MASTER THESIS

THE ASSOCIATION BETWEEN MACRO-SOCIOECONOMIC FACTORS AND GENDER-DISPARITIES IN CANCER INCIDENCE AND MORTALITY

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Abstract

Background: Evidence on sex differences in cancer incidence and mortality and the association with socioeconomic variables is fragmented. This study investigated whether sex differences across countries in cancer incidence and mortality are associated with the Human Development Index (HDI), Gini-index, Gender Inequality Index (GII) and Gross Domestic Product (GDP) per capita, for seven cancer types.

Methods: Data was collected from the Cancer Incidence in 5 continents, WHO mortality data, United Nations Development Program and the World Bank. We included oesophageal, stomach, pancreatic, liver, colorectal, lung and bladder cancer. Age-standardized male-to-female (MF) rate ratios on incidence and mortality for pre-(<50) and postmenopausal(>=50) age groups were calculated. Linear regression analysis was used to determine associations between MF ratios and socioeconomic indicators.

Results: The MF incidence ratios and the GII were negatively related for postmenopausal stomach, colorectal, liver, pancreatic, and lung cancer, coefficients ranging from -1.1 (pancreas) to -7.4 (lung). MF incidence ratios were negatively associated with GDP in postmenopausal colorectal, pancreatic, lung and bladder cancer, -0.75 per $10,000 (lung) being the largest coefficient. MF mortality ratios were negatively associated with the GII in postmenopausal oesophageal, stomach, colorectal, pancreatic and liver cancer. Coefficients ranged from -0.03 (pancreas) to -16.3 (oesophagus). MF mortality ratios and GDP were negatively associated in premenopausal stomach cancer and postmenopausal oesophagus, colorectal, pancreatic, lung and bladder cancer, -0.76 per $10,000 (oesophagus) being the largest coefficient. The HDI and Gini-index associations with MF ratios were not consistently negative or positive.

Discussion and conclusion: Gender inequality and countries' income-level measured by GII and GDP are negatively associated with differences in incidence and mortality for several cancer types. Different exposure to risk factors by gender and differences in diagnostic pathways and treatment receipt might influence these relationships.

Introduction

Worldwide, cancer is the second leading cause of death[1]. It was responsible for one in six deaths in 2018, with a growing global disease burden. In both cancer incidence and mortality, disparities between genders have been observed[2–4]. Multiple studies found that for most cancers, men have a higher incidence and mortality than women. In literature, biological mechanisms, such as genetic differences, are discussed as possible explanations for these gender differences in cancer incidence and mortality, as are differences in risk factors and treatment allocation [2,3,5,6].

The distinction between men and women can be made through gender and sex. Gender is the term used when one wishes to make a distinction between men and women based on socially constructed norms, culture and values[7] that crucially define roles, while the term sex refers to biological differences between men, women and intersex persons. As this study focuses on socioeconomic factors interaction with male and female differences, the term gender will be used.

Gender differences in cancer incidence and mortality differ between countries. Incidence is the number of new cases of a disease in a certain population over a certain period of time[8]. Mortality is the number of people who die from a disease in a certain population over a certain period of time. While there was excess male mortality due to lung cancer found in all Organisation for Economic Cooperation and Development (OECD) -countries, this gender gap was declining over time (between 2002 and 2017), and was not the same in all countries[9]. In a different study, with a worldwide setting, it was shown that men do not have a higher all-cancer mortality rate in all countries[10].

Apart from incidence and mortality as separate measures, differences in mortality-incidence ratios (MIRs) have been studied[11]. Mortality-incidence ratios are calculated by dividing incidence by mortality, thus giving an indication as to how many patients who are diagnosed with a type of cancer die from that cancer[12,13]. MIR's are used as a proxy for the opposite of survival, as survival data is not always available. MIR's of bladder and kidney cancer between men and women in 49 countries, were found not to be significant in all countries, nor was it always the same gender who had a higher risk of dying[11].

Thus, it might be that other factors than biological mechanisms play a role in gender differences in cancer incidence and mortality. It is possible that socioeconomic factors play a role. Some studies show that differences between genders in cancer incidence or mortality are associated with a country's level of development[14–16]. These studies focussed on specific forms of cancer and found conflicting results as to whether a country's level of development is positively or negatively associated with gender differences. These studies used different sources of data and different measures for level of development. Data used was from the global burden of disease study and the GLOBOCAN 2018 database. GLOBOCAN contains estimates of the cancer incidence and mortality in different countries[17]. Level of development was measured using the Human Development Index (HDI) or the WHO ranking[14–16].

Other socioeconomic factors might also play a part in gender differences in cancer incidence and mortality. The difference in incidence of cancer in children between boys and girls has been shown to be associated with per capita Gross Domestic Product[18], using data from the Cancer Incidence in Five Countries project, but this study focussed on cancer in children.

Overall, economic inequality, educational level, income level, health care system efficiency and the availability of national cancer programmes have been shown to be predictors of a country's MIR[19], though their relationship with gender differences was not always studied.

Lastly, it might be useful to consider female emancipation in society as a possible factor of influence. While, to our knowledge, no research has been done studying the effect of gender inequality on gender differences in cancer incidence and mortality, it has been shown that there is an association between gender inequality and sex gaps in life expectancy across countries[20]. Whether this association was positive or negative was dependent on a country's level of income. Also, in lower income countries women are more likely to forego treatment for non-communicable diseases than men because of costs[21], possibly due to different positions in the household. Besides this, gender equality as measured by the Gender Inequality Index (GII) has been associated with better survival in cervical cancer[22].

Thus, it appears that there could be an association between socioeconomic factors and gender differences in cancer incidence and mortality. However, the studies mentioned above which discuss these gender differences all focus on a limited number of cancer-types. Also, there are differences between the studies in chosen socioeconomic variables, definition of these variables and data-sources, with some studies using estimates rather than actual data. Besides this, socioeconomic variables such as gender inequality have not been studied in this context yet. This means that there is a lack of an overall picture on socioeconomic variables and gender differences in cancer. Therefore, the aim of this study was to determine whether differences in the incidence and mortality of different non-gender-specific cancers between men and women are associated variables regarding the development of a country, economic inequality and gender inequality.

Methods

Design

This study was a cross-sectional study, using data from international databases on cancer and mortality registrations and socioeconomic variables.

Sources of data on cancer incidence and mortality

In this study, cancer incidence and mortality were used. Incidence is calculated by dividing the number of people newly diagnosed with cancer during a period of time by the number of years that was lived by the people in the observed population[8]. This is called the number of person-years. Mortality is calculated by dividing the number of people who died of cancer during a period of time by the number of years lived by the people in the observed population. These incidence and mortality can be used to calculate the incidence rate per 100,000 years. If one does for specific age-categories, one can then apply these rates to a standard population, to make sure that the observed rates are not distorted by differences in the age build-up of populations. This process is called standardization.

Data on cancer incidence and mortality in different countries was obtained from the Cancer Incidence in five continents database. The Cancer Incidence in five continents (CI5) database is formed by the International Agency for Research on Cancer and combines information from cancer registries. In its most recent publication, registrations from 65 countries over the period 2008-2012 were included after passing the registrations' quality standards[23]. To reach the CI5's goal of allowing for comparisons in cancer incidence between populations, data is assessed on its comparability, completeness and validity before inclusion in the CI5. Therefore, the data used in this study is of good quality. The data used were the incidence and mortality rates (per 100,000 person-years) for each five-year age group. This distinction per age-group was made because literature suggests that gender disparities in cancer between men and women are not the same for all ages[10].

Due to the scope of the analysis, not all types of cancer were included. A selection was made out of the ten types of non-gender specific cancer that were estimated predicted by GLOBOCAN to have the highest worldwide incidence in 2020[24]. This criterium was made to avoid including types of cancer where the incidence was low enough for small changes to have a large influence on the outcomes. From those cancers, only those were included which are linked to risk factors[25] where a gender difference or difference because of socioeconomic factors can be observed, such as smoking behaviour [26–28] or diet[29–31]. This was done to avoid including cancers that could mostly be the result of genetic factors. It was assumed that genetic factors are less likely to be influenced by socioeconomic factors. This led to the exclusion of thyroid cancer, non-Hodgkin lymphoma and leukaemia. The included types of cancer are listed with their International Classification of Diseases-Oncology (ICD-O) codes[32]. These are, in alphabetical order: Bladder (C67), Colon (C18), Liver (C22), Lung (C34), Oesophagus (C15), Pancreas (C25), Rectum (C20), and Stomach (C16). Due to availability of the mortality data, colon and rectal cancers were combined as colorectal cancer in both mortality and incidence analysis.

Data on socioeconomic factors

As data on cancer incidence and mortality stems from 2008-2012, measures on socioeconomic variables was preferably collected for the year 2012. If data for 2012 was not available, measures from the nearest available year was used. For example, if 2012 was missing, but there were scores for 2010 and 2013, the score from 2013 was used. The socioeconomic factors that were studied in this study are described below.

Human development Index

The Human Development Index (HDI) is an index designed by the United Nations (UN) to judge a country's development on more than its economic growth[33]. The HDI is based on health measures, education and standard of living. Health is measured by the life expectancy at birth. Education is measured by the education index, which is determined by the expected years of schooling for children at school age and the mean years of schooling for adults over 25. Standard of living is determined by the Gross National Income per capita.

This variable is also reported by the UN. HDI is a value between zero and one, in which a higher value means a higher level of development[33]. The data on HDI scores in 2012 was taken from the United Nations Development Programme's (UNDP) data centre[34]. These scores were treated as a continuous variable.

Gini-index

The Gini-index, or Gini-coefficient, is a measurement of economic inequality, which is based on the percentage of the total income of a population which is earned by a certain proportion of the population[35]. The Gini index is calculated using the Lorenz-curve. In the Lorenz-curve, the cumulative percentage of income earned is plotted against the cumulative percentage of a countries' population. To calculate the Gini-index, a straight line from zero to 100 is added. The Gini-index is the percentage of the area under this line that is covered by the area under the Lorenz-curve. Thus, if there is complete income equality in a country, the Gini index is 100. If there is complete inequality, it is zero. The Gini-index was used in this study as it is a useful quantification of income inequality and because it has been associated with cancer mortality[19]. Data on the Gini-index scores for countries in 2012 was obtained from the World Bank data centre[36].

Gender Inequality Index

The Gender Inequality Index (GII) is a quantified measure of emancipation in a country[35]. It is calculated based on scores for reproductive health, empowerment and economic status. The scores for reproductive health are based on maternal mortality and adolescent birth rates. The scores for empowerment are based on educational level for both men and women and the proportion of women in parliament. Economic status is determined by labour market participation by gender. The GII is a score between zero and one. A low score on the GII means that there is a high level of equality in a country. As income is not considered in this index, a poor country can still have a good GII score. Data on countries' GII scores in 2012 was obtained from the UNDP data centre[34]. GII scores were treated as a continuous variable.

Information on countries' level of income

Countries' level of income was measured using the GDP per capita. Data on countries' GDP per capita was obtained from the World Bank databank[37].

Outcomes and calculation of outcomes

For all included types of cancer, the male-to-female incidence ratios and male-to-female mortality ratios were studied. The ratios were calculated by dividing the male incidence or mortality by the female incidence or mortality. These values provide insight in the difference between men and women in incidence and mortality of a certain cancer type. If the value is higher than one, this means that men are more likely to be diagnosed with or die from this type of cancer in this country. If a value is lower than one, this means women are more likely to be diagnosed with or die from this type of cancer.

Data on cancer incidence and mortality was obtained in cases and person-years per type of cancer per five-year age category, from the CI5-database[38]. Incidence and mortality rates were then calculated by calculating the incidence and mortality per 100,000 person-years. This was done using the following formula:

$$incidence = \frac{cases}{person\text{-}years} \cdot 100{,}000$$

The age division of the WHO 2000-2025 standard population was then used to standardize these incidence and mortality figures and calculate the premenopausal and postmenopausal incidence and mortality rates[39] . Incidence rates for each age category were multiplied by the percentage of this age category in that standard population. These rates were then used to calculate male-to-female ratios by dividing the male incidence or mortality by the female incidence or mortality. If the female incidence rate was zero, a male-to-female ratio could not be calculated and this country was excluded in that specific analysis.

To take the influence of female hormonal status into account, the male-to-female ratios were calculated for each country for two categories: women and men in the premenopausal age and women and men in the postmenopausal age. As the actual menopausal state was not reported in the data used, the age of 50 years was used. According to literature, this is an effective proxy for menopause[40]. Premenopausal data for oesophagus, pancreas and bladder cancer was excluded to avoid distortion by too small incidence and mortality numbers.

Statistical analysis

Analysis of the male-to-female ratios was performed by first assessing the normality of the distribution using histograms. In order to assess multicollinearity between the socioeconomic variables, a Spearman correlation test was performed. Then the linearity of individual relationships between socioeconomic variables and the male-to-female ratios was assessed visually using scatterplots. To determine whether there were associations between the male-to-female ratios and the socioeconomic variables, linear regression was then performed using stepwise, forward and backward algorithms in SPSS. When these algorithms yielded different outcomes, the best model was selected based on the normality of the distribution of residuals, the P-P plot, and the R-squared value. If no model with a normal distribution could be found, and the male-to-female ratio data was non-normally distributed, the regression was repeated on ln-transformed data.

Scatterplots were made of the male-to-female ratios against the socioeconomic variables, where countries were categorized into continents. This was done to provide some visual analysis of possible influence by continent. Some examples of these scatterplots are presented in the results.

Statistical analysis was performed using SPSS for Windows, version 26.

Ethical considerations

Ethical approval was obtained from the Ethics Commission of the Behavioural and Management Sciences Faculty of the University of Twente, in the Netherlands.

Results

Male-to-Female incidence ratios

In the analysis of gender differences in cancer incidence, 63 countries were included. They are listed in Appendix table 1, along with the values that were used for the socioeconomic variables.

In the Gini-index, no data was available for six countries: Bahrain, Brunei Darussalam, Kuwait, Qatar, New Zealand and Saudi Arabia. The Gender Inequality Index was not available for the Seychelles. Normality of the distributions of socioeconomic variables was determined via histograms. None of these variables were normally distributed. The median HDI value was 0.83. The median GII value was 0.23. The median GDP per capita was $15,420.90 and the median Gini-index was 35.3. Spearman correlation tests showed that all socioeconomic variables were significantly correlated with all other socioeconomic variables.

Table 1: Number of included countries and median Male-to-Female incidence ratios.

Type of cancer	Age category	Number of countries included (out of 63)	Median Male-to-Female incidence ratio (interquartile range)	Minimum-maximum
Oesophagus	postmenopausal	53	3.8 (2.6-6.0)	0.9-32.7
Stomach	premenopausal	63	1.3 (1.1-1.4)	0.3-3.8
	postmenopausal	63	2.2 (1.8-2.4)	1.0-3.0
Liver	premenopausal	61	1.9 (1.5-2.5)	0.2-7.1
	postmenopausal	63	2.7(1.8-3.0)	0.8-5.2
Pancreas	postmenopausal	60	1.3 (1.2-1.6)	0.7-2.3
Colorectum	premenopausal	63	1.0 (0.9-1.1)	0.7-2.4
	postmenopausal	63	1.5 (1.3-1.6)	1.0-2.1
Bladder	postmenopausal	59	4.0 (3.4-5.4)	1.2-8.5
Lung	premenopausal	62	1.4(1.1-2.1)	0.4-5.2
	postmenopausal	63	3.0 (1.8-4.3)	0.9-11.7

As can be seen in table 1, no median male-to-female incidence ratios below one were found. Most, but not all, male-to-female incidence ratios were not normally distributed, thus the median and interquartile range has been reported in table 1. In table 1, the number of countries included in each analysis is also described, as are the minimum and maximum male-to-female ratios.

In linear regression analysis of the male-to-female cancer incidence ratios, no associations between the male-to-female ratio and the socioeconomic variables were found for premenopausal stomach cancer.

