
2475                                                  0
2476                                                420
2477                                               3653
2478                                                  0
2479                                                 22

      pills_combined_oral_contraceptive_stock_at_hand  …  \
0                                               46036  …
1                                                  58  …
2                                                3542  …
3                                                2588  …
4                                                9289  …
…                                                …  …
2475                                                0  …
2476                                               43  …
2477                                            46174  …
2478                                               60  …
2479                                              208  …

      implants_stock_losses  implants_stock_dispensed  implants_stock_at_hand  \
0                         0                       223                    1670
1                         0                         6                      14
2                         1                       151                    1719
```

```
3                          0                         31                         89
4                          1                         94                       1224
…                        …                         …                        …
2475                       0                          0                          0
2476                       0                          0                          0
2477                       0                          0                          0
2478                       0                          0                          0
2479                       0                          0                          6

      implants_stock_requested  implants_stock_received  iud_stock_losses  \
0                          245                       30                 1
1                           70                       20                 0
2                          100                        0                 0
3                           50                       40                 0
4                          250                       53                 1
…                        …                         …                 …
2475                       300                        0                 0
2476                       500                        0                 0
2477                         0                        0                 0
2478                         0                        0                 0
2479                         0                        6                 0

      iud_stock_dispensed  iud_stock_at_hand  iud_stock_requested  \
0                     253               1445                  368
1                       0                  0                   20
2                      20                 78                  220
3                       2                289                   20
4                       7                444                   25
…                     …                 …                   …
2475                    0                  0                    0
2476                    0                  0                    0
2477                    0                  0                    0
2478                    2                 21                    0
2479                    3                  7                    0

      iud_stock_received
0                     30
1                      0
2                      0
3                      0
4                      0
…                    …
2475                   0
2476                   0
2477                   0
2478                   0
2479                   0
```

```
[2480 rows x 47 columns]
```

[28]:
```
# Check for missing values
df_commodity1.isna().sum().sort_values(ascending=False)
```

[28]:
```
iud_stock_received                                  0
pills_combined_oral_contraceptive_stock_received    0
pills_progestin_only_pills_stock_requested          0
pills_progestin_only_pills_stock_at_hand            0
pills_progestin_only_pills_stock_dispensed          0
pills_progestin_only_pills_stock_losses             0
pills_emergency_pill_stock_received                 0
pills_emergency_pill_stock_requested                0
pills_emergency_pill_stock_at_hand                  0
pills_emergency_pill_stock_dispensed                0
pills_emergency_pill_stock_losses                   0
pills_combined_oral_contraceptive_stock_requested   0
condoms_female_condom_stock_losses                  0
pills_combined_oral_contraceptive_stock_at_hand     0
pills_combined_oral_contraceptive_stock_dispensed   0
pills_combined_oral_contraceptive_stock_losses      0
county_code                                         0
uid                                                 0
county                                              0
country                                             0
year_month                                          0
periodname                                          0
pills_progestin_only_pills_stock_received           0
condoms_female_condom_stock_dispensed               0
iud_stock_requested                                 0
injectables_stock_requested                         0
iud_stock_at_hand                                   0
iud_stock_dispensed                                 0
iud_stock_losses                                    0
implants_stock_received                             0
implants_stock_requested                            0
implants_stock_at_hand                              0
implants_stock_dispensed                            0
implants_stock_losses                               0
injectables_stock_received                          0
injectables_stock_at_hand                           0
condoms_female_condom_stock_at_hand                 0
injectables_stock_dispensed                         0
injectables_stock_losses                            0
condoms_male_condom_stock_received                  0
condoms_male_condom_stock_requested                 0
```

```
condoms_male_condom_stock_at_hand                    0
condoms_male_condom_stock_dispensed                  0
condoms_male_condom_stock_losses                     0
condoms_female_condom_stock_received                 0
condoms_female_condom_stock_requested                0
periodid                                             0
dtype: int64
```

The missing values were interpreted as 'no event reported'

[29]:
```
# Dealing with the missing values

df_commodity1 = df_commodity1.fillna(0)
```

[30]:
```
# Check for duplicates
df_commodity1.duplicated().sum()
```

[30]:
```
0
```

A new column(uid_code) was created by concatenating the year_month column and organisation unit id

[31]:
```
# Create a new column (uid_code)
df_commodity1['uid_code'] = df_commodity1[['year_month','uid' ]].astype(str).
 ↪agg('_'.join, axis=1)

df_commodity1.head()
```

[31]:

	periodid	periodname	year_month	country	county	uid	\
0	201404	14-Apr	201404	Kenya	Kirinyaga County	Ulj33KBau7V	
1	201404	14-Apr	201404	Kenya	Kisii County	sPkRcDvhGWA	
2	201404	14-Apr	201404	Kenya	Kisumu County	tAbBVBbueqD	
3	201404	14-Apr	201404	Kenya	Makueni County	BoDytkJQ4Qi	
4	201404	14-Apr	201404	Kenya	Kwale County	N7YETT3A9r1	

	county_code	pills_combined_oral_contraceptive_stock_losses	\
0	KE_County_20	0	
1	KE_County_45	0	
2	KE_County_42	17	
3	KE_County_17	135	
4	KE_County_2	13	

	pills_combined_oral_contraceptive_stock_dispensed	\
0	5728	
1	8	
2	241	
3	149	
4	693	

```
   pills_combined_oral_contraceptive_stock_at_hand  …  \
0                                            46036  …
1                                               58  …
2                                             3542  …
3                                             2588  …
4                                             9289  …

   implants_stock_dispensed  implants_stock_at_hand  implants_stock_requested  \
0                       223                    1670                       245
1                         6                      14                        70
2                       151                    1719                       100
3                        31                      89                        50
4                        94                    1224                       250

   implants_stock_received  iud_stock_losses  iud_stock_dispensed  \
0                       30                 1                  253
1                       20                 0                    0
2                        0                 0                   20
3                       40                 0                    2
4                       53                 1                    7

   iud_stock_at_hand  iud_stock_requested  iud_stock_received  \
0               1445                  368                  30
1                  0                   20                   0
2                 78                  220                   0
3                289                   20                   0
4                444                   25                   0

           uid_code
0  201404_Ulj33KBau7V
1  201404_sPkRcDvhGWA
2  201404_tAbBVBbueqD
3  201404_BoDytkJQ4Qi
4  201404_N7YETT3A9r1

[5 rows x 48 columns]
```

[32]:
```
# Convert float columns to int64
float_cols_com = df_commodity1.select_dtypes(include=['float', 'float64']).
 ↪columns
df_commodity1[float_cols_com] = df_commodity1[float_cols_com].astype('int64')
df_commodity1.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 2480 entries, 0 to 2479
Data columns (total 48 columns):
```

#	Column	Non-Null Count	Dtype
0	periodid	2480 non-null	int64
1	periodname	2480 non-null	object
2	year_month	2480 non-null	int64
3	country	2480 non-null	object
4	county	2480 non-null	object
5	uid	2480 non-null	object
6	county_code	2480 non-null	object
7	pills_combined_oral_contraceptive_stock_losses	2480 non-null	int64
8	pills_combined_oral_contraceptive_stock_dispensed	2480 non-null	int64
9	pills_combined_oral_contraceptive_stock_at_hand	2480 non-null	int64
10	pills_combined_oral_contraceptive_stock_requested	2480 non-null	int64
11	pills_combined_oral_contraceptive_stock_received	2480 non-null	int64
12	pills_emergency_pill_stock_losses	2480 non-null	int64
13	pills_emergency_pill_stock_dispensed	2480 non-null	int64
14	pills_emergency_pill_stock_at_hand	2480 non-null	int64
15	pills_emergency_pill_stock_requested	2480 non-null	int64
16	pills_emergency_pill_stock_received	2480 non-null	int64
17	pills_progestin_only_pills_stock_losses	2480 non-null	int64
18	pills_progestin_only_pills_stock_dispensed	2480 non-null	int64
19	pills_progestin_only_pills_stock_at_hand	2480 non-null	int64
20	pills_progestin_only_pills_stock_requested	2480 non-null	int64
21	pills_progestin_only_pills_stock_received	2480 non-null	int64
22	condoms_female_condom_stock_losses	2480 non-null	int64
23	condoms_female_condom_stock_dispensed	2480 non-null	int64
24	condoms_female_condom_stock_at_hand	2480 non-null	int64
25	condoms_female_condom_stock_requested	2480 non-null	int64
26	condoms_female_condom_stock_received	2480 non-null	int64
27	condoms_male_condom_stock_losses	2480 non-null	int64
28	condoms_male_condom_stock_dispensed	2480 non-null	int64
29	condoms_male_condom_stock_at_hand	2480 non-null	int64
30	condoms_male_condom_stock_requested	2480 non-null	int64
31	condoms_male_condom_stock_received	2480 non-null	int64
32	injectables_stock_losses	2480 non-null	int64
33	injectables_stock_dispensed	2480 non-null	int64
34	injectables_stock_at_hand	2480 non-null	int64
35	injectables_stock_requested	2480 non-null	int64
36	injectables_stock_received	2480 non-null	int64
37	implants_stock_losses	2480 non-null	int64
38	implants_stock_dispensed	2480 non-null	int64
39	implants_stock_at_hand	2480 non-null	int64
40	implants_stock_requested	2480 non-null	int64
41	implants_stock_received	2480 non-null	int64
42	iud_stock_losses	2480 non-null	int64
43	iud_stock_dispensed	2480 non-null	int64
44	iud_stock_at_hand	2480 non-null	int64
45	iud_stock_requested	2480 non-null	int64

```
 46  iud_stock_received                                2480 non-null   int64
 47  uid_code                                          2480 non-null   object
dtypes: int64(42), object(6)
memory usage: 930.1+ KB
```

3.1.3 3. ke_fp_population_data

[33]:
```
# Make a copy of the data
df_population1 =df_population.copy()
```

[34]:
```
# Standardize column names
df_population1 = standardize_col_labels(df_population1)

# Preview the data
df_population1.head()
```

[34]:

	periodid	periodname	periodcode	perioddescription	orgunitlevel1	orgunitlevel2	organisationunitid	organisationunitname	organisationunitcode	organisationunitdescription	estimated_number_of_pregnant_women	population_10_14_year_old_girls	women_of_childbearing_age_(15_49yrs)	uid_code	uid_year
0	2014	2014	2014	NaN	Kenya	Kajiado County	Hsk1YV8kHkT	Kajiado County	KE_County_34	NaN	30521.0	NaN	174354.0	201401_Hsk1YV8kHkT	2014_Hsk1YV8kHkT
1	2014	2014	2014	NaN	Kenya	Laikipia County	xuFdFy6t9AH	Laikipia County	KE_County_31	NaN	12362.0	NaN	68426.0	201401_xuFdFy6t9AH	2014_xuFdFy6t9AH
2	2014	2014	2014	NaN	Kenya	Turkana County	kphDeKClFch	Turkana County	KE_County_23	NaN	24517.0	NaN			
3	2014	2014	2014	NaN	Kenya	Nandi County	t0J75eHKxz5	Nandi County	KE_County_29	NaN	43784.0	NaN			
4	2014	2014	2014	NaN	Kenya	Elgeyo Marakwet County	MqnLxQBigG0	Elgeyo Marakwet County	KE_County_28	NaN	18424.0	NaN			

```
2                              225176.0  201401_kphDeKClFch  2014_kphDeKClFch
3                              223505.0  201401_t0J75eHKxz5  2014_t0J75eHKxz5
4                              103238.0  201401_MqnLxQBigG0  2014_MqnLxQBigG0

   unnamed:_15  unnamed:_16  unnamed:_17  unnamed:_18
0          NaN          NaN          NaN          NaN
1          NaN          NaN          NaN          NaN
2          NaN          NaN          NaN          NaN
3          NaN          NaN          NaN          NaN
4          NaN          NaN          NaN          NaN
```

[35]:
```
# Rename column names
df_population1 = df_population1.rename(columns=name_map)

df_population1.head()
```

[35]:
```
   periodid  periodname  year_month  perioddescription country  \
0      2014        2014        2014                NaN   Kenya
1      2014        2014        2014                NaN   Kenya
2      2014        2014        2014                NaN   Kenya
3      2014        2014        2014                NaN   Kenya
4      2014        2014        2014                NaN   Kenya

                  county          uid    organisationunitname   county_code  \
0          Kajiado County  Hsk1YV8kHkT          Kajiado County  KE_County_34
1         Laikipia County  xuFdFy6t9AH         Laikipia County  KE_County_31
2          Turkana County  kphDeKClFch          Turkana County  KE_County_23
3            Nandi County  t0J75eHKxz5            Nandi County  KE_County_29
4  Elgeyo Marakwet County  MqnLxQBigG0  Elgeyo Marakwet County  KE_County_28

   organisationunitdescription  estimated_number_of_pregnant_women  \
0                          NaN                             30521.0
1                          NaN                             12362.0
2                          NaN                             24517.0
3                          NaN                             43784.0
4                          NaN                             18424.0

   population_10_14_year_old_girls  women_of_childbearing_age_(15_49yrs)  \
0                              NaN                                174354.0
1                              NaN                                 68426.0
2                              NaN                                225176.0
3                              NaN                                223505.0
4                              NaN                                103238.0

           uid_code          uid_year  unnamed:_15  unnamed:_16  \
0  201401_Hsk1YV8kHkT  2014_Hsk1YV8kHkT          NaN          NaN
1  201401_xuFdFy6t9AH  2014_xuFdFy6t9AH          NaN          NaN
```

```
2  201401_kphDeKClFch  2014_kphDeKClFch          NaN          NaN
3  201401_t0J75eHKxz5  2014_t0J75eHKxz5          NaN          NaN
4  201401_MqnLxQBigG0  2014_MqnLxQBigG0          NaN          NaN

   unnamed:_17  unnamed:_18
0          NaN          NaN
1          NaN          NaN
2          NaN          NaN
3          NaN          NaN
4          NaN          NaN
```

[36]:
```
# Drop unwanted columns
df_population1.drop(columns=['organisationunitname'], axis=1) # This was␣
 ↪dropped because it is the same as county
```

[36]:
```
     periodid  periodname  year_month  perioddescription country  \
0        2014        2014        2014                NaN   Kenya
1        2014        2014        2014                NaN   Kenya
2        2014        2014        2014                NaN   Kenya
3        2014        2014        2014                NaN   Kenya
4        2014        2014        2014                NaN   Kenya
..        …           …           …                  …     …
512      2024        2024        2024                NaN   Kenya
513      2024        2024        2024                NaN   Kenya
514      2024        2024        2024                NaN   Kenya
515      2024        2024        2024                NaN   Kenya
516      2024        2024        2024                NaN   Kenya

                     county          uid   county_code  \
0           Kajiado County  Hsk1YV8kHkT  KE_County_34
1          Laikipia County  xuFdFy6t9AH  KE_County_31
2           Turkana County  kphDeKClFch  KE_County_23
3             Nandi County  t0J75eHKxz5  KE_County_29
4    Elgeyo Marakwet County  MqnLxQBigG0  KE_County_28
..                      …           …           …
512         Makueni County  BoDytkJQ4Qi  KE_County_17
513         Kajiado County  Hsk1YV8kHkT  KE_County_34
514        Kakamega County  BjC1xL40gHo  KE_County_37
515         Muranga County  ahwTMNAJvrL  KE_County_21
516         Nairobi County  jkG3zaihdSs  KE_County_47

     organisationunitdescription  estimated_number_of_pregnant_women  \
0                            NaN                                30521.0
1                            NaN                                12362.0
2                            NaN                                24517.0
3                            NaN                                43784.0
4                            NaN                                18424.0
```

```
..                              …                                 …
512                           NaN                           26248.0
513                           NaN                           43539.0
514                           NaN                           71817.0
515                           NaN                           25812.0
516                           NaN                          175438.0

     population_10_14_year_old_girls  women_of_childbearing_age_(15_49yrs)  \
0                                NaN                                174354.0
1                                NaN                                 68426.0
2                                NaN                                225176.0
3                                NaN                                223505.0
4                                NaN                                103238.0
..                               …                                     …
512                          59388.0                                253333.0
513                          77142.0                                354857.0
514                         172301.0                                523862.0
515                          53629.0                                280830.0
516                         227708.0                               1664602.0

               uid_code          uid_year  unnamed:_15  unnamed:_16  \
0    201401_Hsk1YV8kHkT  2014_Hsk1YV8kHkT          NaN          NaN
1    201401_xuFdFy6t9AH  2014_xuFdFy6t9AH          NaN          NaN
2    201401_kphDeKClFch  2014_kphDeKClFch          NaN          NaN
3    201401_t0J75eHKxz5  2014_t0J75eHKxz5          NaN          NaN
4    201401_MqnLxQBigG0  2014_MqnLxQBigG0          NaN          NaN
..                  …                 …          …            …
512  202401_BoDytkJQ4Qi  2024_BoDytkJQ4Qi          NaN          NaN
513  202401_Hsk1YV8kHkT  2024_Hsk1YV8kHkT          NaN          NaN
514  202401_BjC1xL40gHo  2024_BjC1xL40gHo          NaN          NaN
515  202401_ahwTMNAJvrL  2024_ahwTMNAJvrL          NaN          NaN
516  202401_jkG3zaihdSs  2024_jkG3zaihdSs          NaN          NaN

     unnamed:_17  unnamed:_18
0            NaN          NaN
1            NaN          NaN
2            NaN          NaN
3            NaN          NaN
4            NaN          NaN
..           …          …
512          NaN          NaN
513          NaN          NaN
514          NaN          NaN
515          NaN          NaN
516          NaN          NaN

[517 rows x 18 columns]
```

Calculate Women eligible for FP

[37]:
```
# Insert the new column, treating NaN values as 0 during the calculation
df_population1['eligible_fp'] = (
    df_population1['women_of_childbearing_age_(15_49yrs)']
    .add(df_population1['population_10_14_year_old_girls'], fill_value=0)
    .sub(df_population1['estimated_number_of_pregnant_women'], fill_value=0)
)

# Display the updated DataFrame
df_population1.head()
```

[37]:

	periodid	periodname	year_month	perioddescription	country	\
0	2014	2014	2014	NaN	Kenya	
1	2014	2014	2014	NaN	Kenya	
2	2014	2014	2014	NaN	Kenya	
3	2014	2014	2014	NaN	Kenya	
4	2014	2014	2014	NaN	Kenya	

	county	uid	organisationunitname	county_code	\
0	Kajiado County	Hsk1YV8kHkT	Kajiado County	KE_County_34	
1	Laikipia County	xuFdFy6t9AH	Laikipia County	KE_County_31	
2	Turkana County	kphDeKClFch	Turkana County	KE_County_23	
3	Nandi County	t0J75eHKxz5	Nandi County	KE_County_29	
4	Elgeyo Marakwet County	MqnLxQBigG0	Elgeyo Marakwet County	KE_County_28	

	organisationunitdescription	estimated_number_of_pregnant_women	\
0	NaN	30521.0	
1	NaN	12362.0	
2	NaN	24517.0	
3	NaN	43784.0	
4	NaN	18424.0	

	population_10_14_year_old_girls	women_of_childbearing_age_(15_49yrs)	\
0	NaN	174354.0	
1	NaN	68426.0	
2	NaN	225176.0	
3	NaN	223505.0	
4	NaN	103238.0	

	uid_code	uid_year	unnamed:_15	unnamed:_16	\
0	201401_Hsk1YV8kHkT	2014_Hsk1YV8kHkT	NaN	NaN	
1	201401_xuFdFy6t9AH	2014_xuFdFy6t9AH	NaN	NaN	
2	201401_kphDeKClFch	2014_kphDeKClFch	NaN	NaN	
3	201401_t0J75eHKxz5	2014_t0J75eHKxz5	NaN	NaN	
4	201401_MqnLxQBigG0	2014_MqnLxQBigG0	NaN	NaN	

	unnamed:_17	unnamed:_18	eligible_fp

```
0          NaN          NaN     143833.0
1          NaN          NaN      56064.0
2          NaN          NaN     200659.0
3          NaN          NaN     179721.0
4          NaN          NaN      84814.0
```

3.1.4 4. ke_fp_benchmarks_data.csv

[38]:
```
# Make copies of the benchmarks dataframes
df_core_health_workforce1 = df_core_health_workforce.copy()
df_demand_satisfied1 = df_demand_satisfied.copy()
df_mcpr1 = df_mcpr.copy()
df_teenage_pregnancy1 = df_teenage_pregnancy.copy()
df_unmet_need1 = df_unmet_need.copy()
```

[39]:
```
# Preview the data
df_core_health_workforce1.head()
df_demand_satisfied1.head()
df_mcpr1.head()
df_teenage_pregnancy1.head()
df_unmet_need1.head()
```

[39]:
```
  organisationunitname          uid    county_cou  \
0              baringo  vvOK1BxTbet  KE_County_30
1                bomet  HMNARUV2CW4  KE_County_36
2              bungoma  KGHhQ5GLd4k  KE_County_39
3                busia  Tvf1zgVZ0K4  KE_County_40
4      elgeyo_marakwet  MqnLxQBigG0  KE_County_28

                   benchmark_indicator  Total Unmet Need (Married Women, %)  \
0  Total Unmet Need (Married Women, %)                                 16.6
1  Total Unmet Need (Married Women, %)                                 16.7
2  Total Unmet Need (Married Women, %)                                 14.6
3  Total Unmet Need (Married Women, %)                                 18.6
4  Total Unmet Need (Married Women, %)                                 13.5

   year     source            uid_code
0  2022  KDHS 2022  202201_vvOK1BxTbet
1  2022  KDHS 2022  202201_HMNARUV2CW4
2  2022  KDHS 2022  202201_KGHhQ5GLd4k
3  2022  KDHS 2022  202201_Tvf1zgVZ0K4
4  2022  KDHS 2022  202201_MqnLxQBigG0
```

3.2 *b) Initial Feature Engineering*

3.2.1 CYP computation and grouping

Couple Years of Protection(CYP)-CYP measures the estimated protection provided by FP based on the volume of contraceptive method distribution to clients to help monitor health system performance and track trends and progress over time.

[40]:
```
# Define CYP conversion factors
cyp_factors = {
    'condoms': 0.0083,
    'emergency_pill': 0.05,
    'pills_combined_oral_contraceptives': 0.0067,
    'pills_progestin_only_contraceptives': 0.0833,
    'injections': 0.25,
    'implants_1_rod': 2.5,
    'implants_2_rod': 3.8,
    'iucd_hormonal': 4.8,
    'iucd_non_hormonal': 4.6,
    'surgical': 10.0
}

# Initialize total_cyp column
df_service1['total_cyp'] = 0

# Compute total_cyp based on matching column names
for col in df_service1.columns:
    if 'condom' in col:
        df_service1['total_cyp'] += df_service1[col] * cyp_factors['condoms']

    elif 'emergency' in col and 'pill' in col:
        df_service1['total_cyp'] += df_service1[col] *␣
 ↪cyp_factors['emergency_pill']

    elif 'combined_oral' in col:
        df_service1['total_cyp'] += df_service1[col] *␣
 ↪cyp_factors['pills_combined_oral_contraceptives']

    elif 'progestin_only' in col:
        df_service1['total_cyp'] += df_service1[col] *␣
 ↪cyp_factors['pills_progestin_only_contraceptives']

    elif 'injection' in col or 'dmpa' in col:
        df_service1['total_cyp'] += df_service1[col] * cyp_factors['injections']

    elif '1_rod' in col and 'implant' in col:
        df_service1['total_cyp'] += df_service1[col] *␣
 ↪cyp_factors['implants_1_rod']
```

```
    elif '2_rod' in col and 'implant' in col:
        df_service1['total_cyp'] += df_service1[col] *␣
↪cyp_factors['implants_2_rod']

    elif 'iucd' in col and 'hormonal' in col:
        df_service1['total_cyp'] += df_service1[col] *␣
↪cyp_factors['iucd_hormonal']

    elif 'iucd' in col and 'non_hormonal' in col:
        df_service1['total_cyp'] += df_service1[col] *␣
↪cyp_factors['iucd_non_hormonal']

    elif 'surgical' in col or 'vasectomy' in col or 'btl' in col:
        df_service1['total_cyp'] += df_service1[col] * cyp_factors['surgical']
```

[41]:
```
df_service1.head()
```

[41]:

	year_month	country	county	uid	county_code	\
0	201404	Kenya	Turkana County	kphDeKClFch	KE_County_23	
1	201404	Kenya	Nandi County	t0J75eHKxz5	KE_County_29	
2	201404	Kenya	West Pokot County	XWALbfAPa6n	KE_County_24	
3	201404	Kenya	Bomet County	HMNARUV2CW4	KE_County_36	
4	201404	Kenya	Nairobi County	jkG3zaihdSs	KE_County_47	

	estimated_number_of_pregnant_women	fp_attendance_new_clients	\
0	24517	440	
1	43784	3572	
2	21198	745	
3	39762	2521	
4	158875	11356	

	fp_attendance_re_visits	\
0	896	
1	7044	
2	738	
3	4411	
4	26382	

	adolescent_10_14_yrs_receiving_fp_services_new_clients	\
0	0	
1	0	
2	0	
3	0	
4	0	

	adolescent_10_14_yrs_receiving_fp_services_re_visits	…	\

```
0                                                   0     …
1                                                   0     …
2                                                   0     …
3                                                   0     …
4                                                   0     …

   2020_post_parturm_fp_within_48_hours_new_clients  \
0                                                 0
1                                                 0
2                                                 0
3                                                 0
4                                                 0

   2020_post_parturm_fp_within_48_hours_re_visits  \
0                                               0
1                                               0
2                                               0
3                                               0
4                                               0

   2020_voluntary_surgical_contraception_vasectomy_ist_time_insertion  \
0                                                   0
1                                                   0
2                                                   0
3                                                   0
4                                                   0

   2020_voluntary_surgical_contraception_vasectomy_re_insertion  \
0                                                   0
1                                                   0
2                                                   0
3                                                   0
4                                                   0

   2020_voluntary_surgical_contraception_btl_ist_time_insertion  \
0                                                   0
1                                                   0
2                                                   0
3                                                   0
4                                                   0

   2020_voluntary_surgical_contraception_btl_re_insertion  year  \
0                                                   0       2014
1                                                   0       2014
2                                                   0       2014
3                                                   0       2014
4                                                   0       2014
```

```
             uid_code          uid_year  total_cyp
0  201404_kphDeKClFch  2014_kphDeKClFch    41.5945
1  201404_t0J75eHKxz5  2014_t0J75eHKxz5    80.8429
2  201404_XWALbfAPa6n  2014_XWALbfAPa6n    18.7608
3  201404_HMNARUV2CW4  2014_HMNARUV2CW4    18.5713
4  201404_jkG3zaihdSs  2014_jkG3zaihdSs   342.4399

[5 rows x 56 columns]
```

3.2.2 FP Method Grouping (New vs Revisits)

[42]:
```
# Group FP Methods
df_service1['adolescent_10_24_receiving_fp_new'] = (
    df_service1['adolescent_10_14_yrs_receiving_fp_services_new_clients'] +
    df_service1['adolescent_15_19_yrs_receiving_fp_services_new_clients'] +
    df_service1['adolescent_20_24_yrs_receiving_fp_services_new_clients']
)

df_service1['adolescent_10_24_receiving_fp_revisits'] = (
    df_service1['adolescent_10_14_yrs_receiving_fp_services_re_visits'] +
    df_service1['adolescent_15_19_yrs_receiving_fp_services_re_visits'] +
    df_service1['adolescent_20_24_yrs_receiving_fp_services_re_visits']
)

df_service1['adults_25+_receiving_fp_services_new'] =␣
 ↪df_service1['2020_adults_25+_receiving_fp_services_new_clients']
df_service1['adults_25+_receiving_fp_services_revisits'] =␣
 ↪df_service1['2020_adults_25+_receiving_fp_services_re_visits']

df_service1['condoms_new'] =␣
 ↪df_service1['clients_receiving_female_condoms_new_clients'] +␣
 ↪df_service1['client_receiving_male_condoms_new_clients']
df_service1['condoms_revisits'] = (
    df_service1['clients_receiving_female_condoms_re_visits'] +
    df_service1['client_receiving_male_condoms_re_visits']
)

df_service1['pills_new'] = (
    df_service1['emergency_contraceptive_pill_new_clients'] +
    df_service1['pills_combined_oral_contraceptive_new_clients'] +
    df_service1['pills_progestin_only_new_clients']
)

df_service1['pills_revisits'] = (
    df_service1['emergency_contraceptive_pill_re_visits'] +
```

```
    df_service1['pills_combined_oral_contraceptive_re_visits'] +
    df_service1['pills_progestin_only_re_visits']
)

df_service1['injectable_new'] = (
    df_service1['2020_fp_injections_dmpa__im_new_clients'] +
    df_service1['2020_fp_injections_dmpa__sc_new_clients']
)

df_service1['injectable_revisits'] = (
    df_service1['2020_fp_injections_dmpa__im_re_visits'] +
    df_service1['2020_fp_injections_dmpa__sc_re_visits']
)

df_service1['implants_new'] = (
    df_service1['2020_implants_insertion_1_rod_ist_time_insertion'] +
    df_service1['2020_implants_insertion_2_rod_ist_time_insertion']
)

df_service1['implants_revisits'] = (
    df_service1['2020_implants_insertion_1_rod_re_insertion'] +
    df_service1['2020_implants_insertion_2_rod_re_insertion']
)

df_service1['iucd_new'] = (
    df_service1['2020_iucd_insertion_hormonal_ist_time_insertion'] +
    df_service1['2020_iucd_insertion_non_hormonal_ist_time_insertion']
)

df_service1['iucd_revisits'] = (
    df_service1['2020_iucd_insertion_hormonal_re_insertion'] +
    df_service1['2020_iucd_insertion_non_hormonal_re_insertion']
)

df_service1['surgical_new'] = (
    ␣
 ↪df_service1['2020_voluntary_surgical_contraception_vasectomy_ist_time_insertion']␣
 ↪+
    df_service1['2020_voluntary_surgical_contraception_btl_ist_time_insertion']
)

df_service1['surgical_revisits'] = (
    df_service1['2020_voluntary_surgical_contraception_vasectomy_re_insertion']␣
 ↪+
    df_service1['2020_voluntary_surgical_contraception_btl_re_insertion']
)
```

```
df_service1['traditional_new'] = (
    df_service1['2020_clients_given_cycle_beads_new_clients'] +
    df_service1['clients_counselled_natural_family_planning_new_clients']
)

df_service1['traditional_revisits'] = (
    df_service1['2020_clients_given_cycle_beads_re_visits'] +
    df_service1['clients_counselled_natural_family_planning_re_visits']
)
```

[43]:
```
df_service1
```

[43]:

	year_month	country	county	uid	county_code	\
0	201404	Kenya	Turkana County	kphDeKClFch	KE_County_23	
1	201404	Kenya	Nandi County	t0J75eHKxz5	KE_County_29	
2	201404	Kenya	West Pokot County	XWALbfAPa6n	KE_County_24	
3	201404	Kenya	Bomet County	HMNARUV2CW4	KE_County_36	
4	201404	Kenya	Nairobi County	jkG3zaihdSs	KE_County_47	
…	…	…	…	…	…	
6199	202409	Kenya	Isiolo County	bzOfj0iwfDH	KE_County_11	
6200	202409	Kenya	Trans Nzoia County	mThvosEflAU	KE_County_26	
6201	202409	Kenya	Nakuru County	ob6SxuRcqU4	KE_County_32	
6202	202409	Kenya	Tharaka Nithi County	T4urHM47nlm	KE_County_13	
6203	202409	Kenya	Nyeri County	ptWVfaCIdVx	KE_County_19	

	estimated_number_of_pregnant_women	fp_attendance_new_clients	\
0	24517	440	
1	43784	3572	
2	21198	745	
3	39762	2521	
4	158875	11356	
…	…	…	
6199	7422	240	
6200	35675	2805	
6201	78676	10801	
6202	13004	1061	
6203	19362	1516	

	fp_attendance_re_visits	\
0	896	
1	7044	
2	738	
3	4411	
4	26382	
…	…	
6199	683	
6200	7968	

```
6201                   25114
6202                    4490
6203                    6719

      adolescent_10_14_yrs_receiving_fp_services_new_clients  \
0                                                         0
1                                                         0
2                                                         0
3                                                         0
4                                                         0
…                                                       …
6199                                                      1
6200                                                      1
6201                                                      8
6202                                                      1
6203                                                      5

      adolescent_10_14_yrs_receiving_fp_services_re_visits  …  \
0                                                         0     …
1                                                         0     …
2                                                         0     …
3                                                         0     …
4                                                         0     …
…                                                       …     …
6199                                                      0     …
6200                                                      1     …
6201                                                      5     …
6202                                                      1     …
6203                                                      0     …

      injectable_new  injectable_revisits  implants_new  implants_revisits  \
0                  0                     0             0                  0
1                  0                     0             0                  0
2                  0                     0             0                  0
3                  0                     0             0                  0
4                  0                     0             0                  0
…                …                     …             …                  …
6199             171                   583           133                 84
6200            1164                  6236           949                611
6201            3513                 13416          4675               1371
6202             644                  3420           307                224
6203             539                  2622           398                262

      iucd_new  iucd_revisits  surgical_new  surgical_revisits  \
0            0              0             0                  0
1            0              0             0                  0
2            0              0             0                  0
```