A negative association between the male-to-female incidence ratio and the GII was found in postmenopausal stomach cancer, postmenopausal colorectal cancer, postmenopausal liver cancer, postmenopausal pancreatic cancer and postmenopausal lung cancer (table 2A). As an example, the scatterplot for GII and the male-to-female incidence ratio in lung cancer is shown in Figure 1. All scatterplots of male-to-female incidence ratios and socioeconomic variables can be found in appendix 2.

Figure 1. Scatterplot postmenopausal Male-to-Female lung cancer incidence ratio and Gender Inequality Index.

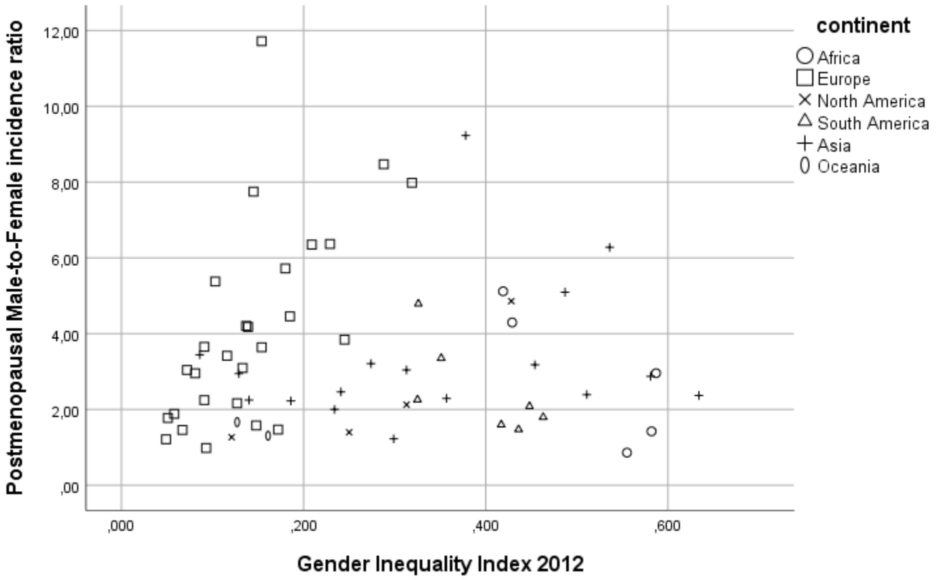

Figure 1. Scatterplot of the postmenopausal Male-to-Female lung cancer incidence ratio and Gender Inequality Index. The dots are shaped by continent.

A negative association between the male-to-female incidence ratio and the HDI was found in postmenopausal stomach cancer, while a positive association was found between the male-to-female incidence ratio and the HDI in postmenopausal bladder cancer (Table 2A).

Similarly, a positive association between the male-to-female incidence ratio and the Gini-index was found in premenopausal colorectal cancer, while a negative association between the male-to-female incidence ratio and the Gini-index was found in postmenopausal colorectal and bladder cancer (Table 2A).

A negative association between the male-to-female incidence ratio and the GDP per capita was found in postmenopausal colorectal cancer, postmenopausal pancreatic cancer, postmenopausal lung cancer, and postmenopausal bladder cancer (Table 2A). As an example, the scatterplot between GDP per capita and the postmenopausal male-to-female bladder cancer ratio is shown in fig 2.

Figure 2. Scatterplot postmenopausal Male-to-Female bladder cancer incidence ratio and Gross Domestic Product per capita.

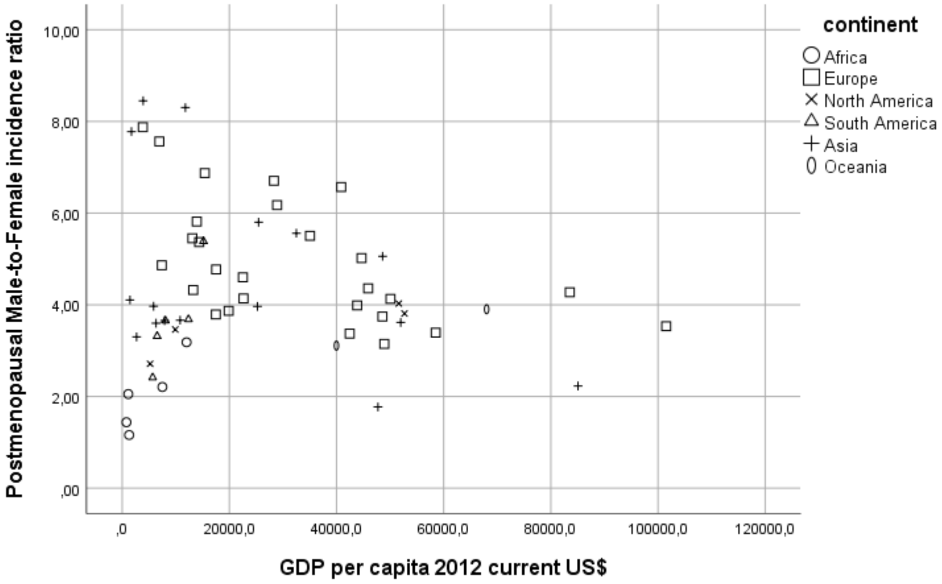

Figure 2. Scatterplot of the postmenopausal Male-to-Female bladder cancer incidence ratio and the Gross Domestic Product per capita in current US dollar. The dots are shaped by continent.

When performing linear regression on the ln-transformed data (table 2B), a negative association between the male-to-female incidence ratio and the GII was found in premenopausal liver cancer. Also, a positive association between the male-to-female incidence ratio and the Gini-index was found in postmenopausal oesophagus cancer, while a negative association between the male-to-female incidence ratio and the Gini index was found in premenopausal liver cancer. Lastly, a negative association between the male-to-female incidence ratio and the GDP per capita was found in premenopausal lung cancer.

The results found have been summarized in table 2A&B below.

Table 2A

Cancer type	Age category	R-squared	Constant (p-value)	Coefficient Gender Inequality Index 2012 (p-value)	Coefficient Human Development Index 2012 (p-value)	Coefficient Gross Domestic Product per capita 2012 current US$* (p-value)	Coefficient Gini-index 2012 (p-value)
Stomach	postmenopausal	24%	3.7 (<0.01)	-1.8 (<0.01)	-1.3 (0.07)	NS	NS
Colorectum	premenopausal	12%	0.7(<0.01)	NS	NS	NS	0.01(<0.01)
	postmenopausal	59%	2.5 (<0.01)	-1.4 (<0.01)	NS	-0.06 (0.01)	-0.01 (<0.01)
Liver	postmenopausal	34%	3.4 (<0.01)	-3.2 (<0.01)	NS	NS	NS
Pancreas	postmenopausal	21%	1.9 (<0.01)	-1.1 (<0.01)	NS	-0.07 (<0.01)	NS
Lung	postmenopausal	28%	7.2 (<0.01)	-7.4 (<0.01)	NS	-0.75 (<0.01)	NS
Bladder	postmenopausal	25%	2.5 (<0.4)	NS	7.2 (0.04)	-0.41 (<0.01)	-0.1 (0.02)

Table 2A: Summary of coefficients and R-squared values for models found linear regression analysis of male-to-female cancer incidence ratios. *Coefficient per 10,000$

Table 2B

Cancer type	Age category	R-squared	Constant (p-value)	Coefficient Ln-Gender Inequality Index 2012 (p-value)	Coefficient Ln-Human Development Index 2012 (p-value)	Coefficient Ln-Gross Domestic Product per capita 2012 current US$ (p-value)	Coefficient Ln-Gini-index 2012 (p-value)
Oesophagus	postmenopausal	19%	7.2 (<0.01)	NS	NS	NS	-1.6 (<0.01)
Liver	premenopausal	19%	-3.8 (0.03)	-0.44 (0.01)	NS	NS	1.1 (0.02)
Lung	premenopausal	18%	2.2 (<0.01)	NS	NS	-0,2 (<0.01)	NS

Table 2B: Summary of coefficients and R-squared values for models found linear regression analysis on ln-transformed data of male-to-female cancer incidence ratios

As can be seen, associations between GII, GDP per capita and the male-to-female incidence ratios are consistently negative. This suggests that an increase in gender inequality and/or GDP per capita is associated with a decrease in the male-to-female incidence ratios of several cancer types. This could indicate that an increase in gender inequality or GDP is associated with a smaller difference in cancer incidence between men and women. For GII, it might also be associated with the difference shifting from men having a higher chance of developing a type of cancer to women having a higher chance. However, the coefficients of the GDP associations are small. Coefficients for Gini-index and HDI are not consistently negative or positive.

Male-to-female mortality ratios

In the analysis of gender differences in cancer mortality, 95 countries were included. These are listed below in appendix table 1. Data on the Gender Inequality Index was not available for one country: Turkmenistan. Data on the Gini-index was not available for 17 countries: Bahamas, Bahrain, Barbados, Belize, Brunei Darussalam, Croatia, Guyana, Kuwait, New Zealand, Qatar, Singapore, Suriname, Syrian Arab Republic, Trinidad and Tobago, Turkmenistan, and the Bolivarian Republic of Venezuela. In the mortality data, no mortality was reported over 80 years of age, so the last two age categories (80-85 and aged over 85) were excluded. Normality of the distribution of socioeconomic variables was assessed visually using histograms. Socioeconomic variables were not normally distributed. In table 4 below, the median and interquartile range for the socioeconomic variables for countries included in the mortality analysis are reported. The median HDI was 0.8. The median GII was 0.27. The median GDP per capita was $13,097.3 and the median Gini-index was 35.2. A Spearman correlation-test was performed to determine whether the socioeconomic variables were correlated to each other. Significant correlations were found between all socio-economic variables.

The normality of the distribution of the male-to-female mortality ratios found was assessed visually using histograms. The ratios are summarized below in table 3, for both the pre- and postmenopausal categories in all types of cancer. The table also describes the number of included countries after excluding countries where a male-to-female ratio could not be calculated, as well as the minimum and maximum male-to-female ratios.

Table 3. Number of countries included and median male-to-female mortality ratio in mortality analysis.

Type of cancer	**Age category**	**Number of countries included (out of 95)**	**Median Male-to-Female mortality ratio (interquartile range)**	**Minimum - Maximum**
Oesophagus	Postmenopausal	95	4.0 (2.6-6.0)	0.9-19.2
Stomach	Premenopausal	93	1.3 (1.1-1.5)	0.1-3.1
	Postmenopausal	95	2.3(1.9-2.6)	0.9-3.4
Liver	Premenopausal	92	1.8(1.4-2.3)	0.3-5.7
	Postmenopausal	94	2.2 (1.5-2.7)	0.7-4.3
Pancreas	Postmenopausal	95	1.4 (1.2-1.7)	0.6-2.8
Colorectum	Premenopausal	94	1.1 (1.0-1.2)	0.2-3.4
	Postmenopausal	95	1.6 (1.3-1.8)	0.5-2.4
Bladder	Postmenopausal	94	3.9 (2.8-5.8)	1.2-11.5
Lung	Premenopausal	94	1.7(1.2-2.8)	0.7-8.7
	postmenopausal	95	2.8 (1.9-5.0)	1.0-13.9

Most, but not all male-to-female mortality ratios were not normally distributed. Thus, the median and interquartile ranges are reported in table 3. As can be seen in table 3, the median male-to-female mortality ratios is above one for all types of cancer for both age categories. Thus, it appears that there is a higher male mortality in all types of cancer analysed in this study.

In linear regression analysis of the male-to-female ratio in cancer mortality, no associations were found between the male-to-female mortality ratio and socioeconomic variables in premenopausal colorectal cancer.

A negative association between the male-to-female mortality ratio and the GII was found in postmenopausal oesophagus cancer, postmenopausal stomach cancer, postmenopausal colorectal cancer and postmenopausal liver cancer (Table 4A). The scatterplot showing GII and male-to-female ratio in postmenopausal colorectal cancer is shown in fig. 3. All scatterplots of male-to-female mortality ratios and socioeconomic variables can be found in appendix 3.

Figure 3. Scatterplot postmenopausal Male-to-Female colorectum cancer mortality ratio and Gender Inequality Index.

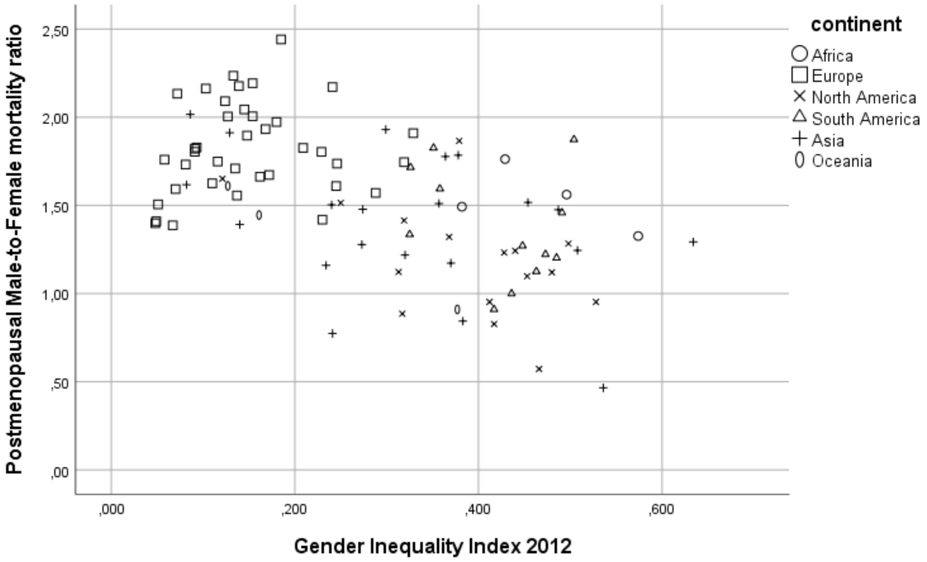

Figure 3. Scatterplot of postmenopausal Male-to-Female colorectal cancer mortality ratio and the Gender Inequality Index. The dots are shaped by continent.

Also, a positive association between the male-to-female mortality ratio and the HDI was found in postmenopausal colorectal cancer.

Besides this, a negative association between the male-to-female mortality ratio and the GDP per capita was found in postmenopausal oesophagus cancer, premenopausal stomach cancer, postmenopausal stomach cancer, postmenopausal colorectal cancer, postmenopausal pancreatic cancer, postmenopausal lung cancer and postmenopausal bladder cancer (Table 4A). The scatterplot of the GDP per capita and the male-to-female postmenopausal oesophagus cancer mortality ratio is shown in fig. 4.

Figure 4. Scatterplot postmenopausal Male-to-Female oesophageal cancer mortality ratio and Gross Domestic Product per capita.

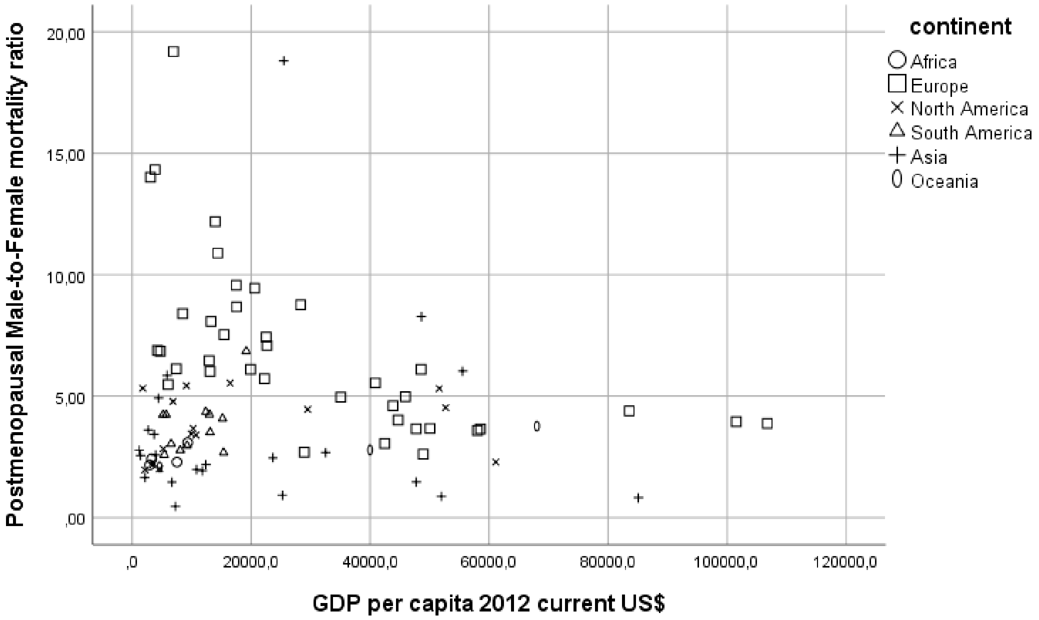

Figure 4. Scatterplot of the postmenopausal Male-to-Female oesophageal cancer mortality ratio and the Gross Domestic Product per capita in current US dollars. The dots are shaped by continent.