```
3              0               0              0                    0
4              0               0              0                    0
…          …               …          …                    …
6199           9               3              1                    0
6200          89              17              1                    0
6201         533             162             18                    0
6202          33               7              0                    0
6203         145              59             10                    0

      traditional_new  traditional_revisits
0                  33                    51
1                   0                    22
2                   0                     0
3                  10                     0
4                  85                    50
…                 …                     …
6199              129                   124
6200              452                   131
6201              527                    16
6202              254                    10
6203               29                     0

[6204 rows x 74 columns]
```

3.2.3 FP Method overal banding (pills, condoms, injectables,implants,iucd & surgical)

[44]:
```
# Combined method categories
df_service1['condoms'] = df_service1['condoms_new'] +␣
 ↪df_service1['condoms_revisits']
df_service1['pills'] = df_service1['pills_new'] + df_service1['pills_revisits']
df_service1['injectables'] = df_service1['injectable_new'] +␣
 ↪df_service1['injectable_revisits']
df_service1['implants'] = df_service1['implants_new'] +␣
 ↪df_service1['implants_revisits']
df_service1['iucd'] = df_service1['iucd_new'] + df_service1['iucd_revisits']
df_service1['surgical'] = df_service1['surgical_new'] +␣
 ↪df_service1['surgical_revisits']


# Compute Total mmodern FP methods
df_service1['total_modern_fp'] = (
    df_service1['condoms'] +
    df_service1['pills'] +
    df_service1['injectables'] +
    df_service1['implants'] +
```

```
    df_service1['iucd'] +
    df_service1['surgical']
)


# Compute Total traditional FP methods
df_service1['traditional'] = df_service1['traditional_new'] +␣
 ↪df_service1['traditional_revisits']
```

[45]:
```
# List of columns to keep
keep_cols = [
    'year_month', 'country', 'county', 'uid', 'uid_code','uid_year',␣
 ↪'county_code',
    'adolescent_10_24_receiving_fp_new',
    'adolescent_10_24_receiving_fp_revisits',
    'adults_25+_receiving_fp_services_new',
    'adults_25+_receiving_fp_services_revisits',
    'condoms_new', 'condoms_revisits', 'traditional_new',
    'pills_new', 'pills_revisits', 'traditional_revisits',
    'injectable_new', 'injectable_revisits', 'traditional',
    'implants_new', 'implants_revisits',
    'iucd_new', 'iucd_revisits',
    'surgical_new', 'surgical_revisits',
    'condoms', 'pills', 'injectables', 'implants', 'iucd', 'surgical',
    'total_modern_fp', 'total_cyp'
]

# Keep only the specified columns
df_service1 = df_service1[keep_cols]
```

Drop underlying columns

[46]:
```
df_service1.columns
```

[46]:
```
Index(['year_month', 'country', 'county', 'uid', 'uid_code', 'uid_year',
       'county_code', 'adolescent_10_24_receiving_fp_new',
       'adolescent_10_24_receiving_fp_revisits',
       'adults_25+_receiving_fp_services_new',
       'adults_25+_receiving_fp_services_revisits', 'condoms_new',
       'condoms_revisits', 'traditional_new', 'pills_new', 'pills_revisits',
       'traditional_revisits', 'injectable_new', 'injectable_revisits',
       'traditional', 'implants_new', 'implants_revisits', 'iucd_new',
       'iucd_revisits', 'surgical_new', 'surgical_revisits', 'condoms',
       'pills', 'injectables', 'implants', 'iucd', 'surgical',
       'total_modern_fp', 'total_cyp'],
      dtype='object')
```

3.2.4 Joining the datasets

A left join was used to merge the four datasets. The service data was used as the base data. Organisation unit id code (uid_code) was used to join the four datasets

[47]:
```
# Merge df_service1 with df_commodity1
fp_service_comm_df = pd.merge(df_service1, df_commodity1, how='left',␣
 ↪on='uid_code')

fp_service_comm_df
```

[47]:
```
      year_month_x country_x              county_x        uid_x  \
0           201404     Kenya        Turkana County  kphDeKClFch
1           201404     Kenya          Nandi County  t0J75eHKxz5
2           201404     Kenya     West Pokot County  XWALbfAPa6n
3           201404     Kenya          Bomet County  HMNARUV2CW4
4           201404     Kenya        Nairobi County  jkG3zaihdSs
…              …       …                    …           …
6199        202409     Kenya         Isiolo County  bzOfj0iwfDH
6200        202409     Kenya    Trans Nzoia County  mThvosEflAU
6201        202409     Kenya         Nakuru County  ob6SxuRcqU4
6202        202409     Kenya  Tharaka Nithi County  T4urHM47nlm
6203        202409     Kenya          Nyeri County  ptWVfaCIdVx

                uid_code          uid_year county_code_x  \
0     201404_kphDeKClFch  2014_kphDeKClFch  KE_County_23
1     201404_t0J75eHKxz5  2014_t0J75eHKxz5  KE_County_29
2     201404_XWALbfAPa6n  2014_XWALbfAPa6n  KE_County_24
3     201404_HMNARUV2CW4  2014_HMNARUV2CW4  KE_County_36
4     201404_jkG3zaihdSs  2014_jkG3zaihdSs  KE_County_47
…                    …                 …             …
6199  202409_bzOfj0iwfDH  2024_bzOfj0iwfDH  KE_County_11
6200  202409_mThvosEflAU  2024_mThvosEflAU  KE_County_26
6201  202409_ob6SxuRcqU4  2024_ob6SxuRcqU4  KE_County_32
6202  202409_T4urHM47nlm  2024_T4urHM47nlm  KE_County_13
6203  202409_ptWVfaCIdVx  2024_ptWVfaCIdVx  KE_County_19

      adolescent_10_24_receiving_fp_new  \
0                                     0
1                                     0
2                                     0
3                                     0
4                                     0
…                                   …
6199                                159
6200                               1169
6201                               5821
6202                                314
```

```
6203                                538

      adolescent_10_24_receiving_fp_revisits  \
0                                          0
1                                          0
2                                          0
3                                          0
4                                          0
…                                        …
6199                                     248
6200                                    2716
6201                                    7755
6202                                     978
6203                                     907

      adults_25+_receiving_fp_services_new  …  implants_stock_losses  \
0                                        0  …                   0.0
1                                        0  …                   0.0
2                                        0  …                   NaN
3                                        0  …                   0.0
4                                        0  …                   4.0
…                                      …  …                     …
6199                                   108  …                   NaN
6200                                  1209  …                   NaN
6201                                  3450  …                   NaN
6202                                   500  …                   NaN
6203                                   764  …                   NaN

      implants_stock_dispensed  implants_stock_at_hand  \
0                          2.0                    63.0
1                          0.0                     0.0
2                          NaN                     NaN
3                          0.0                     0.0
4                       1424.0                 20475.0
…                          …                       …
6199                       NaN                     NaN
6200                       NaN                     NaN
6201                       NaN                     NaN
6202                       NaN                     NaN
6203                       NaN                     NaN

      implants_stock_requested  implants_stock_received  iud_stock_losses  \
0                          0.0                      0.0               0.0
1                          0.0                      0.0               0.0
2                          NaN                      NaN               NaN
3                          0.0                      0.0               0.0
4                       6407.0                  20915.0               6.0
```

```
…                          …                          …                 …
6199                       NaN                        NaN               NaN
6200                       NaN                        NaN               NaN
6201                       NaN                        NaN               NaN
6202                       NaN                        NaN               NaN
6203                       NaN                        NaN               NaN

      iud_stock_dispensed  iud_stock_at_hand  iud_stock_requested  \
0                     0.0               87.0                  0.0
1                     0.0                0.0                  0.0
2                     NaN                NaN                  NaN
3                     0.0                0.0                  0.0
4                   660.0             1990.0               6608.0
…                     …                  …                    …
6199                  NaN                NaN                  NaN
6200                  NaN                NaN                  NaN
6201                  NaN                NaN                  NaN
6202                  NaN                NaN                  NaN
6203                  NaN                NaN                  NaN

      iud_stock_received
0                    0.0
1                    0.0
2                    NaN
3                    0.0
4                  236.0
…                    …
6199                 NaN
6200                 NaN
6201                 NaN
6202                 NaN
6203                 NaN

[6204 rows x 81 columns]
```

[48]:
```
# Rename the column
fp_service_comm_df= fp_service_comm_df.rename(columns={"county_code_x":␣
 ↪"county_code"})

fp_service_comm_df
```

[48]:
```
      year_month_x country_x              county_x        uid_x  \
0           201404     Kenya        Turkana County  kphDeKClFch
1           201404     Kenya          Nandi County  t0J75eHKxz5
2           201404     Kenya     West Pokot County  XWALbfAPa6n
3           201404     Kenya          Bomet County  HMNARUV2CW4
4           201404     Kenya        Nairobi County  jkG3zaihdSs
```

```
…            …       …                    …          …
6199        202409     Kenya         Isiolo County  bzOfj0iwfDH
6200        202409     Kenya    Trans Nzoia County  mThvosEflAU
6201        202409     Kenya         Nakuru County  ob6SxuRcqU4
6202        202409     Kenya  Tharaka Nithi County  T4urHM47nlm
6203        202409     Kenya          Nyeri County  ptWVfaCIdVx

                uid_code          uid_year   county_code  \
0     201404_kphDeKClFch  2014_kphDeKClFch  KE_County_23
1     201404_t0J75eHKxz5  2014_t0J75eHKxz5  KE_County_29
2     201404_XWALbfAPa6n  2014_XWALbfAPa6n  KE_County_24
3     201404_HMNARUV2CW4  2014_HMNARUV2CW4  KE_County_36
4     201404_jkG3zaihdSs  2014_jkG3zaihdSs  KE_County_47
…                    …                 …           …
6199  202409_bzOfj0iwfDH  2024_bzOfj0iwfDH  KE_County_11
6200  202409_mThvosEflAU  2024_mThvosEflAU  KE_County_26
6201  202409_ob6SxuRcqU4  2024_ob6SxuRcqU4  KE_County_32
6202  202409_T4urHM47nlm  2024_T4urHM47nlm  KE_County_13
6203  202409_ptWVfaCIdVx  2024_ptWVfaCIdVx  KE_County_19

      adolescent_10_24_receiving_fp_new  \
0                                     0
1                                     0
2                                     0
3                                     0
4                                     0
…                                     …
6199                                159
6200                               1169
6201                               5821
6202                                314
6203                                538

      adolescent_10_24_receiving_fp_revisits  \
0                                          0
1                                          0
2                                          0
3                                          0
4                                          0
…                                          …
6199                                     248
6200                                    2716
6201                                    7755
6202                                     978
6203                                     907

      adults_25+_receiving_fp_services_new  …  implants_stock_losses  \
```

```
0                                    0  …                    0.0
1                                    0  …                    0.0
2                                    0  …                    NaN
3                                    0  …                    0.0
4                                    0  …                    4.0
…                                  …  …                    …
6199                               108  …                    NaN
6200                              1209  …                    NaN
6201                              3450  …                    NaN
6202                               500  …                    NaN
6203                               764  …                    NaN

      implants_stock_dispensed  implants_stock_at_hand  \
0                          2.0                    63.0
1                          0.0                     0.0
2                          NaN                     NaN
3                          0.0                     0.0
4                       1424.0                 20475.0
…                          …                    …
6199                       NaN                     NaN
6200                       NaN                     NaN
6201                       NaN                     NaN
6202                       NaN                     NaN
6203                       NaN                     NaN

      implants_stock_requested  implants_stock_received  iud_stock_losses  \
0                          0.0                      0.0               0.0
1                          0.0                      0.0               0.0
2                          NaN                      NaN               NaN
3                          0.0                      0.0               0.0
4                       6407.0                  20915.0               6.0
…                          …                    …                 …
6199                       NaN                      NaN               NaN
6200                       NaN                      NaN               NaN
6201                       NaN                      NaN               NaN
6202                       NaN                      NaN               NaN
6203                       NaN                      NaN               NaN

      iud_stock_dispensed  iud_stock_at_hand  iud_stock_requested  \
0                     0.0               87.0                  0.0
1                     0.0                0.0                  0.0
2                     NaN                NaN                  NaN
3                     0.0                0.0                  0.0
4                   660.0             1990.0               6608.0
…                     …                  …                    …
6199                  NaN                NaN                  NaN
6200                  NaN                NaN                  NaN
```

```
6201                   NaN                 NaN                   NaN
6202                   NaN                 NaN                   NaN
6203                   NaN                 NaN                   NaN

      iud_stock_received
0                    0.0
1                    0.0
2                    NaN
3                    0.0
4                  236.0
…                  …
6199                 NaN
6200                 NaN
6201                 NaN
6202                 NaN
6203                 NaN

[6204 rows x 81 columns]
```

[49]:
```
# Replace non-finite values (NaN, inf, -inf) with 0
fp_service_comm_df = fp_service_comm_df.replace([np.inf, -np.inf], np.nan).
 ↪fillna(0)
```

[50]:
```
# Convert float columns to int64
df_float_cols = fp_service_comm_df.select_dtypes(include=['float', 'float64']).
 ↪columns
df_float_cols
```

[50]:
```
Index(['total_cyp', 'periodid', 'year_month_y',
       'pills_combined_oral_contraceptive_stock_losses',
       'pills_combined_oral_contraceptive_stock_dispensed',
       'pills_combined_oral_contraceptive_stock_at_hand',
       'pills_combined_oral_contraceptive_stock_requested',
       'pills_combined_oral_contraceptive_stock_received',
       'pills_emergency_pill_stock_losses',
       'pills_emergency_pill_stock_dispensed',
       'pills_emergency_pill_stock_at_hand',
       'pills_emergency_pill_stock_requested',
       'pills_emergency_pill_stock_received',
       'pills_progestin_only_pills_stock_losses',
       'pills_progestin_only_pills_stock_dispensed',
       'pills_progestin_only_pills_stock_at_hand',
       'pills_progestin_only_pills_stock_requested',
       'pills_progestin_only_pills_stock_received',
       'condoms_female_condom_stock_losses',
       'condoms_female_condom_stock_dispensed',
       'condoms_female_condom_stock_at_hand',
```

```
       'condoms_female_condom_stock_requested',
       'condoms_female_condom_stock_received',
       'condoms_male_condom_stock_losses',
       'condoms_male_condom_stock_dispensed',
       'condoms_male_condom_stock_at_hand',
       'condoms_male_condom_stock_requested',
       'condoms_male_condom_stock_received', 'injectables_stock_losses',
       'injectables_stock_dispensed', 'injectables_stock_at_hand',
       'injectables_stock_requested', 'injectables_stock_received',
       'implants_stock_losses', 'implants_stock_dispensed',
       'implants_stock_at_hand', 'implants_stock_requested',
       'implants_stock_received', 'iud_stock_losses', 'iud_stock_dispensed',
       'iud_stock_at_hand', 'iud_stock_requested', 'iud_stock_received'],
      dtype='object')
```

[51]:
```
fp_service_comm_df[df_float_cols] = fp_service_comm_df[df_float_cols].
↪astype('int64')
```

[52]:
```
fp_service_comm_df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
Int64Index: 6204 entries, 0 to 6203
Data columns (total 81 columns):
 #   Column                                    Non-Null Count  Dtype
---  ------                                    --------------  -----
 0   year_month_x                              6204 non-null   int64
 1   country_x                                 6204 non-null   object
 2   county_x                                  6204 non-null   object
 3   uid_x                                     6204 non-null   object
 4   uid_code                                  6204 non-null   object
 5   uid_year                                  6204 non-null   object
 6   county_code                               6204 non-null   object
 7   adolescent_10_24_receiving_fp_new         6204 non-null   int64
 8   adolescent_10_24_receiving_fp_revisits    6204 non-null   int64
 9   adults_25+_receiving_fp_services_new      6204 non-null   int64
 10  adults_25+_receiving_fp_services_revisits 6204 non-null   int64
 11  condoms_new                               6204 non-null   int64
 12  condoms_revisits                          6204 non-null   int64
 13  traditional_new                           6204 non-null   int64
 14  pills_new                                 6204 non-null   int64
 15  pills_revisits                            6204 non-null   int64
 16  traditional_revisits                      6204 non-null   int64
 17  injectable_new                            6204 non-null   int64
 18  injectable_revisits                       6204 non-null   int64
 19  traditional                               6204 non-null   int64
 20  implants_new                              6204 non-null   int64
 21  implants_revisits                         6204 non-null   int64
```