Lastly, a negative association between the male-to-female mortality ratio and the Gini-index was found in postmenopausal pancreatic cancer, postmenopausal lung cancer and postmenopausal bladder cancer (Table 4A).

When performing linear regression on In-transformed data, a negative association between the male-to-female mortality ratio and the GII was found in premenopausal liver cancer and between the male-to-female mortality ratio and the GDP per capita and Gini index in premenopausal lung cancer (Table 4B).

The results of these analyses are summarized in table 4A&B.

Table 4A

Cancer type	Age category	R-squared	Constant (p-value)	Coefficient Gender Inequality Index 2012 (p-value)	Coefficient Human Development Index 2012 (p-value)	Coefficient Gross Domestic Product per capita 2012 current US$* (p-value)	Coefficient Gini-index 2012 (p-value)
Oesophagus	Postmenopausal	28%	11.3 (<0.01)	-16.3 (<0.01)	NS	-0.76 (<0.01)	NS
Stomach	Premenopausal	8%	1.5 (<0.01)	NS	NS	-0.06 (<0.01)	NS
	Postmenopausal	16%	2.9 (<0.01)	-1.8 (<0.01)	NS	-0.06 (0.06)	NS
Colorectum	Postmenopausal	49%	1.2 (<0.01)	-1.7 (<0.01)	1.2 (0.04)	-0.07 (<0.01)	NS
Liver	Postmenopausal	35%	3.1 (<0.01)	-3.1 (<0.01)	NS	NS	NS
Pancreas	Postmenopausal	42%	2.7 (<0.01)	-0.03 (<0.01)	NS	-0.06 (<0.01)	NS
Lung	Postmenopausal	31%	10.1 (<0.01)	NS	NS	-0.57 (<0.01)	-0.1 (<0.01)
Bladder	postmenopausal	31%	11.6 (<0.01)	NS	NS	-0.4 (<0.01)	-0.2 (<0.01)

Table 4A Summary of coefficients and R-squared values for models found linear regression analysis of male-to-female cancer mortality ratios. *Per 10,000 $.

Table 4B

Cancer type	Age category	R-squared	Constant (p-value)	Coefficient ln-Gender Inequality Index 2012 (p-value)	Coefficient ln-Human Development Index 2012 (p-value)	Coefficient ln-Gross Domestic Product per capita 2012 current US$ (p-value)	Coefficient ln-Gini-index 2012 (p-value)
Liver	premenopausal	7%	0.3 (0.02)	-0.2 (0.03)	NS	NS	NS
Lung	premenopausal	24%	5.5 (<0.01)	NS	NS	-0.3 (<0.01)	-0.7 (0.01)

Table 4B Summary of coefficients and R-squared values for models found linear regression analysis on ln-transformed data of male-to-female cancer mortality ratios.

As can be seen, associations between GII, GDP per capita and the male-to-female mortality ratios are consistently negative. This suggests that an increase in gender inequality and/or GDP per capita is associated with a decrease in the male-to-female mortality ratios of several cancer types. However, the coefficients of the GDP associations are small. It is important to note that the GII only varies between 0 and 1. Thus, the presented coefficient for the GII is the maximum-effect GII could have in these models.

The scatterplots shown above and in appendices 2 and 3 show that when ratios are grouped per continent, the ratios in a continent do not always group together. For instance, in figure 3, the male-to-female mortality ratios in colorectal cancer in European countries all have similar values and GII-scores. Meanwhile the male-to-female mortality ratios in Asian countries show a negative association with GII scores, and appear to vary more widely.

Discussion

Negative associations between the GII and the male-to-female incidence and mortality ratios were found for several types of cancer. To our knowledge, this is the first study in which the association between the gender inequality as defined by the GII and gender differences in cancer was studied. The results found in this study are in accordance with the results from the study in which it was found that differences in male-to-female life expectancy increased when gender equality increased in low-income countries, as a result of an increase in female life-expectancy[20]. However, it was also found in that study that an increase in gender equality was associated with a decrease in the male-to-female difference in high income countries. This does not appear to be in accordance with the results found in this study.

Possible explanations

A possible explanation for the negative association between gender inequality and male-to-female cancer incidence and mortality ratios found in this study might be variation in risk factors between men and women, which is associated with the GII. For instance: female obesity. Obesity has been linked to several types of cancer, including oesophageal liver, pancreas, and colorectal cancer[41,42]. For these types of cancer, a negative association between GII and male-to-female mortality and incidence ratios was found in this study. This suggests that an increase in gender inequality is associated with a decrease in the male-to-female mortality ratio. Obesity has been found to have a higher prevalence in women than in men in most countries[43]. This male-to-female difference in obesity prevalence has been found to be associated with the GII. In this association, countries with higher inequality had larger a larger discrepancy in male and female obesity prevalence. Therefore, it might be that the higher prevalence of female obesity in countries with more inequality negates the biological mechanisms that give women a lower risk of cancer. This could explain why the male-to-female ratios are smaller in countries with high inequality in this current study.

However, a negative association was also found between the male-to-female lung cancer incidence ratio and the GII. As obesity is not related to lung cancer it is unlikely that a discrepancy between male and female obesity prevalence could explain this finding[44]. It might be that indoor air pollution plays a part in this. Indoor air pollution, for instance as a result of using solid fuels for cooking, increases the risk for lung cancer[45]. It is predominantly an issue in low and middle income countries, and exposure is higher in women than in men[46,47].

While smoking is the most important risk factor for lung cancer, it appears less likely to be an explanation for the negative association between gender inequality and the male-to-female lung cancer incidence ratio[44]. An increase in gender emancipation has been linked to an increase in female smoking rates[28,48]. Thus, one would expect an increase in gender inequality to be associated with an increase in the male-to-female ratio. This is not what was found in this study. However, it has also been found that the association between gender emancipation and female ever smoking rates was negative in highly educated women[27].

Contrastingly, differences in smoking behaviour might be an explanation for the negative association between the GDP-per capita and the male-to-female cancer incidence and mortality ratios that were found in this study for several types of cancer. In research, a positive association between GDP per capita and female ever smoking rates was found[27].

The negative association found between GDP per capita and the male-to-female cancer incidence and mortality ratios is in accordance with the study mentioned in the introduction, in which gender differences in children's cancer were studied [18]. In that study, gender differences were generally larger in countries with a lower GDP per capita. However, apart from liver cancer, no types of cancer were included in both that study [18] and our research. Also, as that study focussed on cancer in children, this limits the comparability of those results to the ones found in this current study.

Besides, the coefficients for GDP per capita found in this current analysis are quite small. This might limit the practical relevance of the finding.

In this study, the mean male-to-female mortality ratio for bladder cancer was 3.9. This is not in accordance with literature, as it was described that women generally have lower survival and worse cancer outcomes in bladder cancer than men[49,50]. It could be that while women's' survival is lower, this is not visible in male-to-female mortality ratios due to differences in incidence.

Strengths and limitations

This study has several strengths. Firstly, data on cancer incidence and mortality was used from a reliable and uniform source. Before inclusion in the CI5 project, data is thoroughly checked to determine whether it is of sufficient quality[23].

Another strength of this study is that the analysis is split between premenopausal and postmenopausal categories. One of the hypotheses to explain a lower cancer incidence and mortality in women is that oestrogen has a protective effect[2,3]. Oestrogen levels lower after menopause[51]. Therefore, splitting the analysis in pre- and postmenopausal categories helps might help avoid distortion by male-to-female differences caused by oestrogen.

Lastly, seven cancer types were included in this study. To our knowledge, this is the first study in which the relationship between socioeconomic variables and male-to-female cancer incidence and mortality ratios were studied in this many cancer types. This might help provide a more overall picture of the associations. Because seven cancer types were included, it becomes visible that when associations between GII or GDP per capita and male-to-female cancer incidence or mortality ratios were found, these associations were always negative. This suggests that an increase in gender inequality and an increase in GDP per capita are associated with smaller male-to-female differences in cancer incidence and mortality.

However, this study also has several limitations. The first of these is that the number of countries per region was often too small to perform a valid separate regional analysis. This could be used to determine whether the effects found in the overall analysis could be found within regions too. Thus it cannot be ruled out that the associations found in the analysis are a result of confounding by regional factors. It might be that there are, for instance, cultural differences which influence male-to-female ratios due to modification of risk behaviour. These cultural differences could be associated with socioeconomic variables.

Secondly, data on the socioeconomic variables was not available for all variables for all countries. This might have led to a distortion of the results. Another limitation of this study is that the data on cancer incidence and mortality is relatively old. This was a necessary concession in order to be able to use data of good quality. To our knowledge, using the CI-5 data was the newest source of actual data that had been checked for quality standards. Some studies have used GLOBOCAN's estimates of cancer incidence and mortality[16]. As these estimates are partly based on MIR's, real life data was preferred in this study, to avoid any distortion by the methods used for estimating in GLOBOCAN[17]. Nevertheless, the data used in this study being from 2012 might mean that the associations found in this study are different now. However, one could argue that these kind of associations are not likely to change very rapidly. Lastly, the data used had no information on the tumour stage or treatment. This meant that it was not possible to analyse whether there were differences in stage at presentation between men and women, or gender differences in treatment allocation or receipt, and whether these differences were associated with socioeconomic variables. As research shows that women in low-income countries are more likely than men to forego treatment because of cost, this is not an unlikely scenario[21].

Implications and recommendations

This study adds to the evidence that gender inequality is detrimental to health[52]. The results of the analysis performed in this study suggest that there is a negative association between gender inequality, the GDP per capita and the male-to-female incidence ratios in several types of cancer. However, this is difficult to translate into implications for policy or clinical practice, as there are still some knowledge gaps. This results in the following recommendations for further research:

First, in order to assess the possibility that the results found in this study are due to confounding by region, it might be wise to repeat these analysis with a larger sample, allowing for separate regional analysis to be performed. If this is not possible, because data of sufficient quality cannot be obtained from more countries, it might be wise to determine whether regions can be grouped together, to increase the number of countries in a region.

Secondly, it might be useful to determine what causes the variation in male-to-female ratios. After all, a male-to-female ratio can decrease due to either an increase in female incidence or a decrease in male incidence. If an increase in gender inequality is associated with an increase in female incidence, then a situation with less gender inequality is to be desired. If, however, an increase in gender inequality is associated with a decrease in male incidence the desired situation is less clear. In both cases, it is important information for forming policies. Lastly, it appears important to determine what mechanism(s) creates the associations between GII, GDP per capita and male-to-female cancer incidence and mortality ratios. This could contribute to finding implications for improving cancer prevention and care.

Conclusion

The possible associations between gender emancipation as defined by the GII and countries' level of income as defined by the GDP per capita and male-to-female cancer incidence and mortality ratios are deserving of further attention. Further research on this might contribute to finding the explanatory mechanisms. These could form a basis for a more effective policy in cancer prevention and care, and reducing the negative consequences of gender inequality on health.

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Appendices

Appendix 1: countries included and socioeconomic variables

Continent	Country	Gender Inequality Index 2012	Human Development Index 2012	Gross Domestic Product per capita 2012 in current US$	GINI index 2012	included in mortality analysis	included in incidence analysis
Africa	Mauritius	0,382	0,771	9291,2	38,5	yes	
Africa	Morocco	0,496	0,635	2912,7	39,5	yes	
Africa	South Africa	0,429	0,675	7501,5	63	yes	yes
Africa	Egypt	0,574	0,677	3229,7	28,3	yes	
Africa	Algeria	0,419	0,728	5591,2	27,6		yes
Africa	Kenya	0,582	0,782	1136,9	40,8		yes
Africa	Seychelles		0,755	12006,7	46,8		yes
Africa	Zimbabwe	0,587	0,525	1305	43,2		yes
Africa	Uganda	0,555	0,507	786,7	41		yes
Asia	Bahrain	0,234	0,808	23654,4		yes	yes
Asia	Armenia	0,32	0,756	3681,9	29,6	yes	
Asia	Brunei Darussalam	0,299	0,839	47740,5		yes	yes
Asia	Georgia	0,364	0,767	4421,8	39	yes	
Asia	Israel	0,14	0,903	32511,2	41,3	yes	yes
Asia	Japan	0,129	0,897	48603,5	32,9	yes	yes
Asia	Kazakhstan	0,24	0,782	12386,7	28,2	yes	
Asia	Jordan	0,487	0,735	3909,9	33,7	yes	yes
Asia	Republic of Korea	0,086	0,898	25466,8	31,6	yes	yes
Asia	Kuwait	0,241	0,796	51979,1		yes	yes
Asia	Kyrgyzstan	0,37	0,674	1178	27,4	yes	
Asia	Malaysia	0,274	0,781	10817,4	41,3	yes	yes
Asia	Maldives	0,383	0,704	7265,6	31,3	yes	
Asia	Philippines	0,454	0,684	2694,3	46,5	yes	yes
Asia	Qatar	0,536	0,854	85076,1		yes	yes
Asia	Saudi Arabia	0,634	0,835	25243,4		yes	yes
Asia	Singapore	0,082	0,918	55546,5		yes	
Asia	Syrian Arab Republic	0,508	0,664	1407,2		yes	
Asia	Thailand	0,357	0,737	5860,6	39,3	yes	yes
Asia	Turkey	0,378	0,765	11795,3	40,2	yes	yes
Asia	Turkmenistan		0,679	6675,2		yes	
Asia	Uzbekistan	0,273	0,685	2137	36,1	yes	
Asia	People's Republic of China	0,186	0,716	6316,9	42,2		yes