```
22  iucd_new                                          6204 non-null   int64
23  iucd_revisits                                     6204 non-null   int64
24  surgical_new                                      6204 non-null   int64
25  surgical_revisits                                 6204 non-null   int64
26  condoms                                           6204 non-null   int64
27  pills                                             6204 non-null   int64
28  injectables                                       6204 non-null   int64
29  implants                                          6204 non-null   int64
30  iucd                                              6204 non-null   int64
31  surgical                                          6204 non-null   int64
32  total_modern_fp                                   6204 non-null   int64
33  total_cyp                                         6204 non-null   int64
34  periodid                                          6204 non-null   int64
35  periodname                                        6204 non-null   object
36  year_month_y                                      6204 non-null   int64
37  country_y                                         6204 non-null   object
38  county_y                                          6204 non-null   object
39  uid_y                                             6204 non-null   object
40  county_code_y                                     6204 non-null   object
41  pills_combined_oral_contraceptive_stock_losses    6204 non-null   int64
42  pills_combined_oral_contraceptive_stock_dispensed 6204 non-null   int64
43  pills_combined_oral_contraceptive_stock_at_hand   6204 non-null   int64
44  pills_combined_oral_contraceptive_stock_requested 6204 non-null   int64
45  pills_combined_oral_contraceptive_stock_received  6204 non-null   int64
46  pills_emergency_pill_stock_losses                 6204 non-null   int64
47  pills_emergency_pill_stock_dispensed              6204 non-null   int64
48  pills_emergency_pill_stock_at_hand                6204 non-null   int64
49  pills_emergency_pill_stock_requested              6204 non-null   int64
50  pills_emergency_pill_stock_received               6204 non-null   int64
51  pills_progestin_only_pills_stock_losses           6204 non-null   int64
52  pills_progestin_only_pills_stock_dispensed        6204 non-null   int64
53  pills_progestin_only_pills_stock_at_hand          6204 non-null   int64
54  pills_progestin_only_pills_stock_requested        6204 non-null   int64
55  pills_progestin_only_pills_stock_received         6204 non-null   int64
56  condoms_female_condom_stock_losses                6204 non-null   int64
57  condoms_female_condom_stock_dispensed             6204 non-null   int64
58  condoms_female_condom_stock_at_hand               6204 non-null   int64
59  condoms_female_condom_stock_requested             6204 non-null   int64
60  condoms_female_condom_stock_received              6204 non-null   int64
61  condoms_male_condom_stock_losses                  6204 non-null   int64
62  condoms_male_condom_stock_dispensed               6204 non-null   int64
63  condoms_male_condom_stock_at_hand                 6204 non-null   int64
64  condoms_male_condom_stock_requested               6204 non-null   int64
65  condoms_male_condom_stock_received                6204 non-null   int64
66  injectables_stock_losses                          6204 non-null   int64
67  injectables_stock_dispensed                       6204 non-null   int64
68  injectables_stock_at_hand                         6204 non-null   int64
69  injectables_stock_requested                       6204 non-null   int64
```

```
 70  injectables_stock_received                    6204 non-null   int64
 71  implants_stock_losses                         6204 non-null   int64
 72  implants_stock_dispensed                      6204 non-null   int64
 73  implants_stock_at_hand                        6204 non-null   int64
 74  implants_stock_requested                      6204 non-null   int64
 75  implants_stock_received                       6204 non-null   int64
 76  iud_stock_losses                              6204 non-null   int64
 77  iud_stock_dispensed                           6204 non-null   int64
 78  iud_stock_at_hand                             6204 non-null   int64
 79  iud_stock_requested                           6204 non-null   int64
 80  iud_stock_received                            6204 non-null   int64
dtypes: int64(70), object(11)
memory usage: 3.9+ MB
```

[53]:
```
# Perform a left merge to retain all rows from fp_service_comm_df
fp_service_comm_pop_df = fp_service_comm_df.merge(
    df_population1[['uid_year', 'eligible_fp']],
    on='uid_year',
    how='left'
)

# Preview the merged DataFrame
fp_service_comm_pop_df.head()
```

[53]:

	year_month_x	country_x	county_x	uid_x	uid_code	uid_year	county_code	adolescent_10_24_receiving_fp_new	adolescent_10_24_receiving_fp_revisits	adults_25+_receiving_fp_services_new	…	implants_stock_dispensed
0	201404	Kenya	Turkana County	kphDeKClFch	201404_kphDeKClFch	2014_kphDeKClFch	KE_County_23	0	0	0	…	2
1	201404	Kenya	Nandi County	t0J75eHKxz5	201404_t0J75eHKxz5	2014_t0J75eHKxz5	KE_County_29	0	0			
2	201404	Kenya	West Pokot County	XWALbfAPa6n	201404_XWALbfAPa6n	2014_XWALbfAPa6n	KE_County_24	0	0			
3	201404	Kenya	Bomet County	HMNARUV2CW4	201404_HMNARUV2CW4	2014_HMNARUV2CW4	KE_County_36	0	0			
4	201404	Kenya	Nairobi County	jkG3zaihdSs	201404_jkG3zaihdSs	2014_jkG3zaihdSs	KE_County_47	0	0			

```
1                                    0  …                        0
2                                    0  …                        0
3                                    0  …                        0
4                                    0  …                     1424

   implants_stock_at_hand  implants_stock_requested  implants_stock_received  \
0                      63                         0                        0
1                       0                         0                        0
2                       0                         0                        0
3                       0                         0                        0
4                   20475                      6407                    20915

   iud_stock_losses  iud_stock_dispensed  iud_stock_at_hand  \
0                 0                    0                 87
1                 0                    0                  0
2                 0                    0                  0
3                 0                    0                  0
4                 6                  660               1990

   iud_stock_requested  iud_stock_received  eligible_fp
0                    0                   0     200659.0
1                    0                   0     179721.0
2                    0                   0     123351.0
3                    0                   0     198058.0
4                 6608                 236     822316.0

[5 rows x 82 columns]
```

[54]:
```
# Merge df_core_health_workforce
data_df = fp_service_comm_pop_df.merge(
    df_core_health_workforce[['uid_code',␣
 ↪'core_health_workforce_per_10,000population']],
    on='uid_code', how='left'
)
```

[55]:
```
# Merge df_demand_satisfied
data_df = data_df.merge(
    df_demand_satisfied1[['uid_code', 'Demand_Satisfied_by_Modern_Methods␣
 ↪(%)']],
    on='uid_code', how='left'
)
```

[56]:
```
# Merge df_mcpr
data_df = data_df.merge(
    df_mcpr1[['uid_code', 'mCPR (Married Women, %)']],
    on='uid_code', how='left'
)
```

[57]:
```
# Merge df_teenage_pregnancy
data_df = data_df.merge(
    df_teenage_pregnancy1[['uid_code', 'Teenage Pregnancy Rate (15-19, %)']],
    on='uid_code', how='left'
)
```

[58]:
```
# Merge df_unmet_need
data_df = data_df.merge(
    df_unmet_need1[['uid_code', 'Total Unmet Need (Married Women, %)']],
    on='uid_code', how='left'
)
```

[59]:
```
# Rename the columns by removing suffixes
data_df.columns = [
    col.replace('_x_x', '')
       .replace('_y_y', '')
       .replace('_x', '')
       .replace('_y', '')
       for col in data_df.columns
]
```

[60]:
```
# Preview the data to make sure the columns have been renamed
data_df.head()
```

[60]:

	year_month	country	county	uid	uid_code	\
0	201404	Kenya	Turkana County	kphDeKClFch	201404_kphDeKClFch	
1	201404	Kenya	Nandi County	t0J75eHKxz5	201404_t0J75eHKxz5	
2	201404	Kenya	West Pokot County	XWALbfAPa6n	201404_XWALbfAPa6n	
3	201404	Kenya	Bomet County	HMNARUV2CW4	201404_HMNARUV2CW4	
4	201404	Kenya	Nairobi County	jkG3zaihdSs	201404_jkG3zaihdSs	

	uidear	county_code	adolescent_10_24_receiving_fp_new	\
0	2014_kphDeKClFch	KE_County_23	0	
1	2014_t0J75eHKxz5	KE_County_29	0	
2	2014_XWALbfAPa6n	KE_County_24	0	
3	2014_HMNARUV2CW4	KE_County_36	0	
4	2014_jkG3zaihdSs	KE_County_47	0	

	adolescent_10_24_receiving_fp_revisits	\
0	0	
1	0	
2	0	
3	0	
4	0	

	adults_25+_receiving_fp_services_new	…	iud_stock_dispensed	\
0	0	…	0	

```
1                                    0  …                    0
2                                    0  …                    0
3                                    0  …                    0
4                                    0  …                  660

   iud_stock_at_hand  iud_stock_requested  iud_stock_received  eligible_fp  \
0                 87                    0                   0     200659.0
1                  0                    0                   0     179721.0
2                  0                    0                   0     123351.0
3                  0                    0                   0     198058.0
4               1990                 6608                 236     822316.0

   core_health_workforce_per_10,000population  \
0                                         NaN
1                                         NaN
2                                         NaN
3                                         NaN
4                                         NaN

   Demand_Satisfied_by_Modern_Methods (%)  mCPR (Married Women, %)  \
0                                     NaN                      NaN
1                                     NaN                      NaN
2                                     NaN                      NaN
3                                     NaN                      NaN
4                                     NaN                      NaN

   Teenage Pregnancy Rate (15-19, %)  Total Unmet Need (Married Women, %)
0                                NaN                                 NaN
1                                NaN                                 NaN
2                                NaN                                 NaN
3                                NaN                                 NaN
4                                NaN                                 NaN

[5 rows x 87 columns]
```

[61]:
```
data_df.shape
```

[61]:
```
(6204, 87)
```

[62]:
```
# Remove duplicate columns
data_df = data_df.loc[:, ~data_df.columns.duplicated()]
```

[63]:
```
# Checking the merged data for duplicates
data_df.duplicated().sum()
```

[63]:
```
0
```

[64]:
```
# Replace " county" label with blanks in county column

data_df['county'] = data_df['county'].str.replace(' County', '', regex=False)
print(data_df[['county']].head())
```

```
       county
0     Turkana
1       Nandi
2  West Pokot
3       Bomet
4     Nairobi
```

3.2.5 Export .csv file for data_df

[65]:
```
#data_df_sorted = data_df.sort_values(by='year_month', ascending=False)

# Export to CSV
#data_df_sorted.to_csv("output/data_df.csv", index=False, encoding='utf-8')
```

3.2.6 Composite Calculations

[170]:
```
# Calculate total users receiving FP services
data_df['total_users_receiving_fp'] = (
   data_df['adolescent_10_24_receiving_fp_new'] +
   data_df['adolescent_10_24_receiving_fp_revisits'] +
   data_df['adults_25+_receiving_fp_services_new'] +
   data_df['adults_25+_receiving_fp_services_revisits']
)

# Total actual new (Modern fp)
data_df['total_actual_new_modern_fp_methods'] = data_df[['pills_new',␣
 ↪'condoms_new',
                                                          'injectable_new',␣
 ↪'implants_new',
                                                          'iucd_new',␣
 ↪'surgical_new']].sum(axis=1)


# Total actual revisits(Modern fp)
data_df['total_actual_revisits_modern_fp_methods'] = data_df[['pills_revisits',␣
 ↪'condoms_revisits',
                                                               ␣
 ↪'injectable_revisits',
                                                               ␣
 ↪'implants_revisits', 'iucd_revisits',
```

```
                                                                    ␣
 ↪'surgical_revisits']].sum(axis=1)


# Total actual traditional fp
data_df['total_actual_traditional_methods'] = data_df[['traditional_revisits',␣
 ↪'traditional_revisits']].sum(axis=1)


# Total actual modern fp
data_df['total_actual_modern_fp'] = (
    data_df['total_actual_new_modern_fp_methods'] +
    data_df['total_actual_revisits_modern_fp_methods']
)

# Total FP (both Modern and Traditional)
data_df['total_fp'] = (data_df['total_actual_modern_fp']  +
                       data_df['total_actual_traditional_methods'])

# Proportion adolescents receiving fp
data_df['proportion_adolescents_10_24_yrs_receiving_fp'] = ((␣
 ↪data_df['adolescent_10_24_receiving_fp_new'] +
                                                                    ␣
 ↪data_df['adolescent_10_24_receiving_fp_revisits']) /
                                                                    ␣
 ↪data_df['total_users_receiving_fp'] )

# Number of months
data_df['number_of_months'] = min(data_df['year_month'].nunique(), 12)

# Actual mCPR
data_df['actual_mcpr'] = data_df['total_actual_modern_fp'] /␣
 ↪data_df['eligible_fp']

# Actual mCPR monthly
data_df['actual_mcpr_monthly'] = data_df['total_modern_fp'] /␣
 ↪(data_df['eligible_fp'] / 12)

# Number of women(10_49_yrs) with unmet need for fp
data_df['number_women_10_49_yrs_with_unmet_need_for_fp'] =␣
 ↪data_df['eligible_fp'] - data_df['total_actual_modern_fp']

# Unmet need
data_df['actual_unmet_need_for_modern_fp'] = (
    data_df['number_women_10_49_yrs_with_unmet_need_for_fp'] /
    data_df['eligible_fp']
```

```
)

# Actual core health workers-2013
data_df['actual_core_health_workers_2013_10000_eligible_fp'] =␣
 ↪(data_df['eligible_fp'] / 10000)

# Actual total demand
data_df['actual_total_demand_for_fp'] = data_df['actual_mcpr'] +␣
 ↪data_df['actual_unmet_need_for_modern_fp']

# Actual demand satisfied
data_df['actual_demand_satisfied']  = data_df['actual_mcpr'] /␣
 ↪data_df['actual_total_demand_for_fp']


# Combine pills (COCs + POCs)
data_df['total_pills_dispensed'] = (
    data_df['pills_combined_oral_contraceptive_stock_dispensed'] +
    data_df['pills_progestin_only_pills_stock_dispensed']
)

# Combine condoms (male + female)
data_df['total_condoms_dispensed'] = (
    data_df['condoms_male_condom_stock_dispensed'] +
    data_df['condoms_female_condom_stock_dispensed']
)

# Total all commodities dispensed
data_df['total_commodities_dispensed'] = (
    data_df['total_pills_dispensed'] +
    data_df['total_condoms_dispensed'] +
    data_df['injectables_stock_dispensed'] +
    data_df['implants_stock_dispensed'] +
    data_df['iud_stock_dispensed']
)

# Calculate average monthly commodities dispensed
data_df['average_monthly_commodities_dispensed'] = (
    data_df['total_commodities_dispensed'] /data_df['number_of_months']
)
```

3.3 *c) Exploratory Data Analysis (EDA)*

3.3.1 Descriptive Statistics

i) FP service data descriptives

[81]:
```
# List of columns to describe
eda_cols = [
    'condoms_new', 'condoms_revisits',
    'pills_new', 'pills_revisits',
    'injectable_new', 'injectable_revisits',
    'implants_new', 'implants_revisits',
    'iucd_new', 'iucd_revisits',
    'surgical_new', 'surgical_revisits'
]

# Basic descriptive statistics
eda_summary = df_service1[eda_cols].describe().T
eda_summary['missing'] = df_service1[eda_cols].isnull().sum()
eda_summary['zeros'] = (df_service1[eda_cols] == 0).sum()
eda_summary['unique'] = df_service1[eda_cols].nunique()
eda_summary['dtype'] = df_service1[eda_cols].dtypes

# Show the summary
print(eda_summary)
```

```
                     count         mean          std  min     25%    50%  \
condoms_new         6204.0  1012.755480  2179.557079  4.0  191.75  483.0
condoms_revisits    6204.0   502.967924  1201.564246  0.0   43.00  144.0
pills_new           6204.0   622.910058   860.123122  0.0  183.00  387.0
pills_revisits      6204.0   909.946325  1276.593789  0.0  178.00  492.5
injectable_new      6204.0   426.390071   762.405961  0.0    0.00    0.0
injectable_revisits 6204.0  1470.093649  2597.655200  0.0    0.00    0.0
implants_new        6204.0   427.715506   881.975366  0.0    0.00    0.0
implants_revisits   6204.0   187.019987   380.439558  0.0    0.00    0.0
iucd_new            6204.0    52.249194   137.231216  0.0    0.00    0.0
iucd_revisits       6204.0    17.744842    50.077124  0.0    0.00    0.0
surgical_new        6204.0     3.200838    10.788603  0.0    0.00    0.0
surgical_revisits   6204.0     0.026596     0.460010  0.0    0.00    0.0

                      75%      max  missing  zeros  unique  dtype
condoms_new        1082.00  86502.0        0      0    2194  int64
condoms_revisits    476.25  28442.0        0    176    1501  int64
pills_new           703.00   8793.0        0      1    1639  int64
pills_revisits     1039.25  13292.0        0      3    2186  int64
injectable_new      547.25   5757.0        0   3738    1504  int64
injectable_revisits 2294.00  17377.0        0   3734    2093  int64
implants_new        487.00  11639.0        0   3750    1532  int64
implants_revisits   224.25   4972.0        0   3777    1050  int64
iucd_new             42.00   1343.0        0   3819     486  int64
iucd_revisits        12.00    630.0        0   4050     262  int64
surgical_new          1.00    340.0        0   4594      74  int64
surgical_revisits     0.00     20.0        0   6167      12  int64
```

[82]:
```
# Columns to describe
eda_columns = [
    'year_month', 'country', 'county', 'uid', 'uid_code', 'county_code',
    'adolescent_10_24_receiving_fp_new',␣
 ↪'adolescent_10_24_receiving_fp_revisits',
    'adults_25+_receiving_fp_services_new',␣
 ↪'adults_25+_receiving_fp_services_revisits',
    'condoms_new', 'condoms_revisits',
    'pills_new', 'pills_revisits',
    'injectable_new', 'injectable_revisits',
    'implants_new', 'implants_revisits',
    'iucd_new', 'iucd_revisits',
    'surgical_new', 'surgical_revisits',
    'condoms', 'pills', 'injectables', 'implants', 'iucd', 'surgical',
    'total_modern_fp', 'total_cyp'
]

# Subset the DataFrame
df_eda = df_service1[eda_columns]

# 1. General info
print("=== Basic Info ===")
print(df_eda.info())

# 2. Missing values
print("=== Missing Values ===")
print(df_eda.isnull().sum())

# 3. Descriptive statistics for numeric columns
print("=== Summary Statistics ===")
print(df_eda.describe().T)

# 4. Unique value counts for categorical columns
cat_cols = ['year_month', 'country', 'county', 'uid', 'uid_code', 'county_code']
print("=== Unique Values in Categorical Columns ===")
for col in cat_cols:
    print(f"{col}: {df_eda[col].nunique()} unique values")

# 5. Trends over time (optional)
if pd.api.types.is_datetime64_any_dtype(df_eda['year_month']):
    trend_data = df_eda.groupby('year_month')['total_fp'].sum()
    trend_data.plot(title="Total FP Over Time", figsize=(10, 4))
    plt.ylabel("Total FP")
    plt.xlabel("Month")
    plt.xticks(rotation=45)
    plt.tight_layout()
    plt.show()
```

```python
# 6. Distribution plots for select variables (optional)
num_vars = ['total_modern_fp', 'total_cyp', 'condoms', 'pills', 'injectables']
for var in num_vars:
    plt.figure(figsize=(6, 3))
    sns.histplot(df_eda[var], bins=30, kde=True)
    plt.title(f'Distribution of {var}')
    plt.tight_layout()
    plt.show()
```

```
=== Basic Info ===
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 6204 entries, 0 to 6203
Data columns (total 30 columns):
 #   Column                                    Non-Null Count  Dtype
---  ------                                    --------------  -----
 0   year_month                                6204 non-null   int64
 1   country                                   6204 non-null   object
 2   county                                    6204 non-null   object
 3   uid                                       6204 non-null   object
 4   uid_code                                  6204 non-null   object
 5   county_code                               6204 non-null   object
 6   adolescent_10_24_receiving_fp_new         6204 non-null   int64
 7   adolescent_10_24_receiving_fp_revisits    6204 non-null   int64
 8   adults_25+_receiving_fp_services_new      6204 non-null   int64
 9   adults_25+_receiving_fp_services_revisits 6204 non-null   int64
 10  condoms_new                               6204 non-null   int64
 11  condoms_revisits                          6204 non-null   int64
 12  pills_new                                 6204 non-null   int64
 13  pills_revisits                            6204 non-null   int64
 14  injectable_new                            6204 non-null   int64
 15  injectable_revisits                       6204 non-null   int64
 16  implants_new                              6204 non-null   int64
 17  implants_revisits                         6204 non-null   int64
 18  iucd_new                                  6204 non-null   int64
 19  iucd_revisits                             6204 non-null   int64
 20  surgical_new                              6204 non-null   int64
 21  surgical_revisits                         6204 non-null   int64
 22  condoms                                   6204 non-null   int64
 23  pills                                     6204 non-null   int64
 24  injectables                               6204 non-null   int64
 25  implants                                  6204 non-null   int64
 26  iucd                                      6204 non-null   int64
 27  surgical                                  6204 non-null   int64
 28  total_modern_fp                           6204 non-null   int64
 29  total_cyp                                 6204 non-null   float64
dtypes: float64(1), int64(24), object(5)
```

```
memory usage: 1.4+ MB
None
=== Missing Values ===
year_month                                  0
country                                     0
county                                      0
uid                                         0
uid_code                                    0
county_code                                 0
adolescent_10_24_receiving_fp_new           0
adolescent_10_24_receiving_fp_revisits      0
adults_25+_receiving_fp_services_new        0
adults_25+_receiving_fp_services_revisits   0
condoms_new                                 0
condoms_revisits                            0
pills_new                                   0
pills_revisits                              0
injectable_new                              0
injectable_revisits                         0
implants_new                                0
implants_revisits                           0
iucd_new                                    0
iucd_revisits                               0
surgical_new                                0
surgical_revisits                           0
condoms                                     0
pills                                       0
injectables                                 0
implants                                    0
iucd                                        0
surgical                                    0
total_modern_fp                             0
total_cyp                                   0
dtype: int64
=== Summary Statistics ===
                                           count           mean          std  \
year_month                                6204.0  201906.500000   316.272098
adolescent_10_24_receiving_fp_new         6204.0     951.515796  1235.004562
adolescent_10_24_receiving_fp_revisits    6204.0    1097.991457  1311.978571
adults_25+_receiving_fp_services_new      6204.0     488.387653   987.737741
adults_25+_receiving_fp_services_revisits 6204.0    1466.582366  2959.620140
condoms_new                               6204.0    1012.755480  2179.557079
condoms_revisits                          6204.0     502.967924  1201.564246
pills_new                                 6204.0     622.910058   860.123122
pills_revisits                            6204.0     909.946325  1276.593789
injectable_new                            6204.0     426.390071   762.405961
injectable_revisits                       6204.0    1470.093649  2597.655200
implants_new                              6204.0     427.715506   881.975366
```

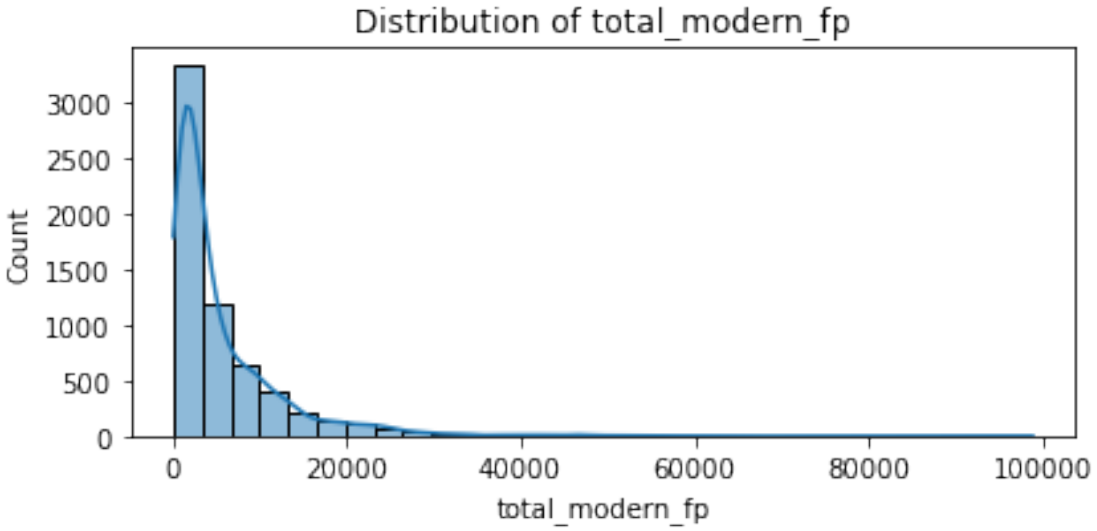
implants_revisits	6204.0	187.019987	380.439558
iucd_new	6204.0	52.249194	137.231216
iucd_revisits	6204.0	17.744842	50.077124
surgical_new	6204.0	3.200838	10.788603
surgical_revisits	6204.0	0.026596	0.460010
condoms	6204.0	1515.723404	2939.649534
pills	6204.0	1532.856383	2084.882141
injectables	6204.0	1896.483720	3295.194265
implants	6204.0	614.735493	1240.657953
iucd	6204.0	69.994036	184.294491
surgical	6204.0	3.227434	10.830335
total_modern_fp	6204.0	5633.020471	7022.298919
total_cyp	6204.0	2932.328082	5641.835617

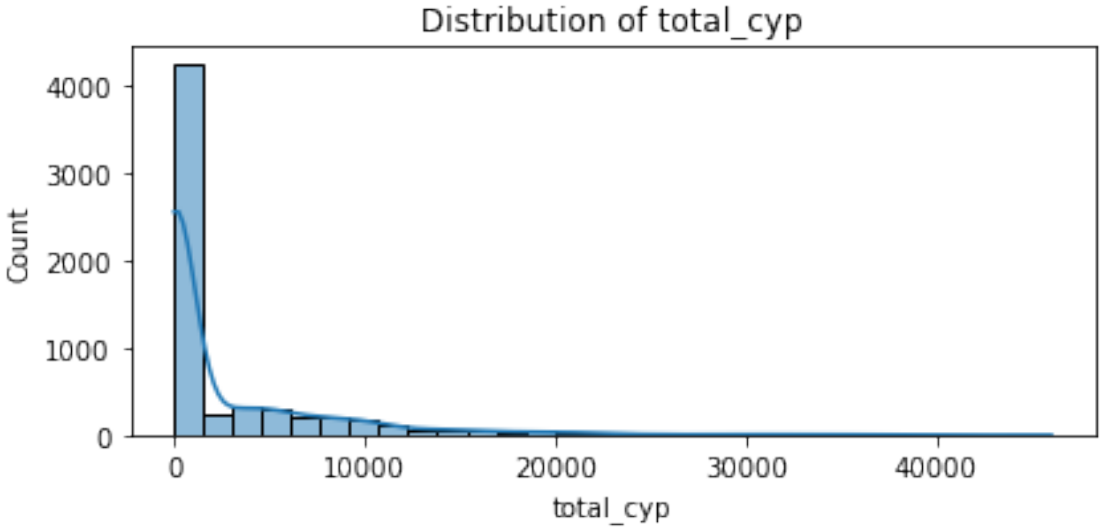
	min	25%	\
year_month	201401.0000	201609.7500	
adolescent_10_24_receiving_fp_new	0.0000	110.0000	
adolescent_10_24_receiving_fp_revisits	0.0000	78.0000	
adults_25+_receiving_fp_services_new	0.0000	0.0000	
adults_25+_receiving_fp_services_revisits	0.0000	0.0000	
condoms_new	4.0000	191.7500	
condoms_revisits	0.0000	43.0000	
pills_new	0.0000	183.0000	
pills_revisits	0.0000	178.0000	
injectable_new	0.0000	0.0000	
injectable_revisits	0.0000	0.0000	
implants_new	0.0000	0.0000	
implants_revisits	0.0000	0.0000	
iucd_new	0.0000	0.0000	
iucd_revisits	0.0000	0.0000	
surgical_new	0.0000	0.0000	
surgical_revisits	0.0000	0.0000	
condoms	4.0000	304.0000	
pills	2.0000	375.0000	
injectables	0.0000	0.0000	
implants	0.0000	0.0000	
iucd	0.0000	0.0000	
surgical	0.0000	0.0000	
total_modern_fp	30.0000	1444.0000	
total_cyp	0.4704	25.6157	

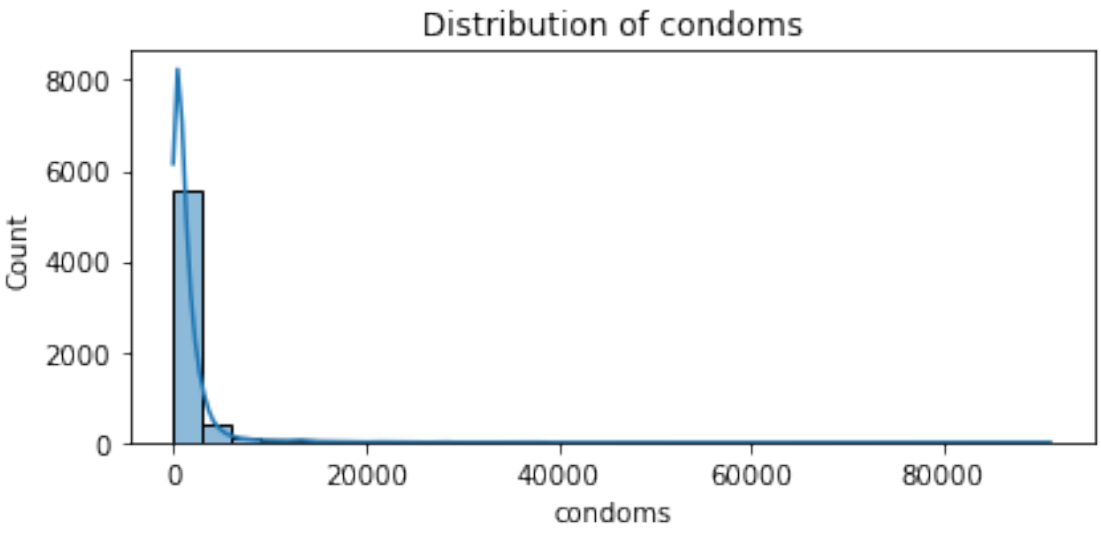
	50%	75%	\
year_month	201906.50000	202203.250000	
adolescent_10_24_receiving_fp_new	537.00000	1332.000000	
adolescent_10_24_receiving_fp_revisits	745.00000	1596.250000	
adults_25+_receiving_fp_services_new	0.00000	604.250000	
adults_25+_receiving_fp_services_revisits	0.00000	2071.250000	
condoms_new	483.00000	1082.000000	

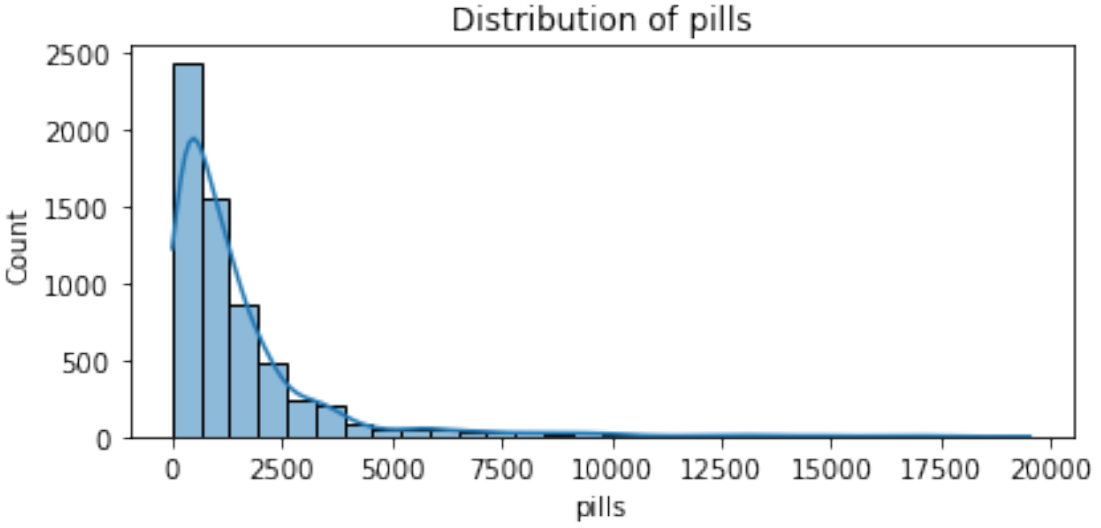
```
condoms_revisits                          144.00000     476.250000
pills_new                                 387.00000     703.000000
pills_revisits                            492.50000    1039.250000
injectable_new                              0.00000     547.250000
injectable_revisits                         0.00000    2294.000000
implants_new                                0.00000     487.000000
implants_revisits                           0.00000     224.250000
iucd_new                                    0.00000      42.000000
iucd_revisits                               0.00000      12.000000
surgical_new                                0.00000       1.000000
surgical_revisits                           0.00000       0.000000
condoms                                   765.00000    1678.500000
pills                                     918.00000    1792.000000
injectables                                 0.00000    2897.500000
implants                                    0.00000     720.250000
iucd                                        0.00000      60.000000
surgical                                    0.00000       1.000000
total_modern_fp                          2964.50000    7310.500000
total_cyp                                  67.22275    3866.048375