Asia	Islamic Republic of Iran	0,511	0,768	7927,8	37,4		yes
Asia	India	0,581	0,597	1443,9	35,7		yes
Asia	Viet Nam	0,313	0,676	1735,1	35,6		yes
Europe	Albania	0,23	0,775	4247,6	29	yes	
Europe	Austria	0,127	0,908	48567,7	30,8	yes	yes
Europe	Belgium	0,081	0,913	44673,1	27,5	yes	yes
Europe	Bulgaria	0,229	0,795	7395,8	36	yes	yes
Europe	Belarus	0,154	0,806	6940,2	26,5	yes	yes
Europe	Croatia	0,139	0,825	13258,4	32,5	yes	yes
Europe	Cyprus	0,137	0,859	28912,2	34,3	yes	yes
Europe	Czech Republic	0,133	0,874	19870,8	26,1	yes	yes
Europe	Denmark	0,049	0,931	58507,5	27,8	yes	yes
Europe	Estonia	0,18	0,865	17534,4	32,9	yes	yes
Europe	Finland	0,07	0,921	47710,8	27,1	yes	
Europe	France	0,091	0,885	40874,7	33,1	yes	yes
Europe	Germany	0,091	0,934	43858,4	30,9	yes	yes
Europe	Greece	0,135	0,865	22242,7	36,3	yes	
Europe	Hungary	0,241	0,831	12950,7	30,8	yes	
Europe	Iceland	0,093	0,915	45910	26,8	yes	yes
Europe	Ireland	0,148	0,903	48917,9	33,2	yes	yes
Europe	Italy	0,116	0,882	35053,5	35,2	yes	yes
Europe	Latvia	0,209	0,832	13926,3	35,2	yes	yes
Europe	Lithuania	0,145	0,841	14373,1	35,1	yes	yes
Europe	Luxembourg	0,11	0,9	106749	34,3	yes	
Europe	Malta	0,245	0,86	22527,6	29,4	yes	yes
Europe	Republic of Moldova	0,246	0,726	3045,7	29,2	yes	
Europe	Netherlands	0,051	0,928	50073	27,6	yes	yes
Europe	Norway	0,067	0,941	101524,1	25,7	yes	yes
Europe	Poland	0,154	0,842	13097,3	33	yes	yes
Europe	Portugal	0,124	0,833	20564,9	36	yes	
Europe	Romania	0,329	0,803	8507,1	36,5	yes	
Europe	Russian Federation	0,288	0,798	15420,9	40,7	yes	yes
Europe	Serbia	0,168	0,775	6015,9	39,9	yes	
Europe	Slovakia	0,185	0,843	17481,9	26,1	yes	yes
Europe	Slovenia	0,072	0,884	22643,1	25,6	yes	yes
Europe	Spain	0,103	0,881	28324,4	35,4	yes	yes
Europe	Sweden	0,048	0,914	58037,8	27,6	yes	
Europe	Switzerland	0,058	0,944	83538,2	31,6	yes	yes
Europe	Ukraine	0,319	0,764	3855,4	24,7	yes	yes
Europe	North Macedonia	0,162	0,748	4698,1	38,1	yes	
Europe	United Kingdom of Great Britain	0,172	0,904	42462,8	32,3	yes	yes

	and Northern Ireland						
North America	Bahamas	0,379	0,807	29485,6		yes	
North America	Barbados	0,319	0,808	16451,2		yes	
North America	Belize	0,44	0,701	4568,5		yes	
North America	Canada	0,121	0,906	52678,4	33,5	yes	yes
North America	Costa Rica	0,313	0,783	9913,2	48,6	yes	
North America	Cuba	0,317	0,769	6837,7		yes	
North America	Dominican Republic	0,48	0,714	61104	46,1	yes	
North America	El Salvador	0,412	0,669	3428,4	41,8	yes	
North America	Guatemala	0,528	0,618	3408,8	48,3	yes	
North America	Honduras	0,466	0,612	2144,3	56,1	yes	
North America	Jamaica	0,428	0,731	5209,9	45,5	yes	yes
North America	Mexico	0,368	0,759	10241,7	48,7	yes	
North America	Nicaragua	0,453	0,633	1760,5	46,2	yes	
North America	Panama	0,498	0,786	10722,3	51,7	yes	
North America	Saint Lucia	0,417	0,73	9086,8	51,2	yes	
North America	United States of America	0,25	0,92	51610,6	40,9	yes	yes
Oceania	Australia	0,127	0,937	68012,1	34,4	yes	yes
Oceania	Fiji	0,377	0,722	4591,6	36,7	yes	
Oceania	New Zealand	0,161	0,911	39982,8		yes	yes
South America	Argentina	0,351	0,834	13082,7	41,3	yes	yes
South America	Brazil	0,448	0,735	12370	46,1	yes	yes
South America	Chile	0,325	0,388	15351,6	45,8	yes	yes
South America	Colombia	0,463	0,739	8050,3	52,6	yes	yes
South America	Ecuador	0,417	0,751	5682	46,1	yes	yes
South America	Guyana	0,491	0,662	5378,7		yes	

South America	Paraguay	0,473	0,701	5183,1	47,6	yes	
South America	Peru	0,436	0,742	6529	44,4	yes	yes
South America	Suriname	0,504	0,729	9201		yes	
South America	Trinidad and Tobago	0,358	0,78	19157,4		yes	
South America	Uruguay	0,326	0,793	15171,6	39,9	yes	yes
South America	Venezuela (Bolivarian Republic of)	0,485	0,772	12985,5		yes	

Appendix 2. Scatterplots Male-to-Female incidence ratios.

Below are the scatterplots showing the male-to-female against the socioeconomic variables. The dots are shaped to distinguish continents.

Figure 1. Scatterplot postmenopausal Male-to-Female oesophagus cancer incidence ratio and Gender Inequality Index.

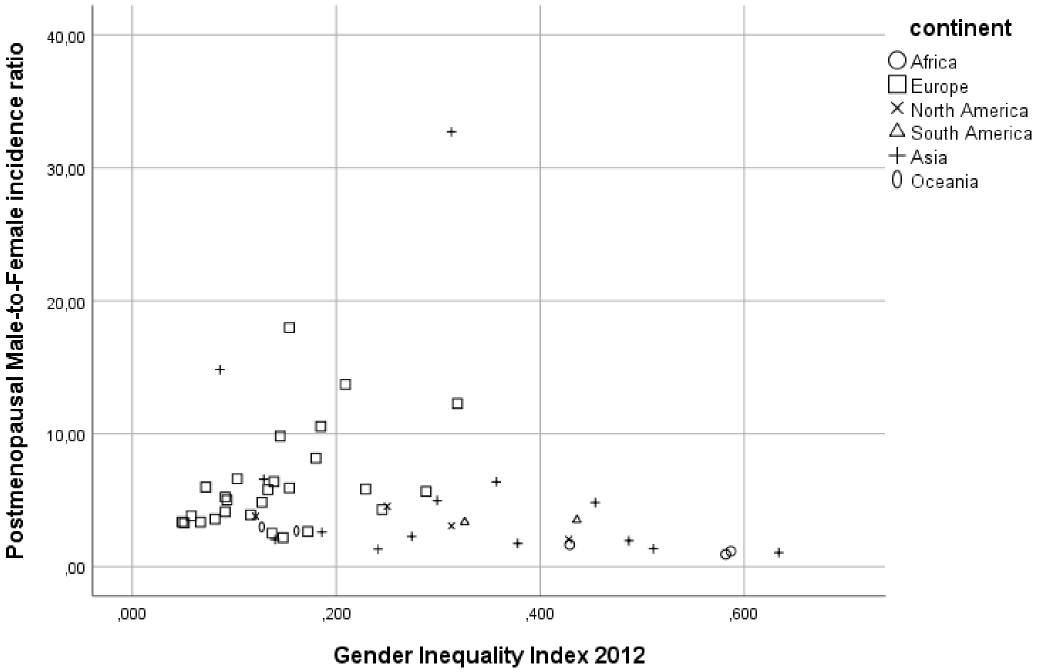


Figure 2. Scatterplot postmenopausal Male-to-Female oesophagus cancer incidence ratio and Human Development Index.

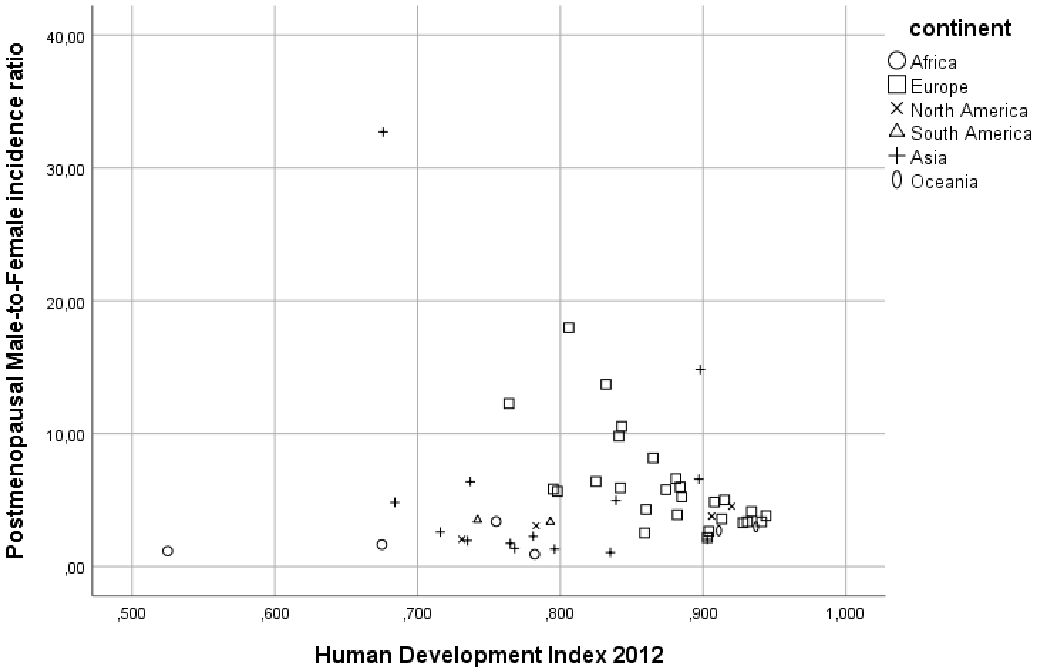


Figure 3. Scatterplot postmenopausal Male-to-Female oesophagus cancer incidence ratio and Gross Domestic Product per capita.

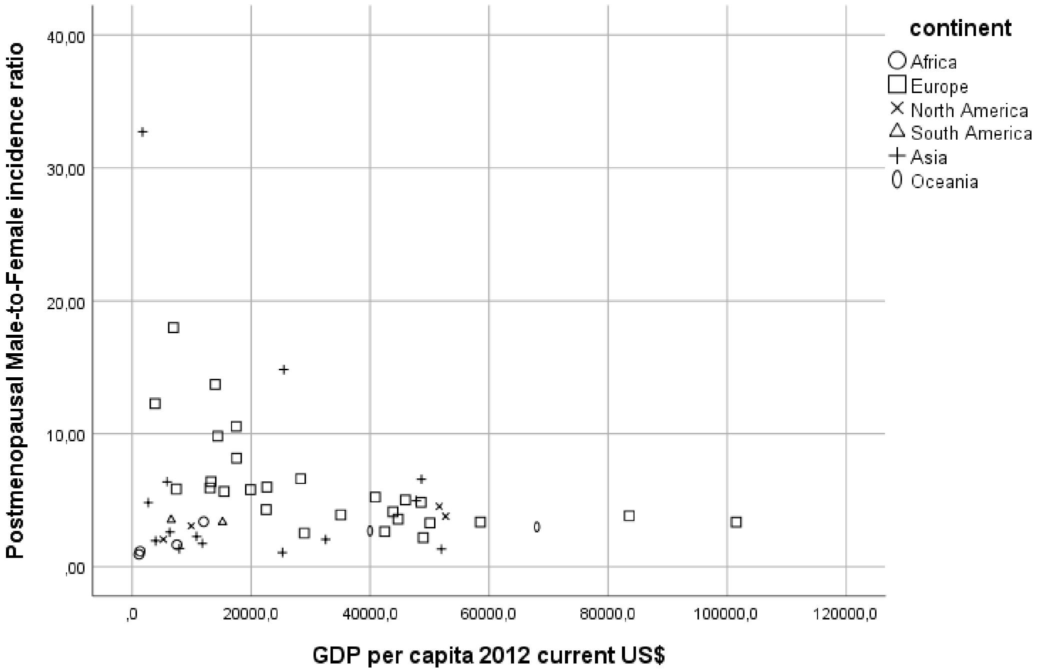


Figure 4. Scatterplot postmenopausal Male-to-Female oesophagus cancer incidence ratio and Gini-index.

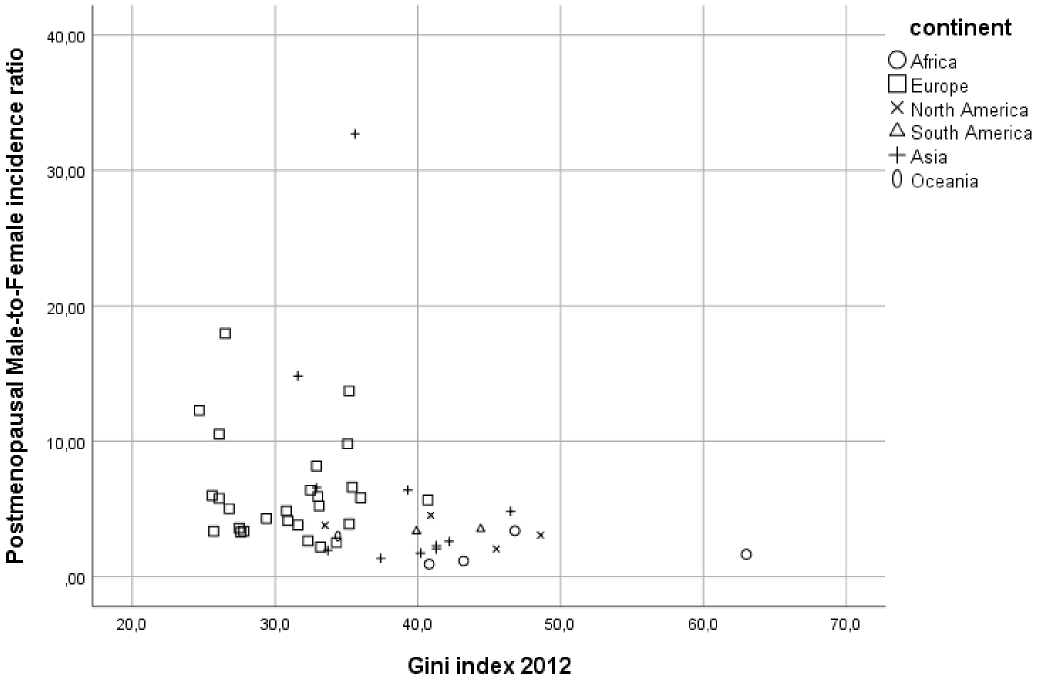


Figure 5. Scatterplot premenopausal Male-to-Female stomach cancer incidence ratio and Gender Inequality Index.

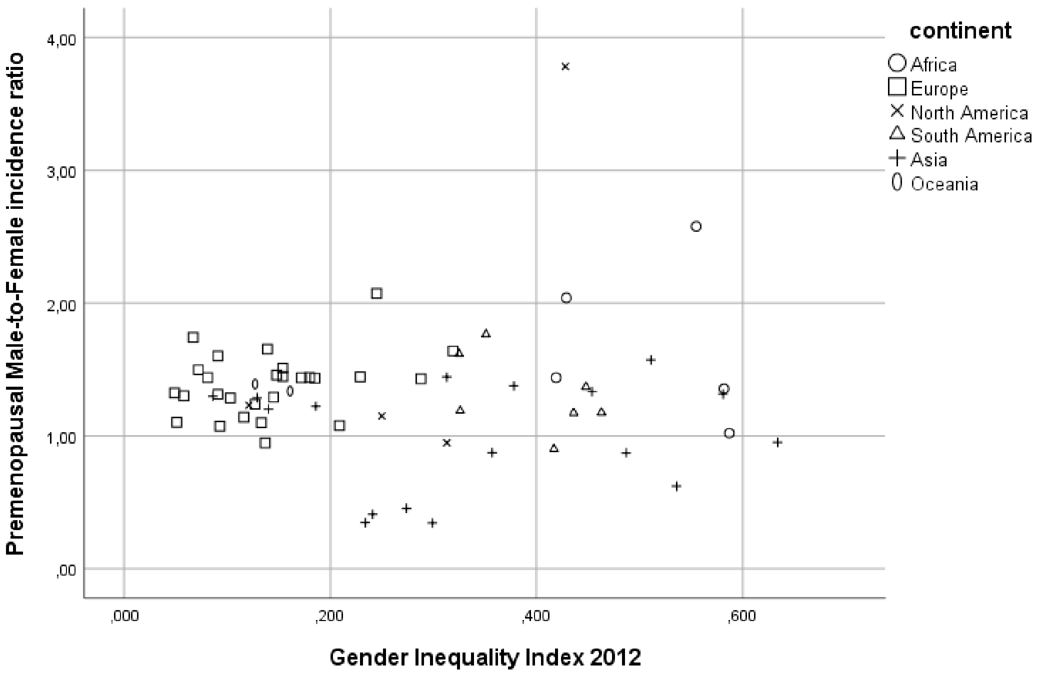


Figure 6. Scatterplot premenopausal Male-to-Female stomach cancer incidence ratio and Human Development Index.