                                                max
year_month                                202412.0000
adolescent_10_24_receiving_fp_new          12244.0000
adolescent_10_24_receiving_fp_revisits     12542.0000
adults_25+_receiving_fp_services_new        8558.0000
adults_25+_receiving_fp_services_revisits  88217.0000
condoms_new                                86502.0000
condoms_revisits                           28442.0000
pills_new                                   8793.0000
pills_revisits                             13292.0000
injectable_new                              5757.0000
injectable_revisits                        17377.0000
implants_new                               11639.0000
implants_revisits                           4972.0000
iucd_new                                    1343.0000
iucd_revisits                                630.0000
surgical_new                                 340.0000
surgical_revisits                             20.0000
condoms                                    91084.0000
pills                                      19528.0000
injectables                                22859.0000
implants                                   11838.0000
iucd                                        1851.0000
surgical                                     340.0000
total_modern_fp                            98876.0000
total_cyp                                  46015.0367
=== Unique Values in Categorical Columns ===
year_month: 132 unique values
```

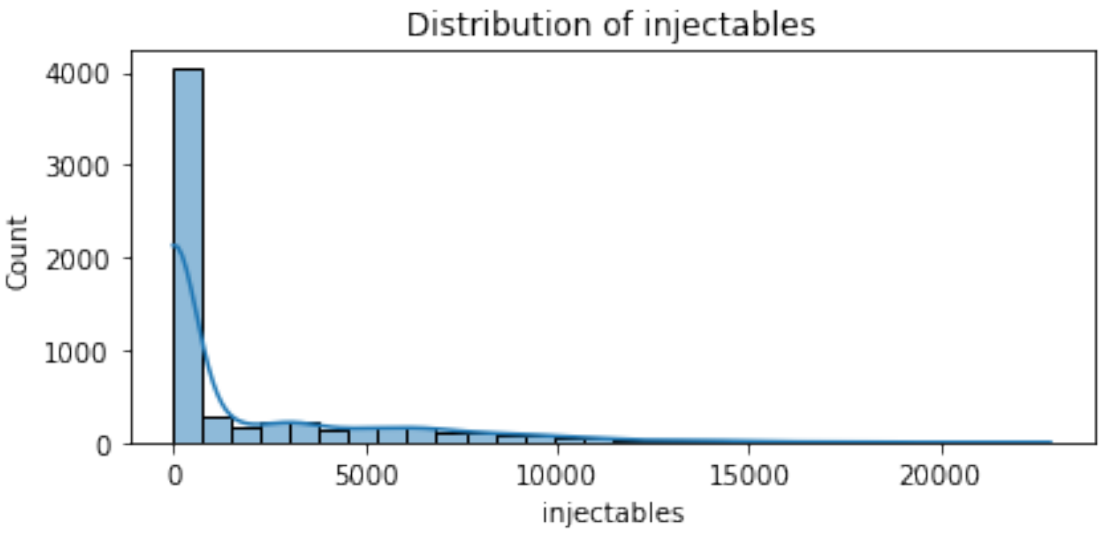
```
country: 1 unique values
county: 47 unique values
uid: 47 unique values
uid_code: 6204 unique values
county_code: 47 unique values
```



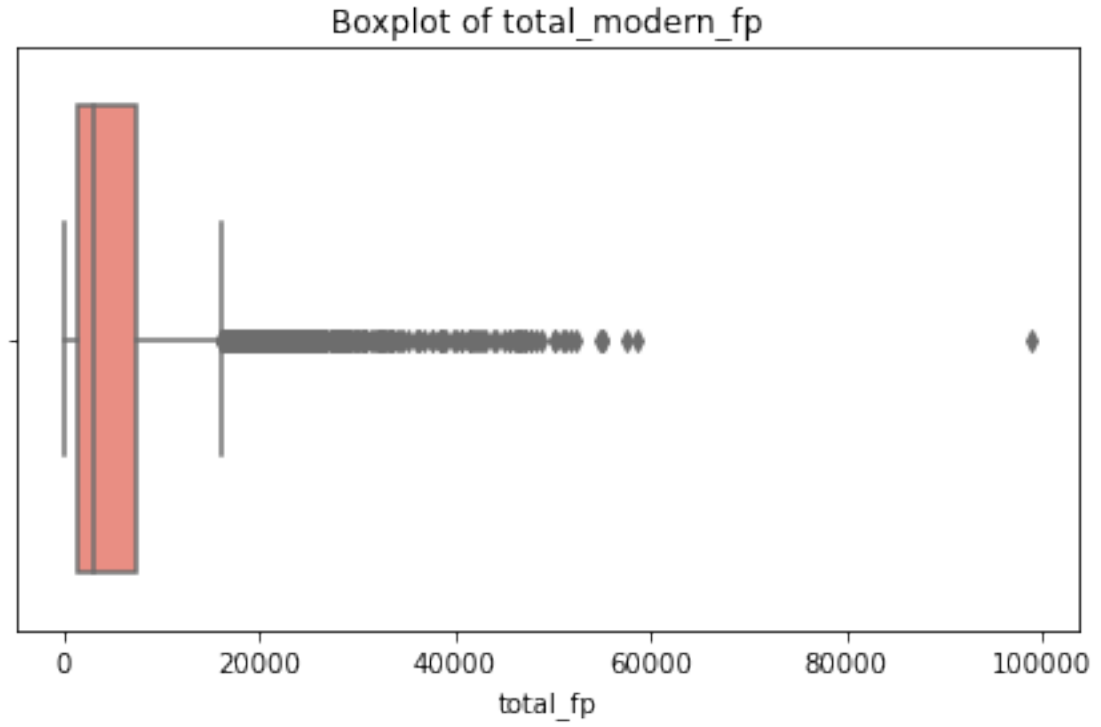



Distribution of condoms
8000
6000
4000
2000
0
Count
0
20000
40000
60000
80000
condoms


Distribution of pills
2500
2000
1500
1000
500
0
Count
0
2500
5000
7500
10000
12500
15000
17500
20000
pills



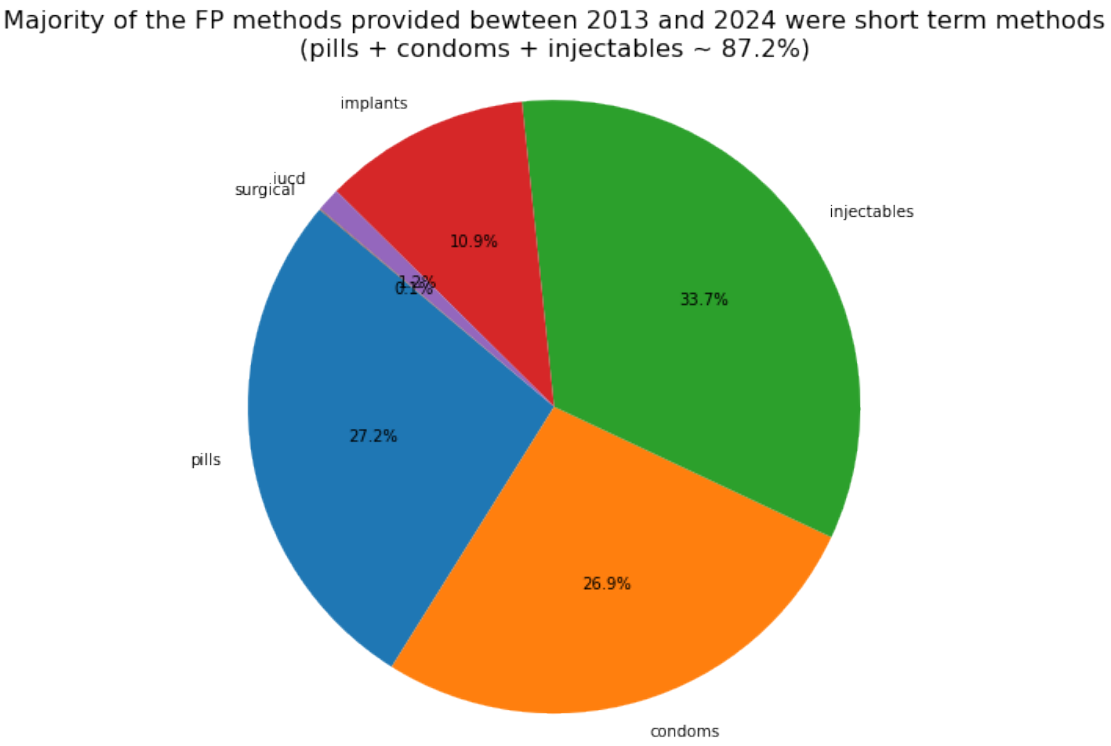
[83]:
```
# Boxplot of total modern fp
plt.figure(figsize=(6,4))
sns.boxplot(x=data_df['total_modern_fp'].dropna(), color='salmon')
plt.title('Boxplot of total_modern_fp') # Set title
plt.xlabel('total_fp') # Set X_label
plt.tight_layout() # Spacing
plt.show()
```



[84]:
```
# Convert year_month values into datetime objects
data_df['year_month'] = data_df['year_month'].astype(str) # Convert to string

# Split into year and month
data_df['year'] = data_df['year_month'].str[:4].astype(int)
data_df['month'] = data_df['year_month'].str[4:].astype(int)
```

3.3.2 What's the FP method mix composition for the period in focus?

[85]:
```
import matplotlib.pyplot as plt
# Group data by year_month and sum the method counts
method_mix = data_df.groupby('year_month')[['pills', 'condoms', 'injectables',␣
 ↪'implants', 'iucd', 'surgical']].sum()

# Calculate the total for each method across the entire period
total_method_counts = method_mix.sum()

# Plotting the pie chart
plt.figure(figsize=(10, 8))
plt.pie(total_method_counts, labels=total_method_counts.index, autopct='%1.
 ↪1f%%', startangle=140)
plt.title('Majority of the FP methods provided bewteen 2013 and 2024 were short␣
 ↪term methods\n(pills + condoms + injectables ~ 87.2%)', fontsize=16)
plt.axis('equal')  # Equal aspect ratio ensures that pie is drawn as a circle.
plt.show()
```

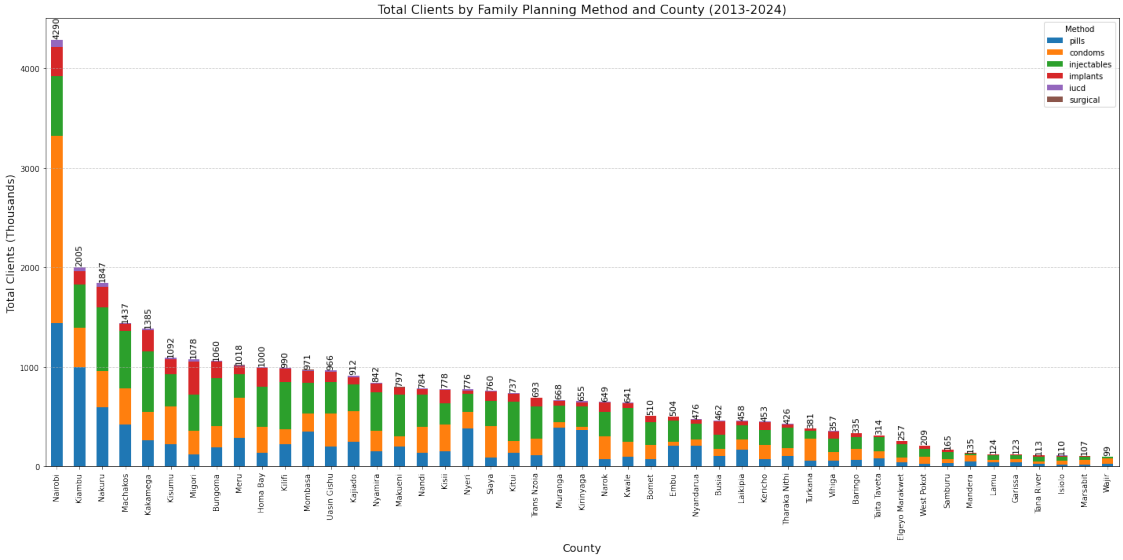


What's the FP method volume by county?

[86]:
```
# Method Mix volume by county

# Sum the total counts for each method by county
county_method_totals = data_df.groupby('county')[['pills', 'condoms',␣
 ↪'injectables', 'implants', 'iucd', 'surgical']].sum()

# Calculate the total for all methods per county for sorting
county_method_totals['total'] = county_method_totals.sum(axis=1)

# Sort counties by total count in descending order
county_method_totals = county_method_totals.sort_values('total',␣
 ↪ascending=False).drop(columns='total')

# Convert values to thousands and format to 0 decimal places
county_method_totals_thousands = county_method_totals / 1000

# Plotting the stacked bar chart
plt.figure(figsize=(20, 10))
ax = county_method_totals_thousands.plot(kind='bar', stacked=True, figsize=(20,␣
 ↪10))
```

```
# Add labels and title
plt.xlabel('County', fontsize=14)
plt.ylabel('Total Clients (Thousands)', fontsize=14)
plt.title('Total Clients by Family Planning Method and County (2013-2024)',␣
 ↪fontsize=16)
plt.xticks(rotation=90)
plt.legend(title='Method')
plt.grid(axis='y', linestyle='--', alpha=0.7)

# Add total labels on top of bars
for i, county in enumerate(county_method_totals_thousands.index):
    total_value = county_method_totals_thousands.loc[county].sum()
    # Position the text slightly above the bar. Adjust text position as needed.
    ax.text(i, total_value + 10, f'{total_value:.0f}', ha='center',␣
 ↪va='bottom', rotation=90, fontsize=11)


plt.tight_layout() # Adjust layout to prevent labels overlapping
plt.show()
```

```
<Figure size 1440x720 with 0 Axes>
```

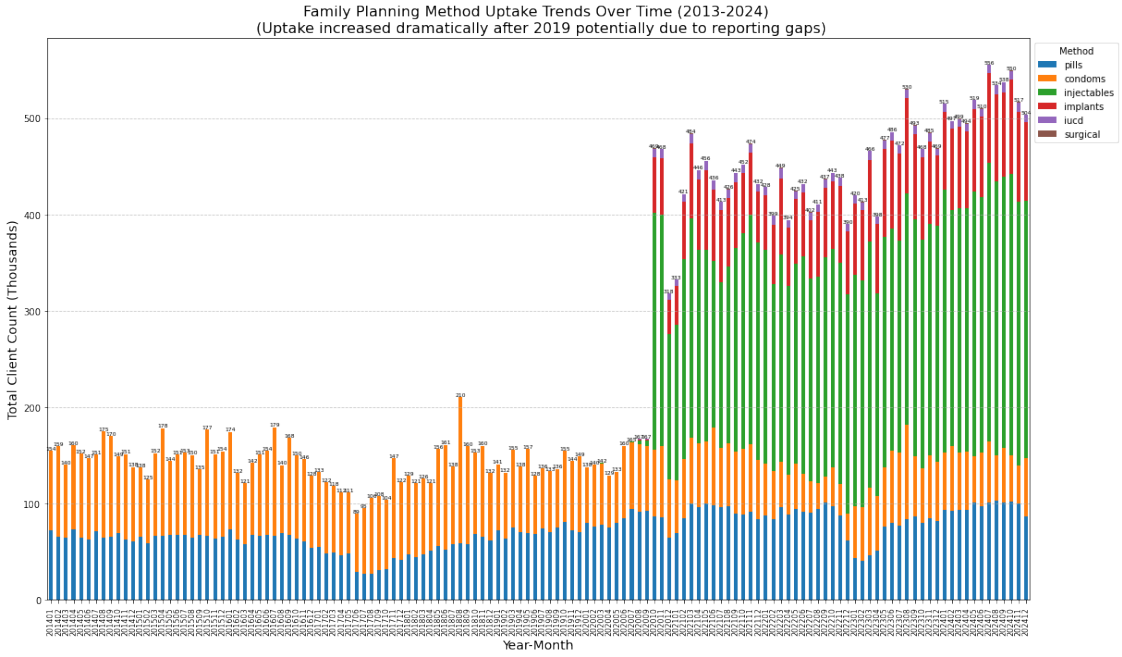


3.3.3 What are the trends in FP Method uptake over time?

[87]:
```
# Plot FP method uptake trends over time

# Group data by year_month and sum the method counts
```

```
method_uptake_time = data_df.groupby('year_month')[['pills', 'condoms',␣
 ↪'injectables', 'implants', 'iucd', 'surgical']].sum()

# Convert values to thousands
method_uptake_time_thousands = method_uptake_time / 1000

# Plotting the stacked bar chart
plt.figure(figsize=(20, 10))
ax = method_uptake_time_thousands.plot(kind='bar', stacked=True, figsize=(20,␣
 ↪10))

# Add labels and title
plt.xlabel('Year-Month', fontsize=14)
plt.ylabel('Total Client Count (Thousands)', fontsize=14)
plt.title('Family Planning Method Uptake Trends Over Time (2013-2024) \n␣
 ↪(Uptake increased dramatically after 2019 potentially due to reporting␣
 ↪gaps)', fontsize=16)
plt.xticks(rotation=90, fontsize=8)
plt.legend(title='Method', loc='upper left', bbox_to_anchor=(1, 1))
plt.grid(axis='y', linestyle='--', alpha=0.7)

# Add total labels on top of bars
for i, year_month in enumerate(method_uptake_time_thousands.index):
    total_value = method_uptake_time_thousands.loc[year_month].sum()
    # Position the text slightly above the bar. Adjust text position as needed.
    ax.text(i, total_value, f'{total_value:.0f}', ha='center', va='bottom',␣
 ↪fontsize=6)


plt.tight_layout(rect=[0, 0, 0.85, 1]) # Adjust layout to prevent legend␣
 ↪overlapping
plt.show()
```

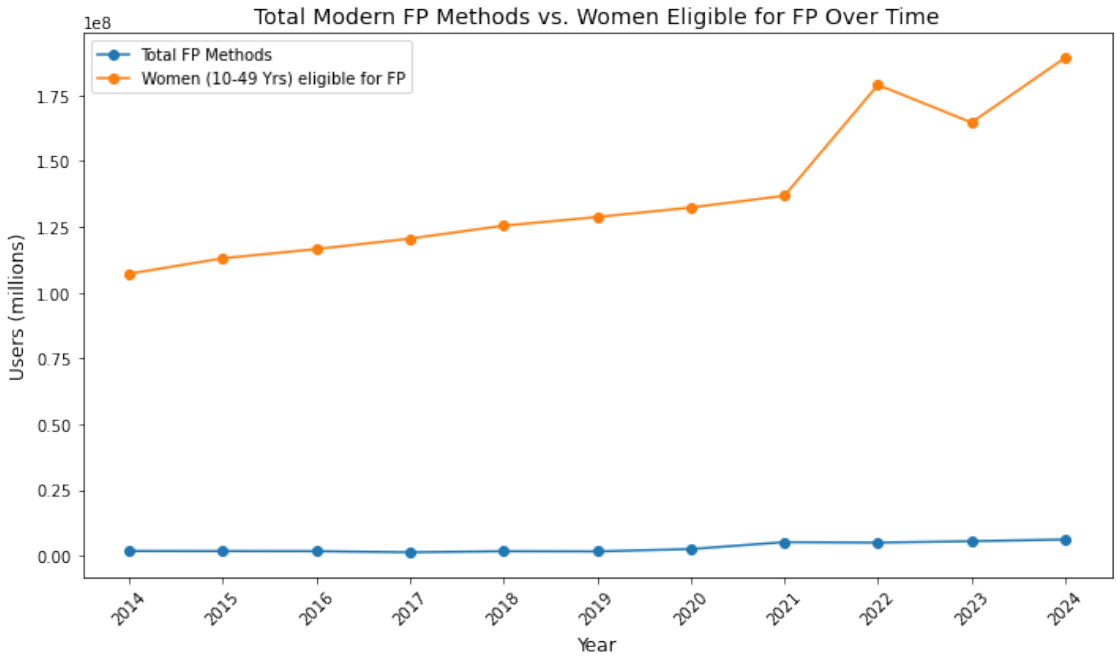
```
<Figure size 1440x720 with 0 Axes>
```



3.3.4 Total FP Methods vs Women Eligible for FP Over Time

[88]:
```
# Plot Total modern FP Methods vs. Women Eligible for FP Over Time

# Group by year and sum 'total_fp', then get the maximum 'eligible_fp' for each␣
 ↪year
trends = data_df.groupby(data_df['year'])[['total_modern_fp', 'eligible_fp']].
 ↪agg(
    {'total_modern_fp': 'sum', 'eligible_fp': 'sum'}
)


# Plotting
plt.figure(figsize=(10, 6))
plt.plot(trends.index, trends['total_modern_fp'], label='Total FP Methods',␣
 ↪marker='o')
plt.plot(trends.index, trends['eligible_fp'], label='Women (10-49 Yrs) eligible␣
 ↪for FP' , marker='o')

# Add labels and title
plt.xlabel('Year', fontsize=12)
plt.ylabel('Users (millions)', fontsize=12)
plt.title('Total Modern FP Methods vs. Women Eligible for FP Over Time',␣
 ↪fontsize=14)
plt.xticks(trends.index, rotation=45)
```

```
plt.legend()
plt.grid(False)

# Show plot
plt.tight_layout()
plt.show()
```



3.3.5 Which FP commodities face the greatest supply-demand mismatch?

[89]:
```
# Create month column (Period) for aggregation
if 'date' not in data_df.columns:
    data_df['date'] = pd.to_datetime(data_df['year_month'], format='%Y%m')

# Define the commodity columns we need (issued / stock received)
commodities = {
    'male_condoms': ('condoms_male_condom_stock_dispensed',␣
 ↪'condoms_male_condom_stock_received'),
    'female_condoms': ('condoms_female_condom_stock_dispensed',␣
 ↪'condoms_female_condom_stock_received'),
    'pills': ('pills_combined_oral_contraceptive_stock_dispensed',␣
 ↪'pills_combined_oral_contraceptive_stock_received'),
    'injectables': ('injectables_stock_dispensed',␣
 ↪'injectables_stock_received'),
    'implants': ('implants_stock_dispensed', 'implants_stock_received')
}
```

```
# Make sure the measure columns are numeric
for issued_col, received_col in commodities.values():
    data_df[issued_col] = pd.to_numeric(data_df[issued_col], errors='coerce')
    data_df[received_col] = pd.to_numeric(data_df[received_col],␣
 ↪errors='coerce')

# Build a tidy dataframe with national-level monthly totals for each commodity
agg_list = []
for name, (issued_col, received_col) in commodities.items():
    monthly = (
        data_df
        .groupby('date')[[issued_col, received_col]]
        .sum()
        .rename(columns={issued_col: 'issued', received_col: 'received'})
    )
    monthly['commodity'] = name
    monthly['coverage_ratio'] = monthly['issued'] / monthly['received'].
 ↪replace(0, pd.NA)
    monthly['stockout_flag'] = monthly['issued'] > monthly['received']
    agg_list.append(monthly.reset_index())

commod_df = pd.concat(agg_list, ignore_index=True)

# Count the number of months where issued exceeded receipts (potential␣
 ↪stock-out months)
stockouts = commod_df.groupby('commodity')['stockout_flag'].sum().
 ↪reset_index(name='months_with_potential_stockout')
print(stockouts)

# Visualise issued vs received with stock-out shading
sns.set_style('whitegrid')
fig, axes = plt.subplots(len(commodities), 1, figsize=(14, 4 *␣
 ↪len(commodities)), sharex=True)
for ax, (name, grp) in zip(axes, commod_df.groupby('commodity')):
    ax.plot(grp['date'], grp['issued'], label='Issued', color='steelblue')
    ax.plot(grp['date'], grp['received'], label='Received', color='orange')
    ax.fill_between(grp['date'], grp['issued'], grp['received'],␣
 ↪where=grp['stockout_flag'], color='red', alpha=0.25, label='Potential␣
 ↪stock-out')
    ax.set_title(name.replace('_', ' ').title())
    ax.legend()
plt.tight_layout()
plt.show()
```

```
        commodity  months_with_potential_stockout
0  female_condoms                               0
```

1	implants	82
2	injectables	82
3	male_condoms	0
4	pills	92


Female Condoms
Issued
Received
Potential stock-out
0.04
0.02
0.00
−0.02
−0.04
Implants
Issued
Received
Potential stock-out
25000
20000
15000
10000
5000
0
Injectables
Issued
Received
Potential stock-out
200000
150000
100000
50000
0
Male Condoms
Issued
Received
Potential stock-out
0.04
0.02
0.00
−0.02
−0.04
Pills
Issued
Received
Potential stock-out
250000
200000
150000
100000
50000
0
2014
2016
2018
2020
2022
2024

3.3.6 How well do clients stay on or return for each family planning method once they start, and which methods need the most support to improve continuation?

[90]:
```
# New vs revisits columns
methods = {
    'condoms': ('condoms_new', 'condoms_revisits'),
    'pills': ('pills_new', 'pills_revisits'),
    'injectables': ('injectable_new', 'injectable_revisits'),
    'implants': ('implants_new', 'implants_revisits'),
    'iucd': ('iucd_new', 'iucd_revisits')
}

data_df['date'] = pd.to_datetime(data_df['year_month'], format='%Y%m')

for pair in methods.values():
    for col in pair:
        data_df[col] = pd.to_numeric(data_df[col], errors='coerce')

cont_list = []
for name, (new_col, rev_col) in methods.items():
    monthly = data_df.groupby('date')[[new_col, rev_col]].sum().
 ↪rename(columns={new_col: 'new', rev_col: 'revisit'})
    monthly['method'] = name
    monthly['continuation_rate'] = monthly['revisit'] / (monthly['new'] +␣
 ↪monthly['revisit']).replace(0, pd.NA)
    cont_list.append(monthly.reset_index())

cont_df = pd.concat(cont_list)

# Summary continuation stats
cont_summary = cont_df.groupby('method')['continuation_rate'].
 ↪describe()[['mean','50%','min','max']]
print(cont_summary)

# Plot continuation over time for injectables and implants (common methods)
plt.figure(figsize=(14,6))
for method in ['injectables','implants','condoms','pills', 'iucd']:
    subset = cont_df[cont_df['method'] == method]
    plt.plot(subset['date'], subset['continuation_rate'], label=method)
plt.title('Monthly continuation rate (revisit share)')
plt.ylabel('Continuation rate')
plt.xlabel('Date')
plt.ylim(0,1)
plt.grid(True)
plt.legend()
plt.tight_layout()
plt.show()
```

method	mean	50%	min	max
condoms	0.344502	0.402424	0.081719	0.626936
implants	0.283543	0.301429	0.000000	0.500000
injectables	0.749550	0.771955	0.275000	0.840952
iucd	0.245525	0.250819	0.000000	0.447761
pills	0.593910	0.576025	0.477298	0.708238

[91]:
```
correlation = data_df['total_users_receiving_fp'] .corr(data_df['total_fp'])
print(f"Correlation between total_users_receiving_fp and total_fp: {correlation:
  ↪.2f}")
```

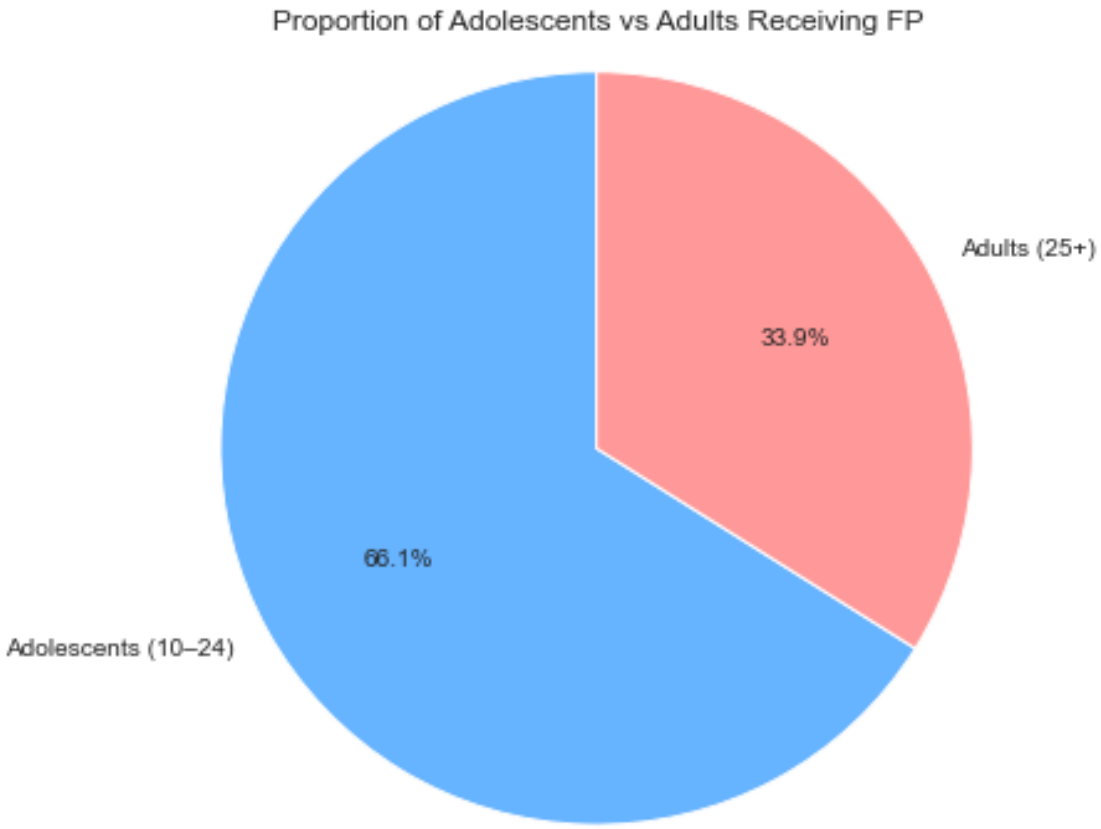
```
Correlation between total_users_receiving_fp and total_fp: 0.83
```

3.3.7 Proportion of adolescents receiving FP and Adults receiving FP

[92]:
```
# Sum totals
adolescents_total = df_service1['adolescent_10_24_receiving_fp_new'].sum()
adults_total = df_service1['adults_25+_receiving_fp_services_new'].sum()
total = adolescents_total + adults_total

# Calculate proportions
adolescents_prop = adolescents_total / total
adults_prop = adults_total / total

# Display
print(f"Proportion of Adolescents (10-24) receiving FP: {adolescents_prop:.2%}")
print(f"Proportion of Adults (25+) receiving FP: {adults_prop:.2%}")
```

```
Proportion of Adolescents (10-24) receiving FP: 66.08%
Proportion of Adults (25+) receiving FP: 33.92%
```

[93]:
```
# Data
labels = ['Adolescents (10-24)', 'Adults (25+)']
sizes = [adolescents_total, adults_total]
colors = ['#66b3ff', '#ff9999']

# Plot
plt.figure(figsize=(6, 6))
plt.pie(sizes, labels=labels, autopct='%1.1f%%', colors=colors, startangle=90)
plt.title('Proportion of Adolescents vs Adults Receiving FP')
plt.axis('equal')  # Equal aspect ratio ensures the pie is circular.
plt.show()
```



3.3.8 Modern Contraceptive Prevalence Rate(mCPR) vs Unmet need

[94]:
```
fig = plt.figure(figsize=(20, 16))
fig.suptitle('Analysis of Unmet Need vs Modern Contraceptive Prevalence Rate␣
↪(mCPR)', fontsize=20)

mcpr_col = 'mCPR (Married Women, %)'
```

```
unmet_need_col = 'Total Unmet Need (Married Women, %)'
demand_satisfied_col = 'Demand_Satisfied_by_Modern_Methods (%)'

# Filter to rows that have both mCPR and unmet need data
complete_data = data_df.dropna(subset=[mcpr_col, unmet_need_col])
print(f"Number of rows with both mCPR and unmet need data:␣
 ↪{len(complete_data)}")

# Calculate service statistics-based mCPR
if 'total_modern_fp' in data_df.columns and 'eligible_fp' in data_df.columns:
    data_df['calculated_mcpr'] = (data_df['total_modern_fp'] /␣
 ↪data_df['eligible_fp']) * 100

# 2. Create county-level summary for comparison
county_summary = data_df.groupby('county').agg({
    'total_modern_fp': 'sum',
    'eligible_fp': 'sum',
    'traditional': 'sum',
    mcpr_col: 'mean',
    unmet_need_col: 'mean',
    demand_satisfied_col: 'mean'
}).reset_index()

# Calculate mCPR at county level based on service statistics
county_summary['calculated_mcpr'] = (county_summary['total_modern_fp'] /␣
 ↪county_summary['eligible_fp']) * 100

# Filter to counties with complete data
counties_with_data = county_summary.dropna(subset=[mcpr_col, unmet_need_col])
print(f"Number of counties with both mCPR and unmet need data:␣
 ↪{len(counties_with_data)}")

# Initialize correlation variable
correlation = 0

# If we have counties with both metrics available
if len(counties_with_data) > 0:
    # 3. Scatterplot of mCPR vs Unmet Need
    ax1 = fig.add_subplot(2, 2, 1)
    scatter = sns.scatterplot(
        x=mcpr_col,
        y=unmet_need_col,
        data=counties_with_data,
        s=100,
        ax=ax1
    )
```

```
    # Add county labels to points
    for i, row in counties_with_data.iterrows():
        ax1.annotate(row['county'],
                     (row[mcpr_col], row[unmet_need_col]),
                     xytext=(5, 5),
                     textcoords='offset points')

    # Calculate correlation
    correlation = counties_with_data[[mcpr_col, unmet_need_col]].corr().iloc[0,␣
↪1]
    ax1.set_title(f'Unmet Need vs mCPR by County\nCorrelation: {correlation:.
↪2f}', fontsize=14)
    ax1.set_xlabel('mCPR (Married Women, %)', fontsize=12)
    ax1.set_ylabel('Total Unmet Need (Married Women, %)', fontsize=12)

    # Add regression line
    sns.regplot(x=mcpr_col, y=unmet_need_col, data=counties_with_data,
                scatter=False, ax=ax1, color='red')

    # 4. Relationship with Demand Satisfied
    if demand_satisfied_col in counties_with_data.columns:
        ax2 = fig.add_subplot(2, 2, 2)
        demand_corr = counties_with_data[[mcpr_col, demand_satisfied_col]].
↪corr().iloc[0, 1]

        sns.scatterplot(
            x=mcpr_col,
            y=demand_satisfied_col,
            data=counties_with_data,
            s=100,
            ax=ax2
        )