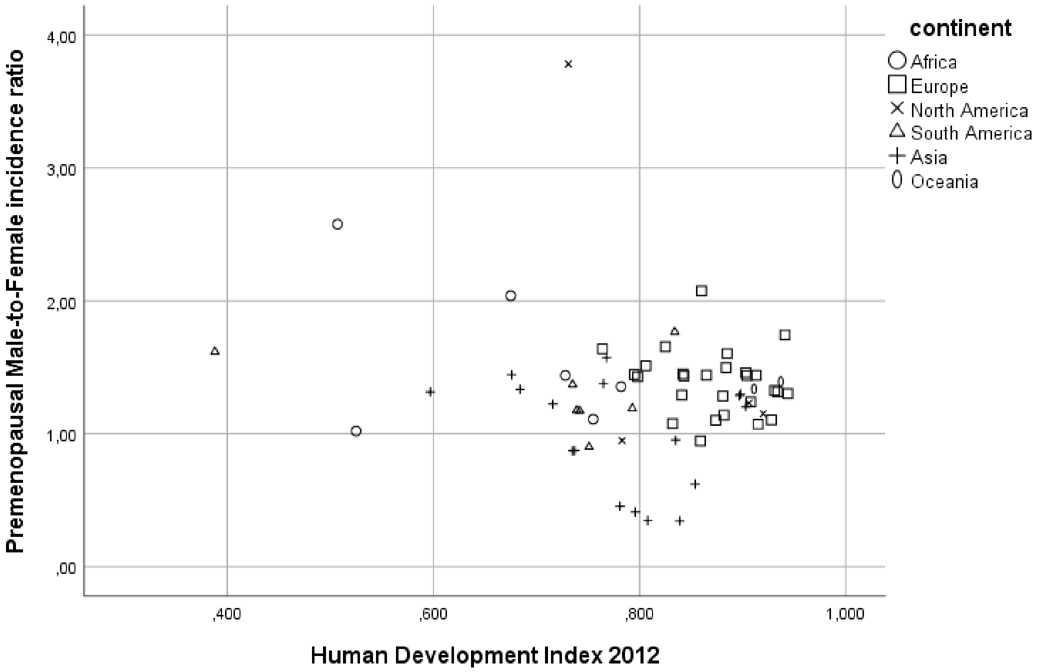


Figure 7. Scatterplot premenopausal Male-to-Female stomach cancer incidence ratio and Gross Domestic Product per capita.

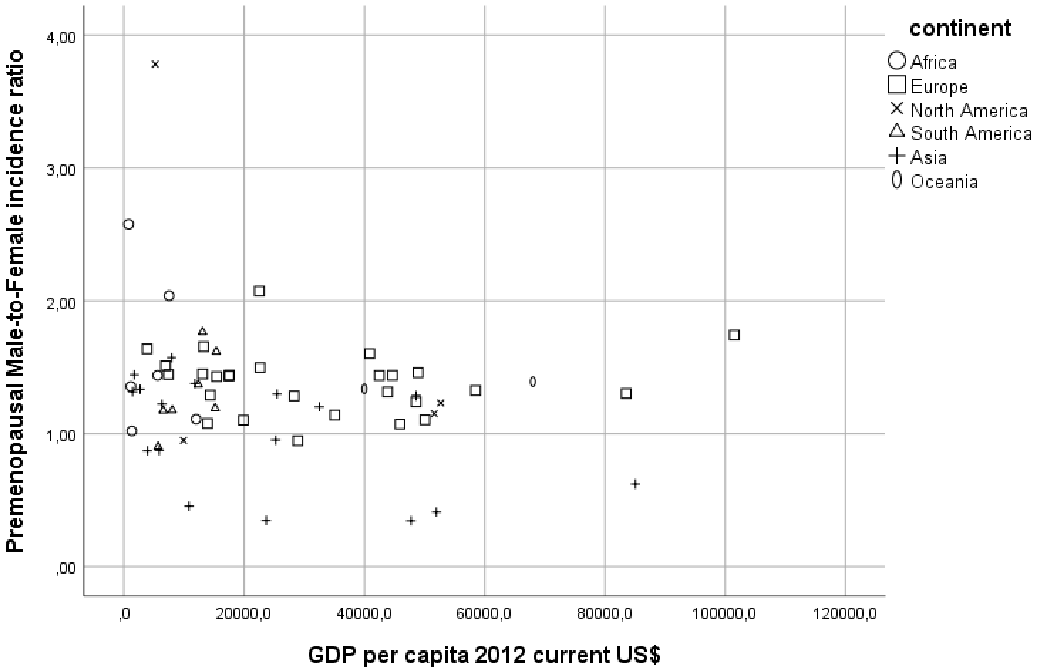


Figure 8. Scatterplot premenopausal Male-to-Female stomach cancer incidence ratio and Gini-index.

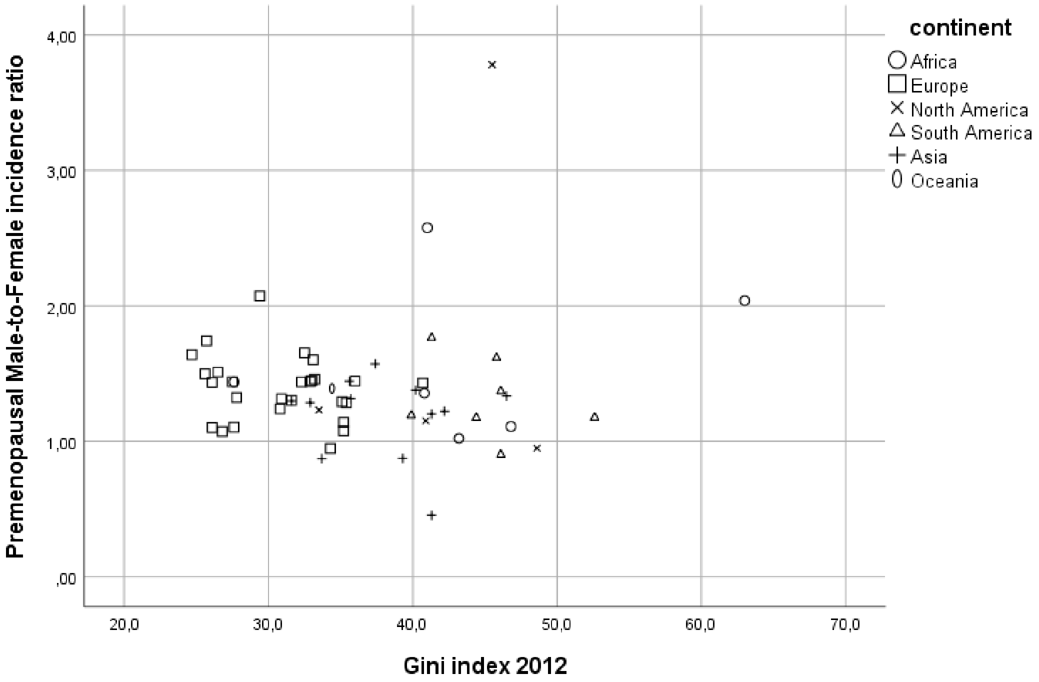


Figure 9. Scatterplot postmenopausal Male-to-Female stomach cancer incidence ratio and Gender Inequality Index.

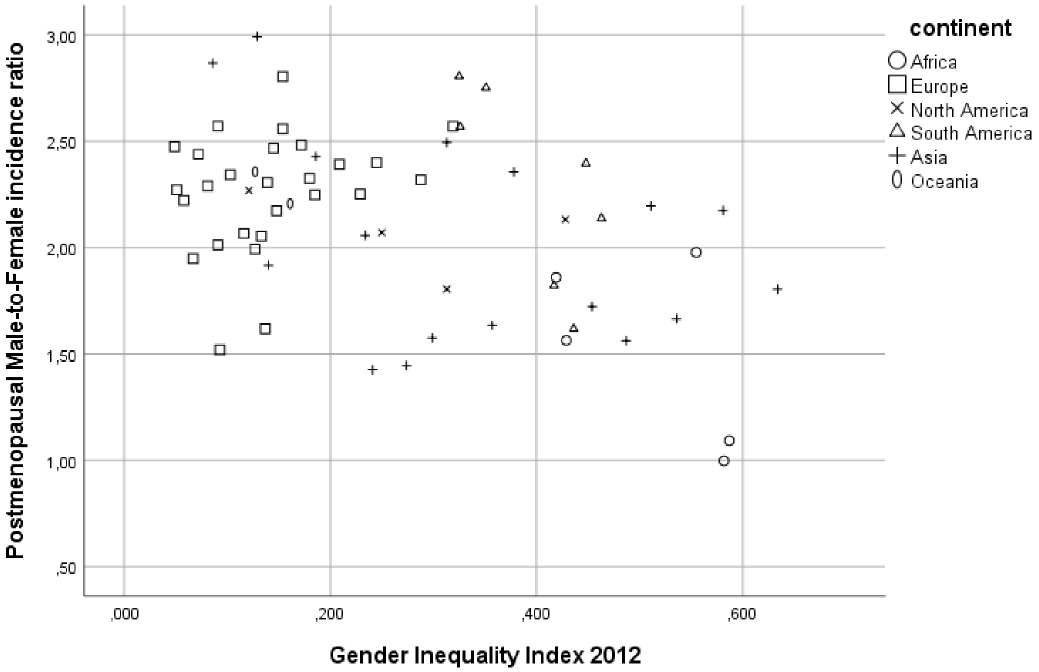


Figure 10. Scatterplot postmenopausal Male-to-Female stomach cancer incidence ratio and Human Development Index.

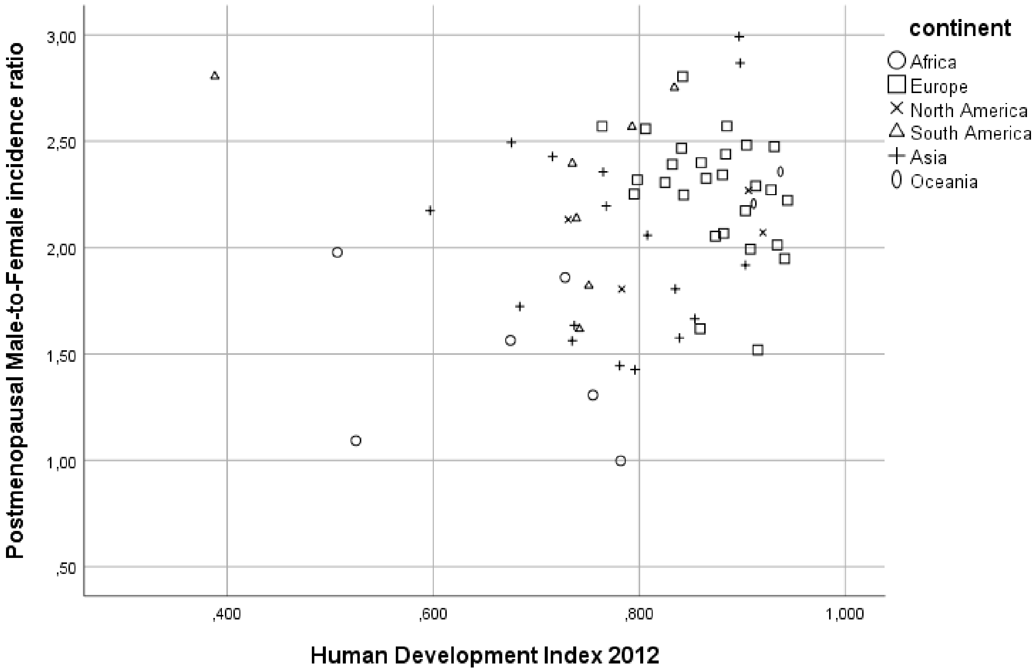


Figure 11. Scatterplot postmenopausal Male-to-Female stomach cancer incidence ratio and Gross Domestic Product per capita.

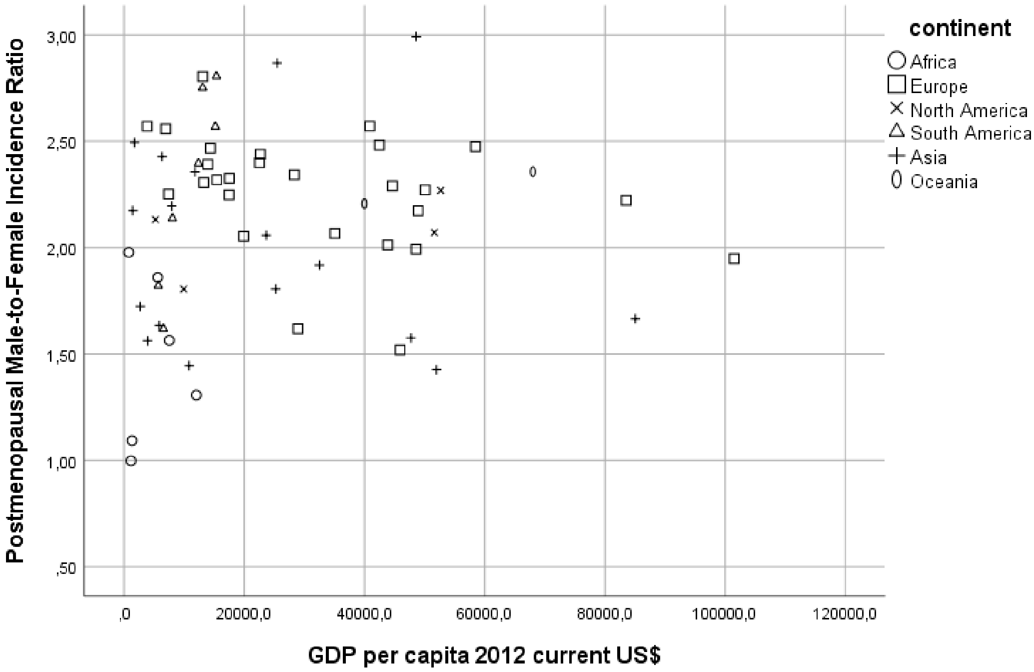


Figure 12. Postmenopausal Male-to-Female stomach cancer incidence ratio and Gini-index.

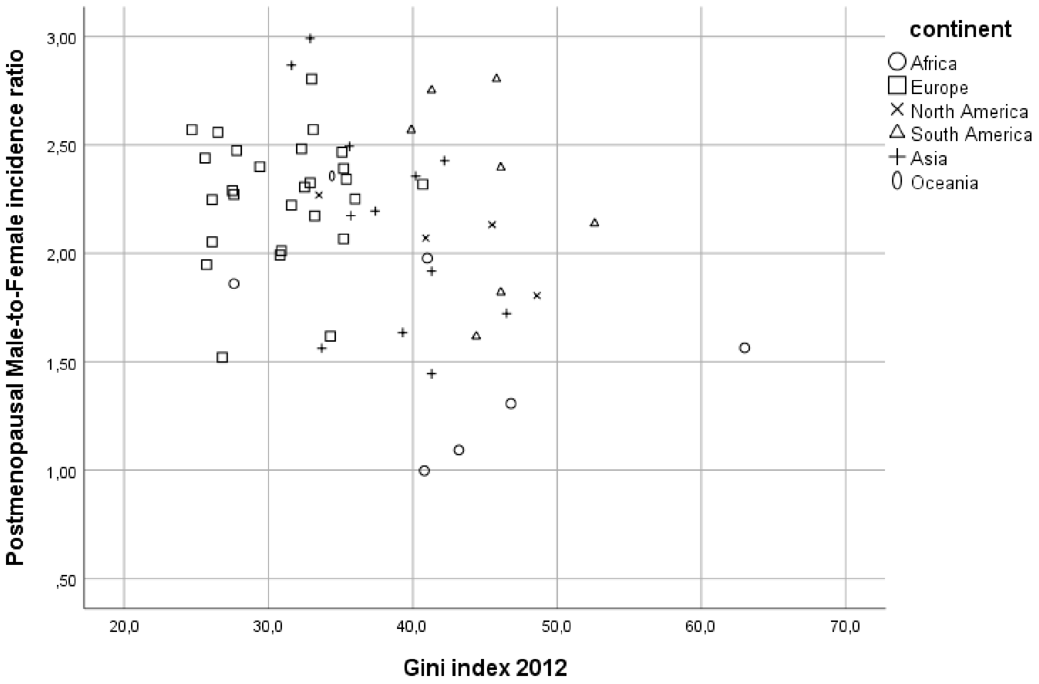


Figure 13. Scatterplot premenopausal Male-to-Female liver cancer incidence ratio and Gender Inequality Index.

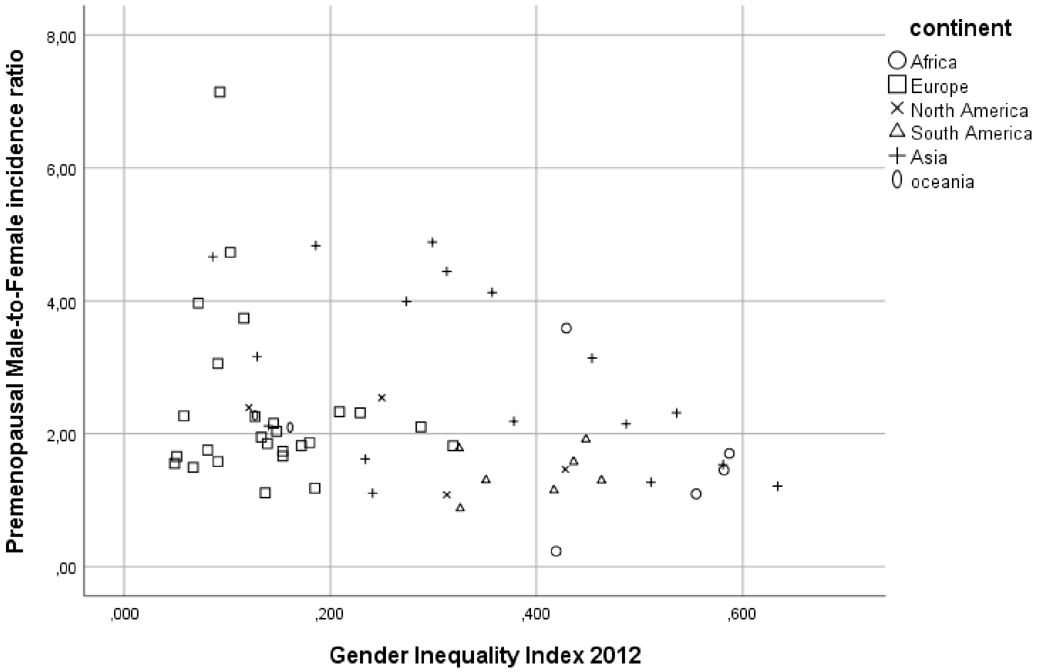


Figure 14. Scatterplot premenopausal Male-to-Female liver cancer incidence ratio and Human Development Index.

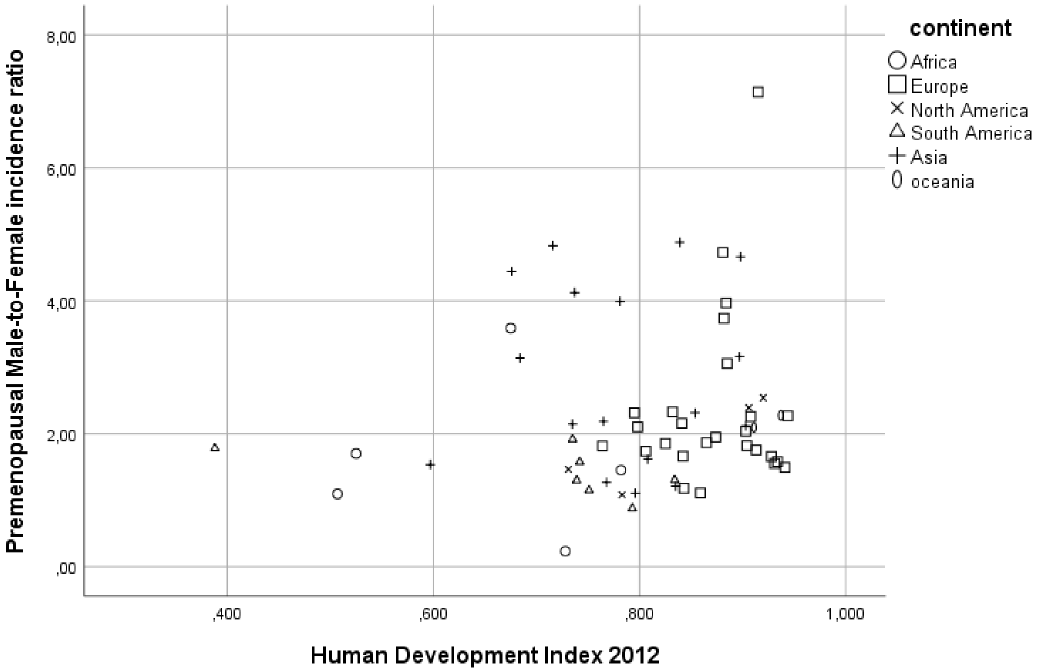


Figure 15. Scatterplot premenopausal Male-to-Female liver cancer incidence ratio and Gross Domestic Product per capita.

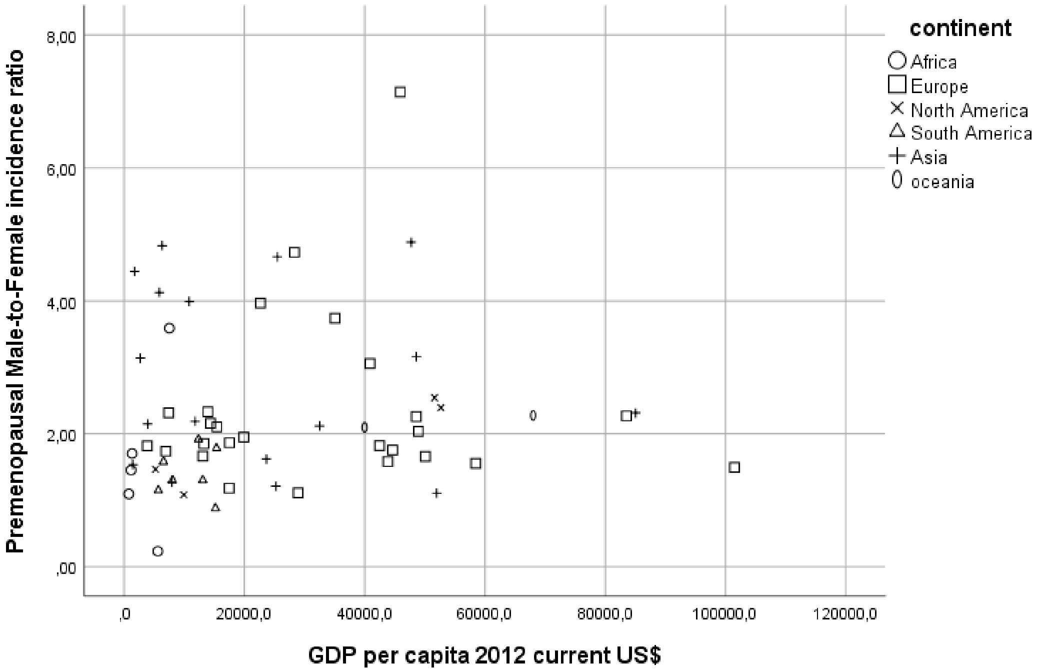


Figure 16. Scatterplot premenopausal Male-to-Female liver cancer incidence ratio and Gini-index.

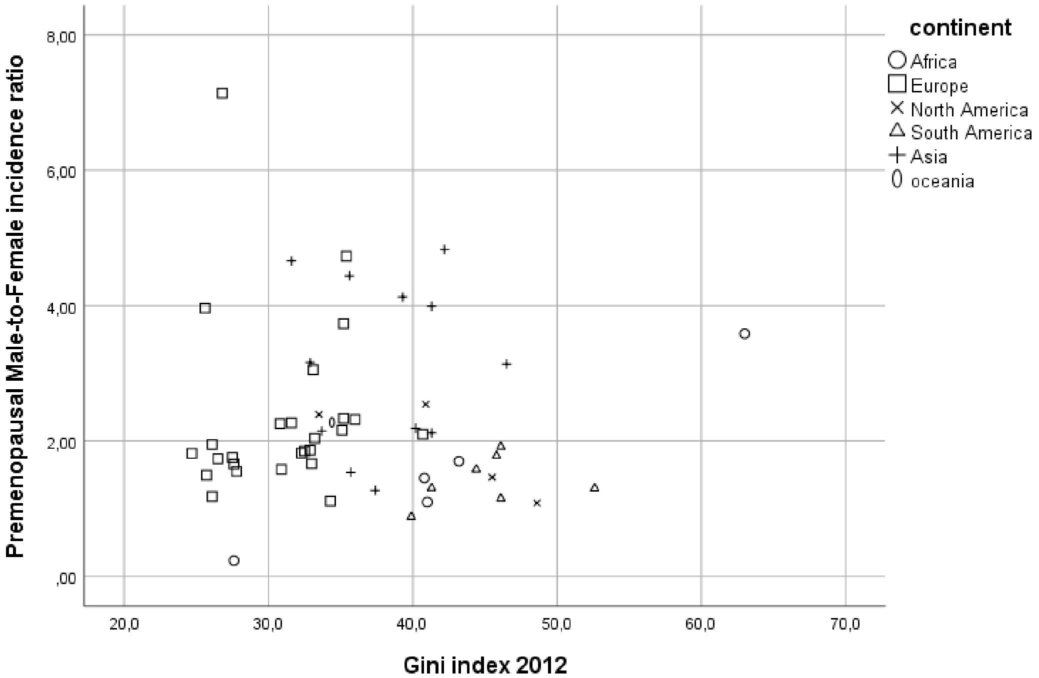


Figure 17. Scatterplot postmenopausal Male-to-Female liver cancer incidence ratio and Gender Inequality Index.

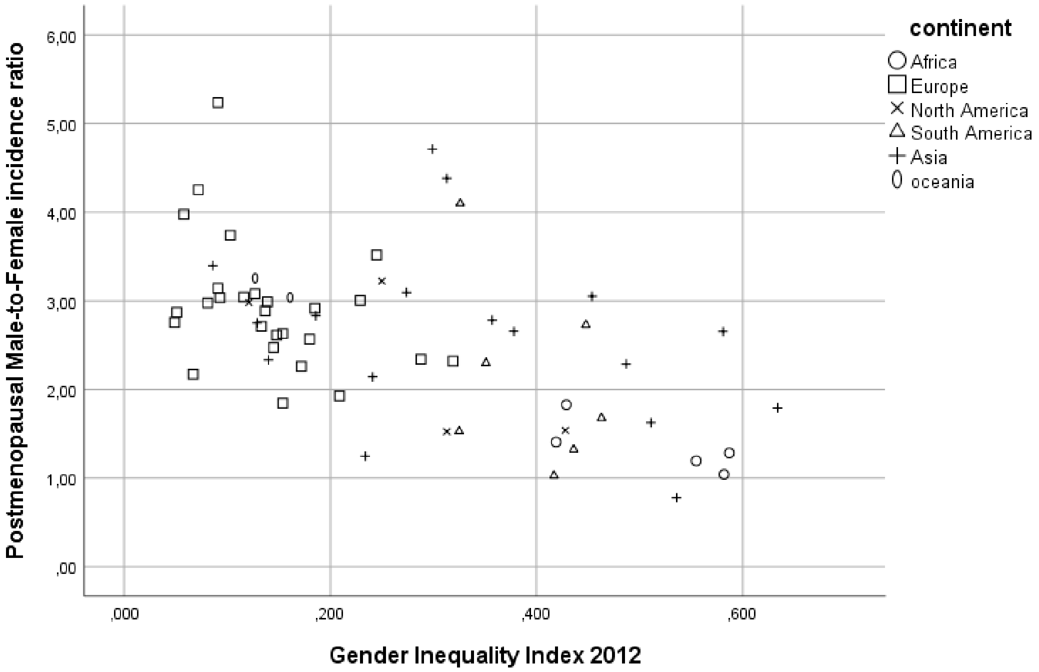


Figure 18. Scatterplot postmenopausal Male-to-Female liver cancer incidence ratio and Human Development Index.

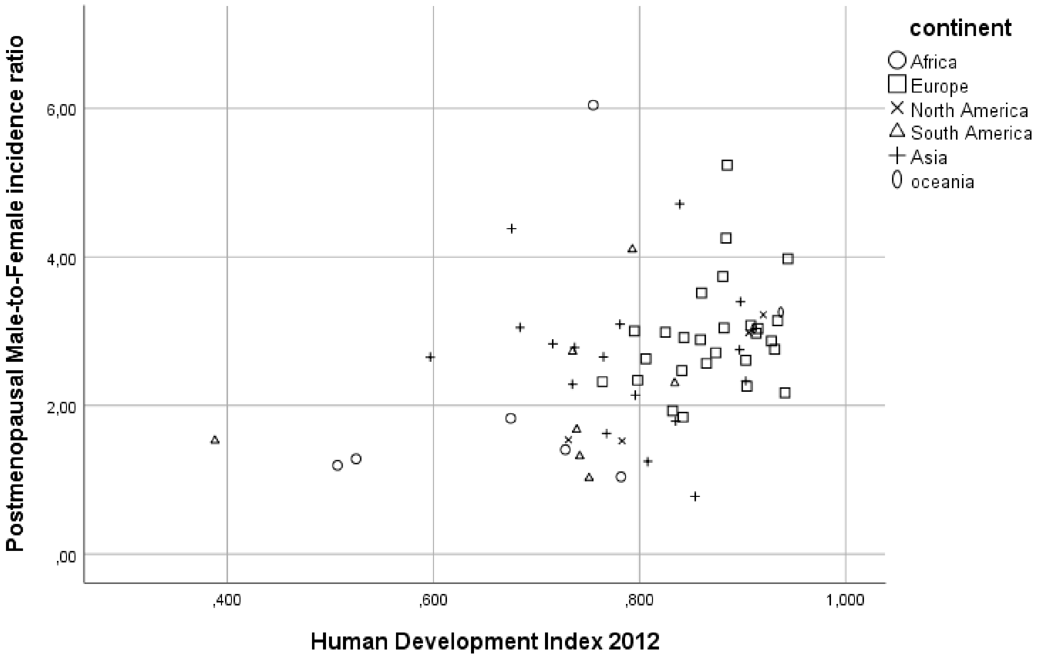


Figure 19. Scatterplot postmenopausal Male-to-Female liver cancer incidence ratios and Gross Domestic Product per capita.

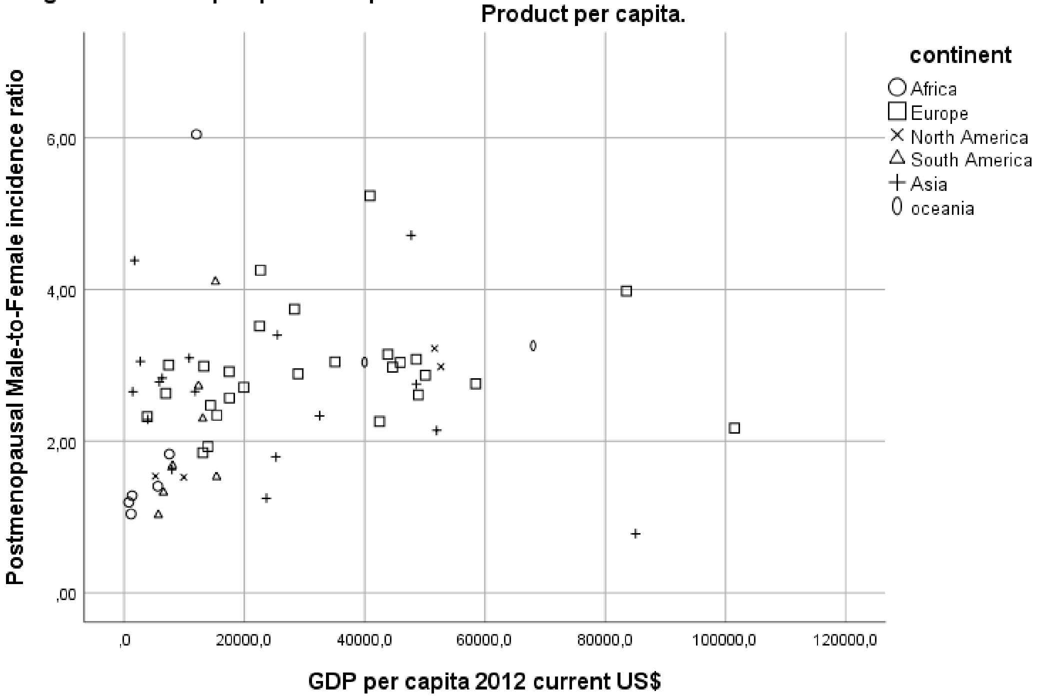


Figure 20. Scatterplot postmenopausal Male-to-Female liver cancer incidence ratios and Gini-index.