        # Add regression line
        sns.regplot(x=mcpr_col, y=demand_satisfied_col, data=counties_with_data,
                    scatter=False, ax=ax2, color='red')

        ax2.set_title(f'Demand Satisfied vs mCPR\nCorrelation: {demand_corr:.
↪2f}', fontsize=14)
        ax2.set_xlabel('mCPR (Married Women, %)', fontsize=12)
        ax2.set_ylabel('Demand Satisfied by Modern Methods (%)', fontsize=12)

# 5. Compare calculated mCPR with unmet need
counties_with_calculated = county_summary.dropna(subset=[unmet_need_col]).copy()
if len(counties_with_calculated) > 0:
    ax3 = fig.add_subplot(2, 2, 3)
    calculated_corr = np.nan
```

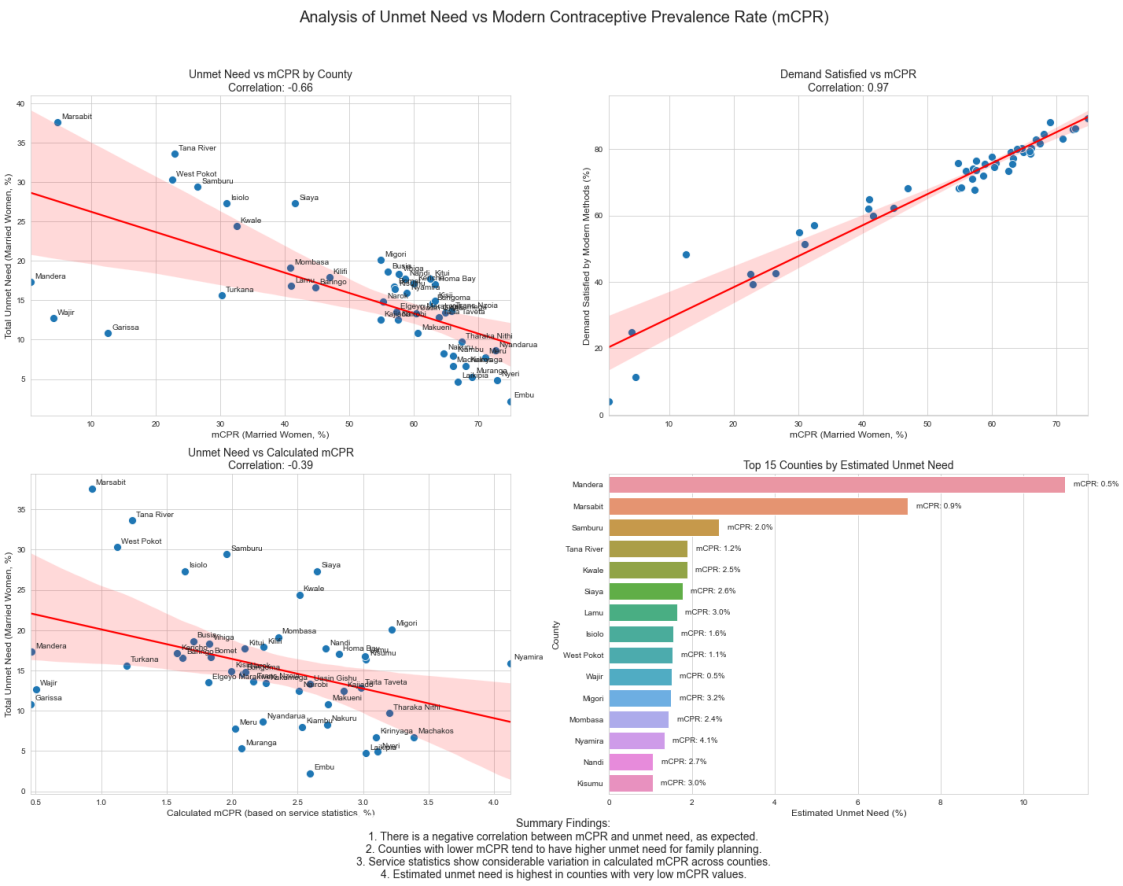
```
    # Only calculate correlation if we have enough data points
    if len(counties_with_calculated) >= 3:
        calculated_corr = counties_with_calculated[['calculated_mcpr',␣
 ↪unmet_need_col]].corr().iloc[0, 1]

    sns.scatterplot(
        x='calculated_mcpr',
        y=unmet_need_col,
        data=counties_with_calculated,
        s=100,
        ax=ax3
    )

    for i, row in counties_with_calculated.iterrows():
        ax3.annotate(row['county'],
                     (row['calculated_mcpr'], row[unmet_need_col]),
                     xytext=(5, 5),
                     textcoords='offset points')

    # Add regression line if we have enough data points
    if len(counties_with_calculated) >= 3:
        sns.regplot(x='calculated_mcpr', y=unmet_need_col,␣
 ↪data=counties_with_calculated,
                    scatter=False, ax=ax3, color='red')

    title = f'Unmet Need vs Calculated mCPR\nCorrelation: '
    if not np.isnan(calculated_corr):
        title += f"{calculated_corr:.2f}"
    else:
        title += "N/A"
    ax3.set_title(title, fontsize=14)
    ax3.set_xlabel('Calculated mCPR (based on service statistics, %)',␣
 ↪fontsize=12)
    ax3.set_ylabel('Total Unmet Need (Married Women, %)', fontsize=12)

# 6. Estimate unmet need for counties that have demand satisfied data
ax4 = fig.add_subplot(2, 2, 4)

counties_with_demand = county_summary.dropna(subset=[demand_satisfied_col]).
 ↪copy()
if len(counties_with_demand) > 0:
    # Estimate unmet need using the formula:
    # Unmet Need = (mCPR / Demand Satisfied) - mCPR
    # Or alternatively: mCPR * ((100 / Demand Satisfied) - 1)
    counties_with_demand['estimated_unmet_need'] =␣
 ↪counties_with_demand['calculated_mcpr'] * \
```

```
        ((100 / counties_with_demand[demand_satisfied_col]) - 1)

    # Sort by estimated unmet need
    top_unmet_need = counties_with_demand.sort_values('estimated_unmet_need',␣
 ↪ascending=False).head(15)

    # Create bar chart
    sns.barplot(
        x='estimated_unmet_need',
        y='county',
        data=top_unmet_need,
        ax=ax4
    )

    # Add calculated mCPR as text annotations
    for i, row in enumerate(top_unmet_need.itertuples()):
        ax4.text(
            row.estimated_unmet_need + 0.2,
            i,
            f'mCPR: {row.calculated_mcpr:.1f}%',
            va='center'
        )

    ax4.set_title('Top 15 Counties by Estimated Unmet Need', fontsize=14)
    ax4.set_xlabel('Estimated Unmet Need (%)', fontsize=12)
    ax4.set_ylabel('County', fontsize=12)

# Add a textbox with summary findings
text_x = 0.5
text_y = 0.02
summary_text = ("Summary Findings:\n"
                "1. There is a negative correlation between mCPR and unmet need,␣
 ↪as expected.\n"
                "2. Counties with lower mCPR tend to have higher unmet need for␣
 ↪family planning.\n"
                "3. Service statistics show considerable variation in calculated␣
 ↪mCPR across counties.\n"
                "4. Estimated unmet need is highest in counties with very low␣
 ↪mCPR values.")

fig.text(text_x, text_y, summary_text, ha='center', va='bottom',
         fontsize=14, bbox=dict(facecolor='white', alpha=0.8))

plt.tight_layout(rect=[0, 0.08, 1, 0.95])


# Output detailed data
```

```
print("\n=== DETAILED RESULTS ===")
print("\nTop 10 counties by unmet need:")
if len(counties_with_data) > 0:
    print(counties_with_data.sort_values(unmet_need_col,␣
 ↪ascending=False)[['county', mcpr_col, unmet_need_col, demand_satisfied_col]].
 ↪head(10).to_string(index=False))
else:
    print("No counties have both mCPR and unmet need data")

print("\nTop 10 counties by estimated unmet need:")
if len(counties_with_demand) > 0:
    print(counties_with_demand.sort_values('estimated_unmet_need',␣
 ↪ascending=False)[['county', 'calculated_mcpr', 'estimated_unmet_need']].
 ↪head(10).to_string(index=False))
else:
    print("No counties have data to estimate unmet need")

print("\nCounties with lowest mCPR:")
if len(counties_with_data) > 0:
    print(counties_with_data.sort_values(mcpr_col)[['county', mcpr_col,␣
 ↪unmet_need_col]].head(10).to_string(index=False))
else:
    print(county_summary.sort_values('calculated_mcpr')[['county',␣
 ↪'calculated_mcpr']].head(10).to_string(index=False))

print("\nAnalysis complete. See '/workspace/unmet_need_vs_mcpr_analysis.png'␣
 ↪for visualization.")
```

```
Number of rows with both mCPR and unmet need data: 47
Number of counties with both mCPR and unmet need data: 47

=== DETAILED RESULTS ===

Top 10 counties by unmet need:
     county  mCPR (Married Women, %)  Total Unmet Need (Married Women, %)
Demand_Satisfied_by_Modern_Methods (%)
   Marsabit                      4.8                                 37.6
11.4
 Tana River                     22.9                                 33.6
39.4
 West Pokot                     22.6                                 30.3
42.3
    Samburu                     26.5                                 29.4
42.5
      Siaya                     41.6                                 27.3
59.9
     Isiolo                     31.0                                 27.3
```

```
51.5
      Kwale                     32.5                                  24.4
57.1
     Migori                     54.9                                  20.1
68.3
    Mombasa                     40.9                                  19.1
62.0
      Busia                     56.0                                  18.6
73.4

Top 10 counties by estimated unmet need:
     county  calculated_mcpr  estimated_unmet_need
    Mandera         0.470532             11.005856
   Marsabit         0.928126              7.213332
    Samburu         1.958949              2.650342
 Tana River         1.235877              1.900867
      Kwale         2.513248              1.888237
      Siaya         2.648887              1.773295
       Lamu         3.013592              1.637013
     Isiolo         1.640353              1.544798
 West Pokot         1.122974              1.531810
      Wajir         0.500968              1.510953

Counties with lowest mCPR:
     county  mCPR (Married Women, %)  Total Unmet Need (Married Women, %)
    Mandera                      0.7                                17.3
      Wajir                      4.2                                12.7
   Marsabit                      4.8                                37.6
    Garissa                     12.6                                10.8
 West Pokot                     22.6                                30.3
 Tana River                     22.9                                33.6
    Samburu                     26.5                                29.4
    Turkana                     30.2                                15.6
     Isiolo                     31.0                                27.3
      Kwale                     32.5                                24.4

Analysis complete. See '/workspace/unmet_need_vs_mcpr_analysis.png' for
visualization.
```



3.4 *d) Modelling*

3.4.1 Baseline Model_Linear Regression

[187]:
```
# Target and feature columns
target_cols = [
    'total_actual_revisits_modern_fp_methods',
    'total_actual_modern_fp',
    'total_fp',
    'proportion_adolescents_10_24_yrs_receiving_fp',
    'actual_core_health_workers_2013_10000_eligible_fp',
    'average_monthly_commodities_dispensed',
]

feature_cols= feature_cols = ['year','year_month','county','number_of_months']
```

[188]:
```
X_train, X_test, y_train, y_test = train_test_split(
    X, y, test_size=0.2, random_state=42
)
```

[190]:
```
#  Identify numeric features
categorical_features = X.select_dtypes(include=['object']).columns.tolist()
numeric_features = X.select_dtypes(include=['int64', 'float64']).columns.
 ↪tolist()


# Define preprocessing steps for numeric data
numeric_transformer = Pipeline(steps=[
    ('imputer', SimpleImputer(strategy='median')),       # Handle missing values
    ('scaler', StandardScaler())                         # Feature scaling
])

# Categorical preprocessing pipeline
categorical_transformer = Pipeline(steps=[
    ('imputer', SimpleImputer(strategy='most_frequent')),
    ('onehot', OneHotEncoder(handle_unknown='ignore'))
])

# Combine transformers
preprocessor = ColumnTransformer(transformers=[
    ('num', numeric_transformer, numeric_features),
    ('cat', categorical_transformer, categorical_features)
])

#  Define full pipeline with estimator
model_pipeline = Pipeline(steps=[
    ('preprocessor', preprocessor),
    ('regressor', MultiOutputRegressor(LinearRegression()))
])

#  Fit the pipeline
model_pipeline.fit(X_train, y_train.fillna(0))  # Fill y_train NaNs with 0 or␣
 ↪another value if needed

#  Predict on test set
y_pred = model_pipeline.predict(X_test)
```

[191]:
```
# Evaluate each target separately
for i, column in enumerate(y.columns):
    mse = mean_squared_error(y_test.iloc[:, i], y_pred[:, i])
    r2 = r2_score(y_test.iloc[:, i], y_pred[:, i])
    print(f"{column}:")
    print(f"  MSE = {mse:.2f}")
    print(f"  R²  = {r2:.2f}")
    print("-" * 40)
```

```
total_actual_revisits_modern_fp_methods:
```

```
  MSE = 4125334.24
  R²  = 0.73
----------------------------------------
total_actual_modern_fp:
  MSE = 11561131.61
  R²  = 0.74
----------------------------------------
total_fp:
  MSE = 11615332.03
  R²  = 0.74
----------------------------------------
proportion_adolescents_10_24_yrs_receiving_fp:
  MSE = 0.01
  R²  = 0.94
----------------------------------------
actual_core_health_workers_2013_10000_eligible_fp:
  MSE = 27.07
  R²  = 0.94
----------------------------------------
average_monthly_commodities_dispensed:
  MSE = 77847.34
  R²  = 0.24
----------------------------------------
```

3.4.2 XGBoost

[199]:
```python
# Preprocessing for numeric columns
numeric_transformer = Pipeline(steps=[
    ('imputer', SimpleImputer(strategy='median')),
    ('scaler', StandardScaler())
])

# Preprocessing for categorical columns
categorical_transformer = Pipeline(steps=[
    ('imputer', SimpleImputer(strategy='most_frequent')),
    ('encoder', OneHotEncoder(handle_unknown='ignore'))
])

# Combine preprocessing
preprocessor = ColumnTransformer(
    transformers=[
        ('num', numeric_transformer, numeric_features),
        ('cat', categorical_transformer, categorical_features)
    ]
)

# Full pipeline with XGBoost
```

```
xgb_pipeline = Pipeline(steps=[
    ('preprocessor', preprocessor),
    ('regressor', MultiOutputRegressor(XGBRegressor(
        objective='reg:squarederror',
        n_estimators=100,
        learning_rate=0.1,
        max_depth=5,
        random_state=42
    )))
])

# Hyperparameter grid
param_grid = {
    'regressor__estimator__n_estimators': [50, 100],
    'regressor__estimator__learning_rate': [0.05, 0.1],
    'regressor__estimator__max_depth': [3, 5],
    'regressor__estimator__subsample': [0.8, 1.0],
    'regressor__estimator__colsample_bytree': [0.8, 1.0]
}

# Grid search with 3-fold cross-validation
grid_search = GridSearchCV(xgb_pipeline, param_grid, cv=3, scoring='r2',␣
 ↪verbose=2, n_jobs=-1)

# Fit grid search
grid_search.fit(X_train, y_train)

# Fit model
xgb_pipeline.fit(X_train, y_train)

# Predict
y_pred = xgb_pipeline.predict(X_test)
```

```
Fitting 3 folds for each of 32 candidates, totalling 96 fits
```

[200]:
```
# Evaluate the model
for i, col in enumerate(target_cols):
    mse = mean_squared_error(y_test[col], y_pred[:, i])
    r2 = r2_score(y_test[col], y_pred[:, i])
    print(f"{col}:\n  MSE = {mse:.2f}\n  R²  = {r2:.2f}\n" + "-"*40)
```

```
total_actual_revisits_modern_fp_methods:
  MSE = 7025875.02
  R²  = 0.54
----------------------------------------
total_actual_modern_fp:
  MSE = 18007509.17
```

```
  R²  = 0.59
----------------------------------------
total_fp:
  MSE = 18141660.95
  R²  = 0.59
----------------------------------------
proportion_adolescents_10_24_yrs_receiving_fp:
  MSE = 0.06
  R²  = 0.64
----------------------------------------
actual_core_health_workers_2013_10000_eligible_fp:
  MSE = 44.23
  R²  = 0.89
----------------------------------------
average_monthly_commodities_dispensed:
  MSE = 82126.79
  R²  = 0.20
----------------------------------------
```

Observation * XGBoost improved overall performance for some targets but underperformed for others. * The workforce target remains the most predictable — good sign. * Commodities dispensed remains poorly predicted

[203]:
```
import joblib

# Save model
joblib.dump(XGBRegressor, 'my_model.pkl')

# Load model
model = joblib.load('my_model.pkl')
```