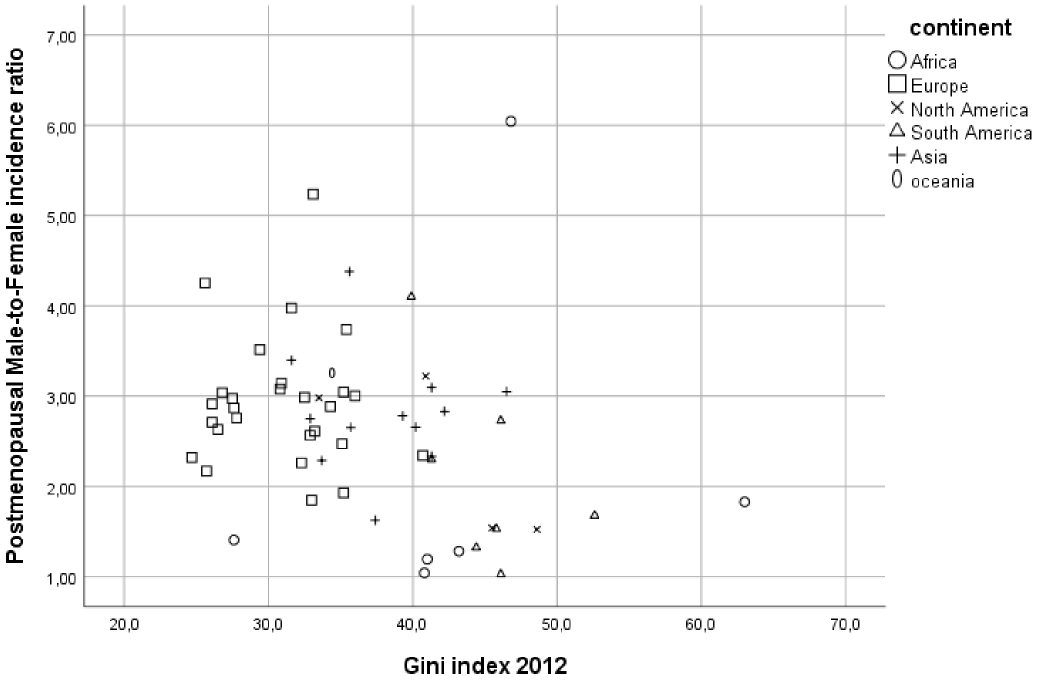


Figure 21. Scatterplot postmenopausal Male-to-Female pancreas cancer incidence ratio and Gender Inequality Index.

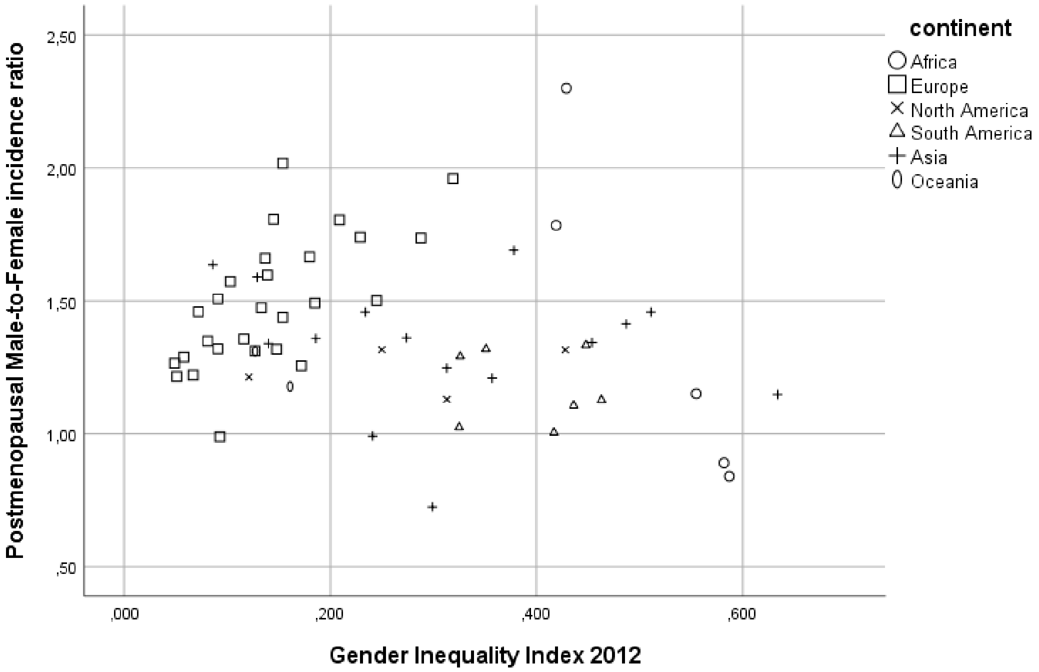


Figure 22. Scatterplot postmenopausal Male-to-Female pancreas cancer incidence ratio and Human Development Index.

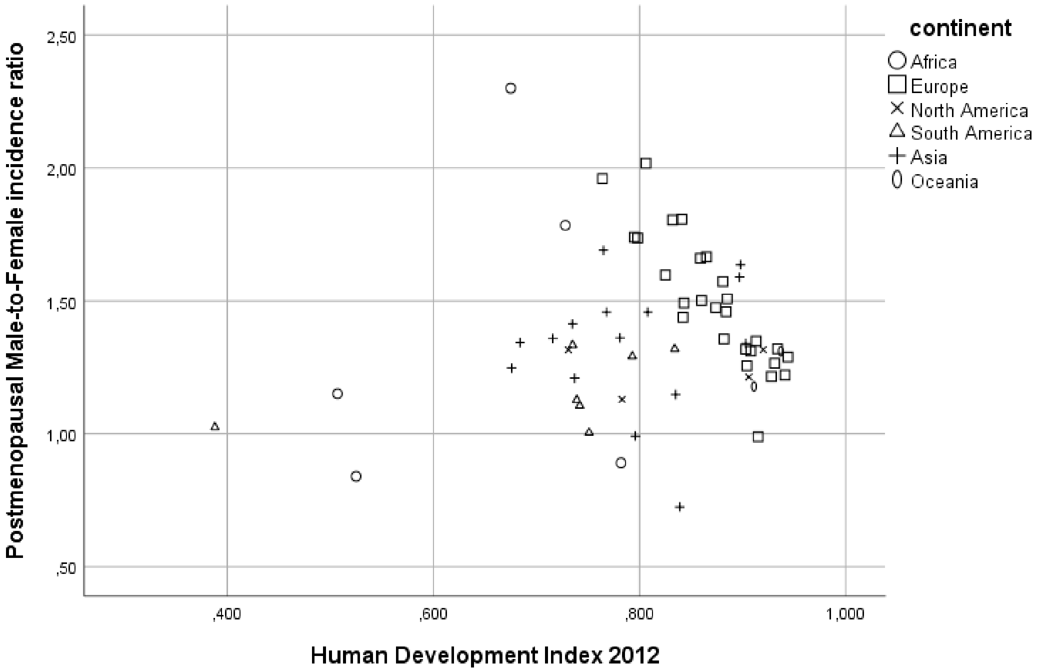


Figure 23. Scatterplot postmenopausal Male-to-Female pancreas cancer incidence ratio and Gross Domestic Product per capita.

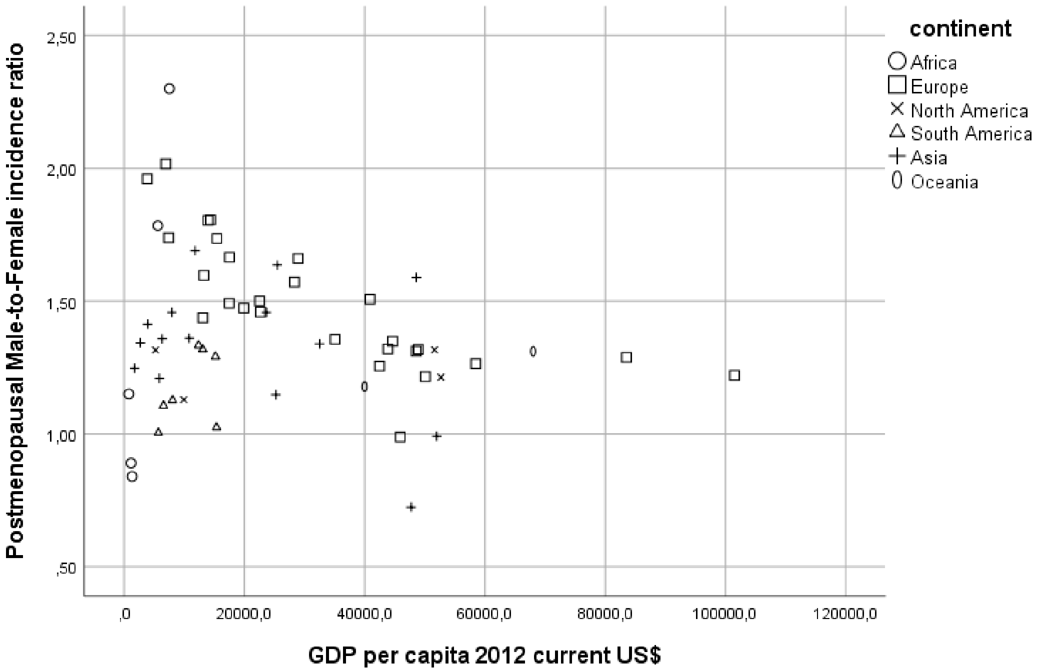


Figure 24. Postmenopausal Male-to-Female pancreas cancer incidence ratio and Gini-index.

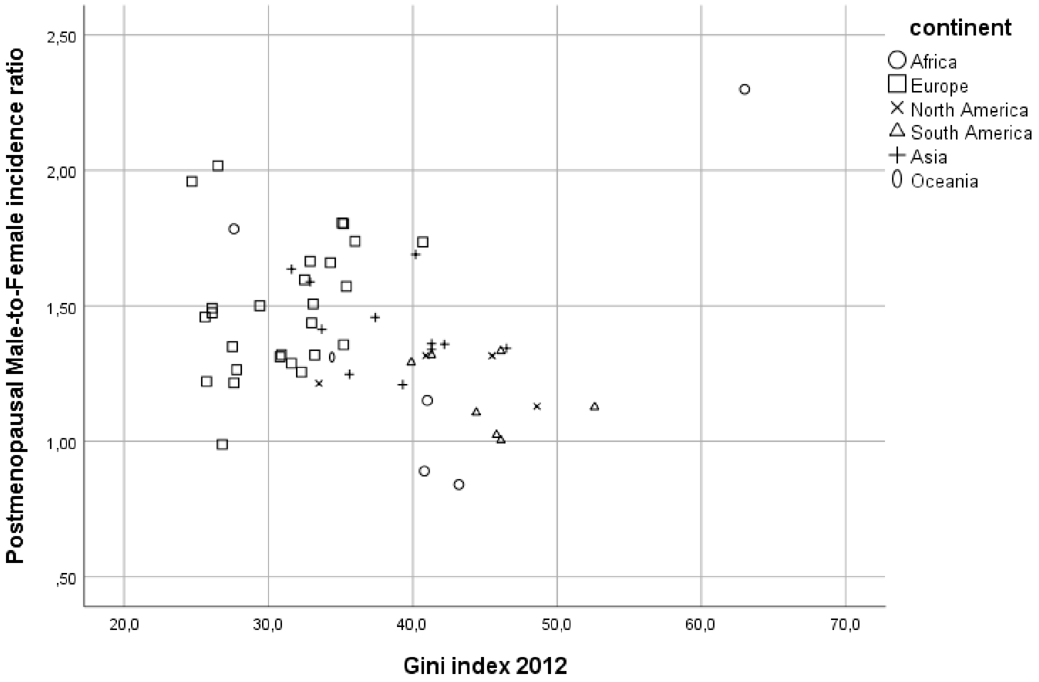


Figure 25. Scatterplot premenopausal Male-to-Female colorectum cancer incidence ratio and Gender Inequality Index.

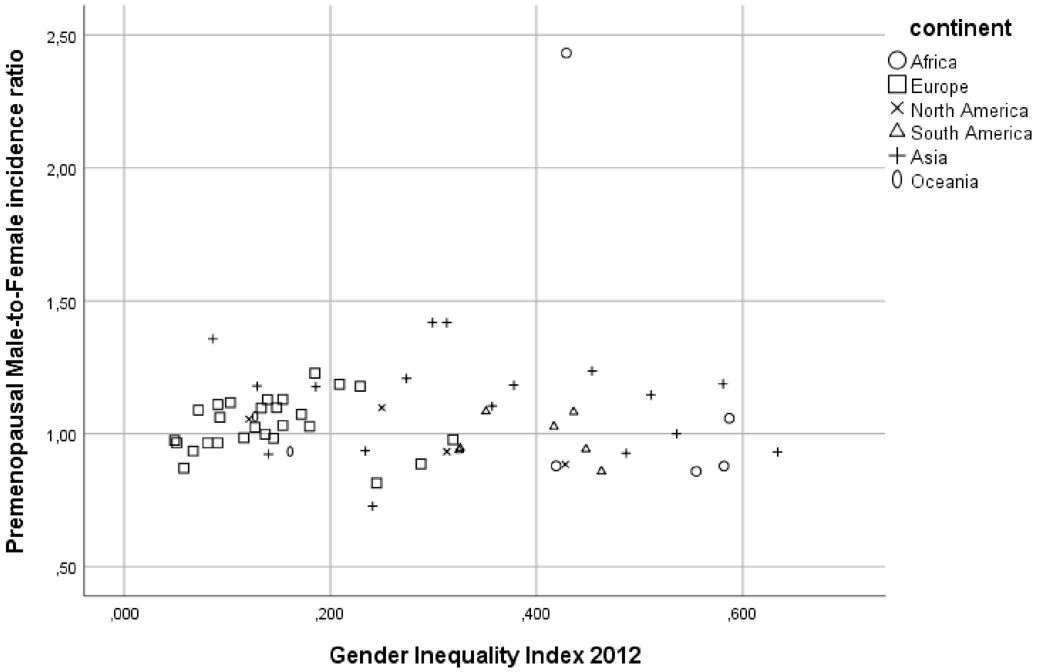


Figure 26. Scatterplot premenopausal Male-to-Female colorectum cancer incidence ratio and Human Development Index.

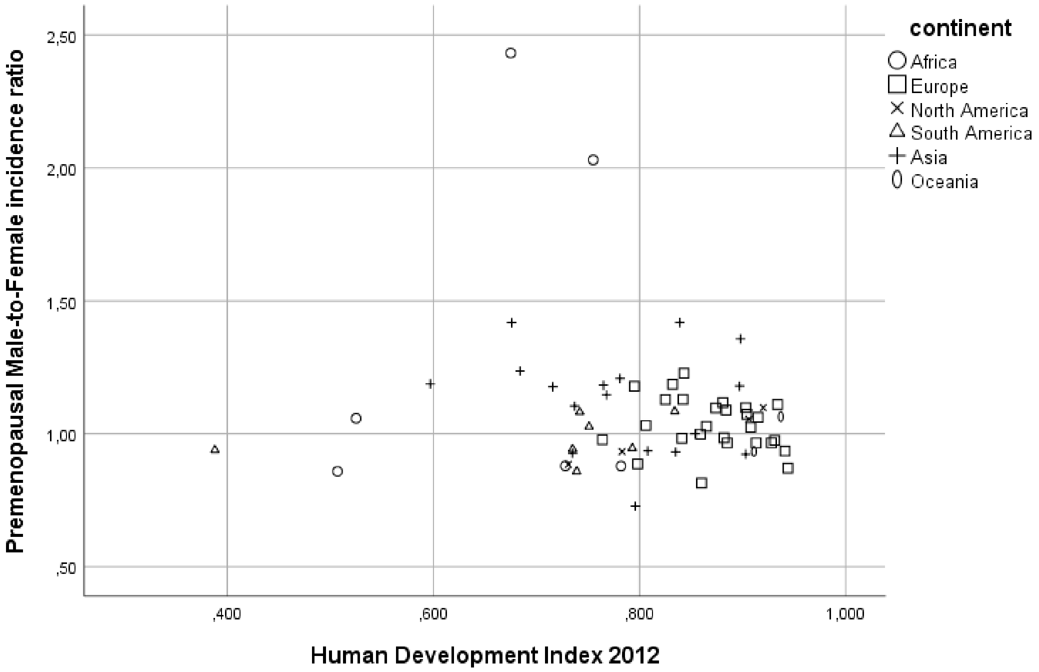


Figure 27. Scatterplot premenopausal Male-to-Female colorectum cancer incidence ratio and Gross Domestic Product per capita.

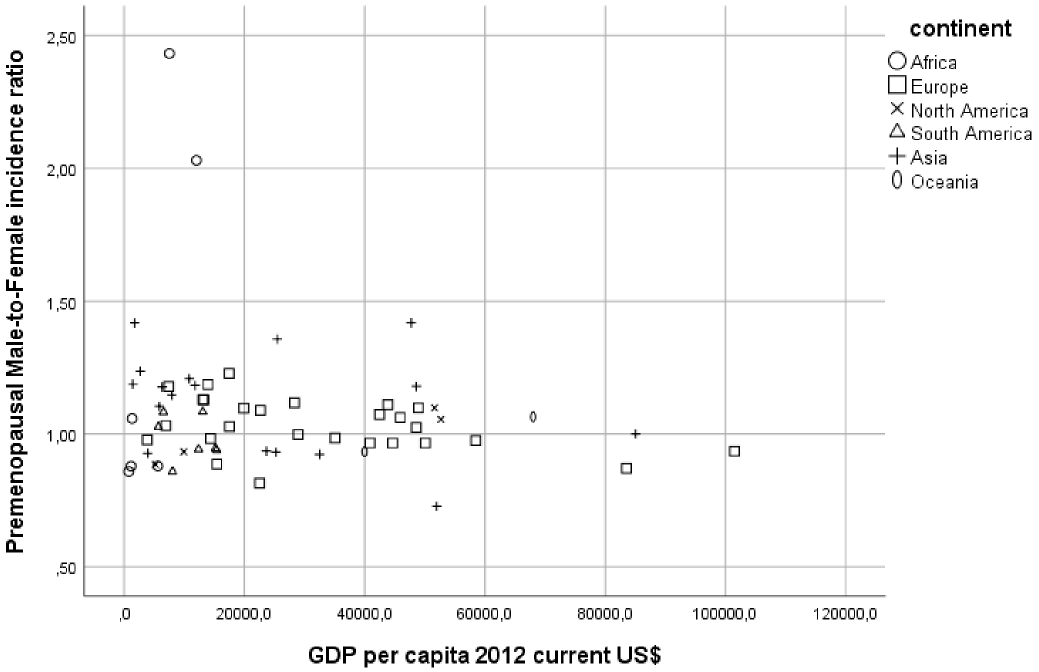


Figure 28. Scatterplot premenopausal Male-to-Female incidence ratio and Gini-index.

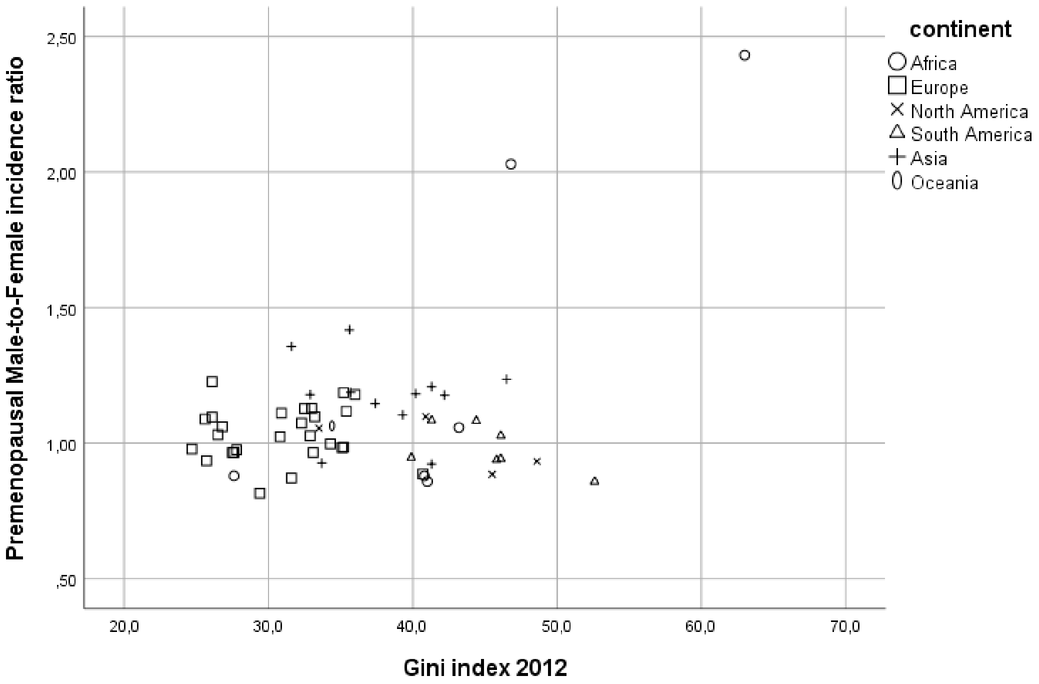


Figure 29. Scatterplot postmenopausal Male-to-Female coloretum cancer incidence ratio and Gender Inequality Index.

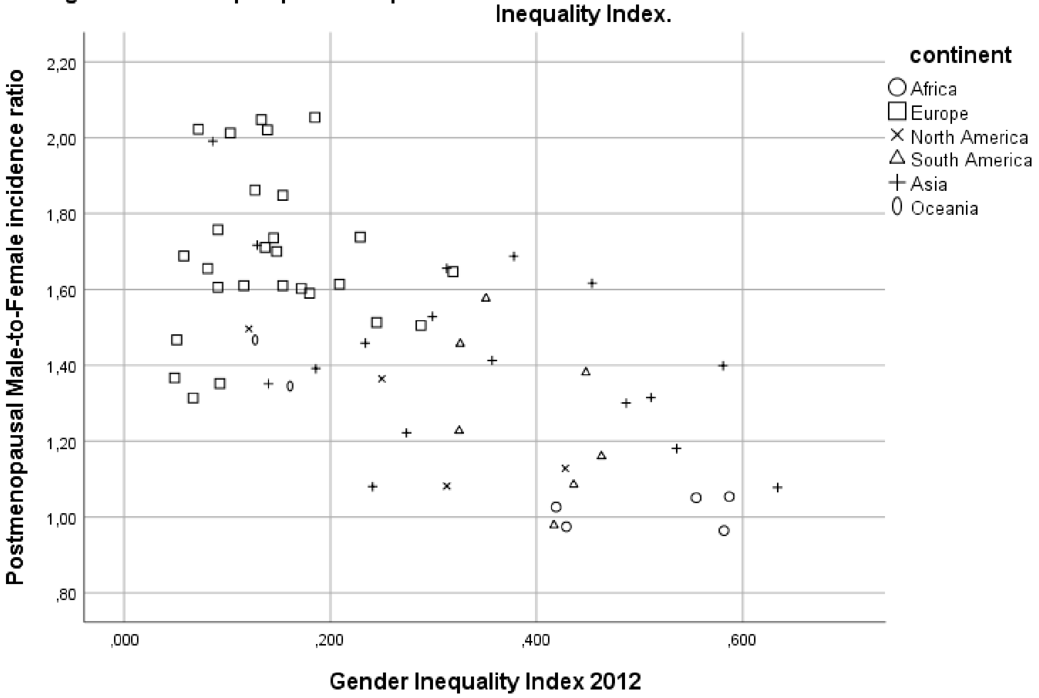


Figure 30. Scatterplot postmenopausal Male-to-Female colorectum cancer incidence ratio and Human Development Index.

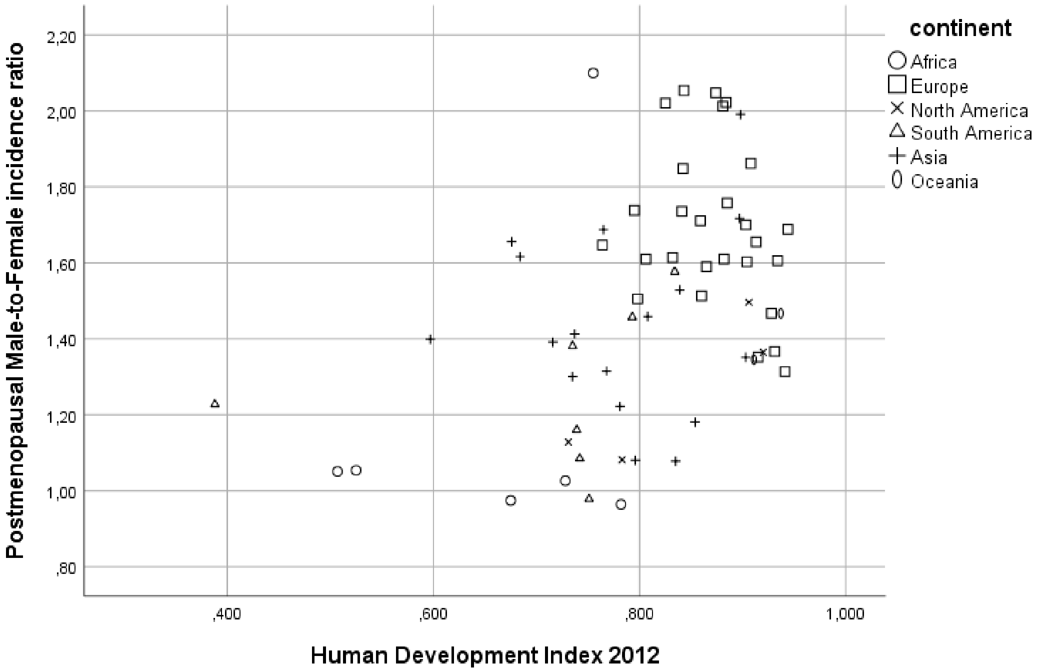


Figure 31. Scatterplot postmenopausal Male-to-Female colorectum cancer incidence ratio and Gross Domestic Product per capita.

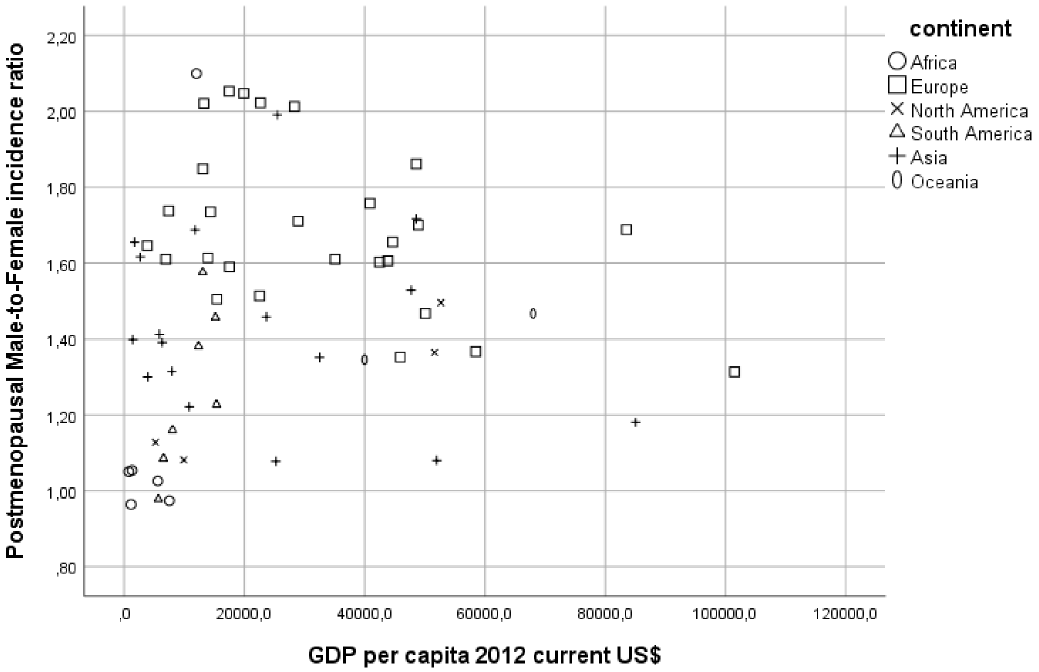


Figure 32. Scatterplot postmenopausal Male-to-Female colorectum cancer incidence ratio and Gini-index.

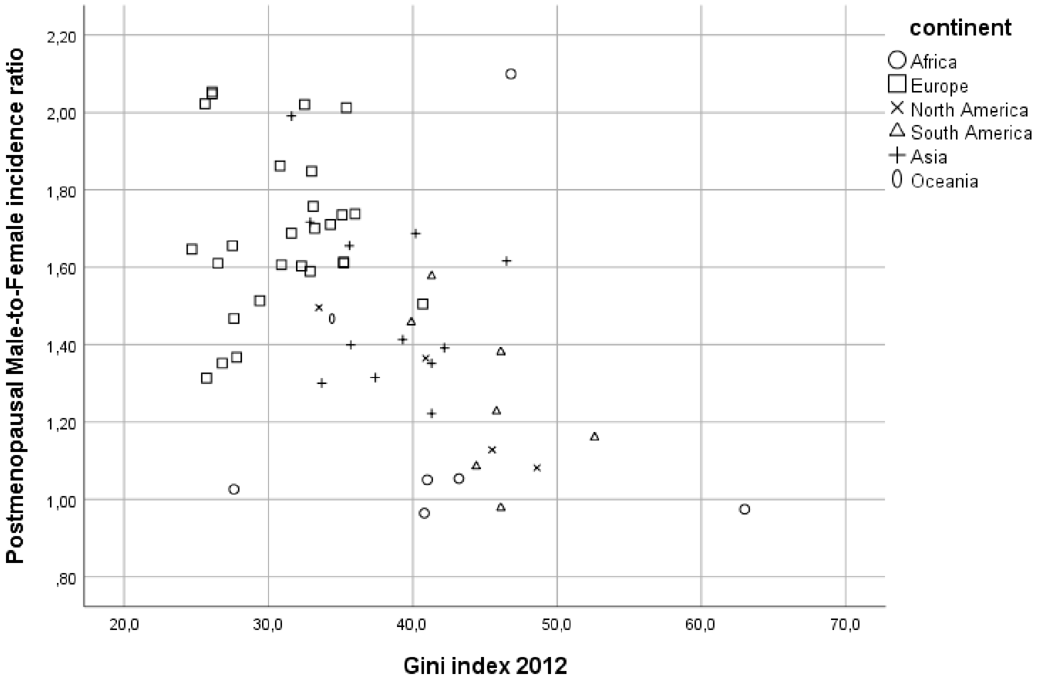


Figure 33. Scatterplot postmenopausal Male-to-Female bladder cancer incidence ratio and Gender Inequality Index.

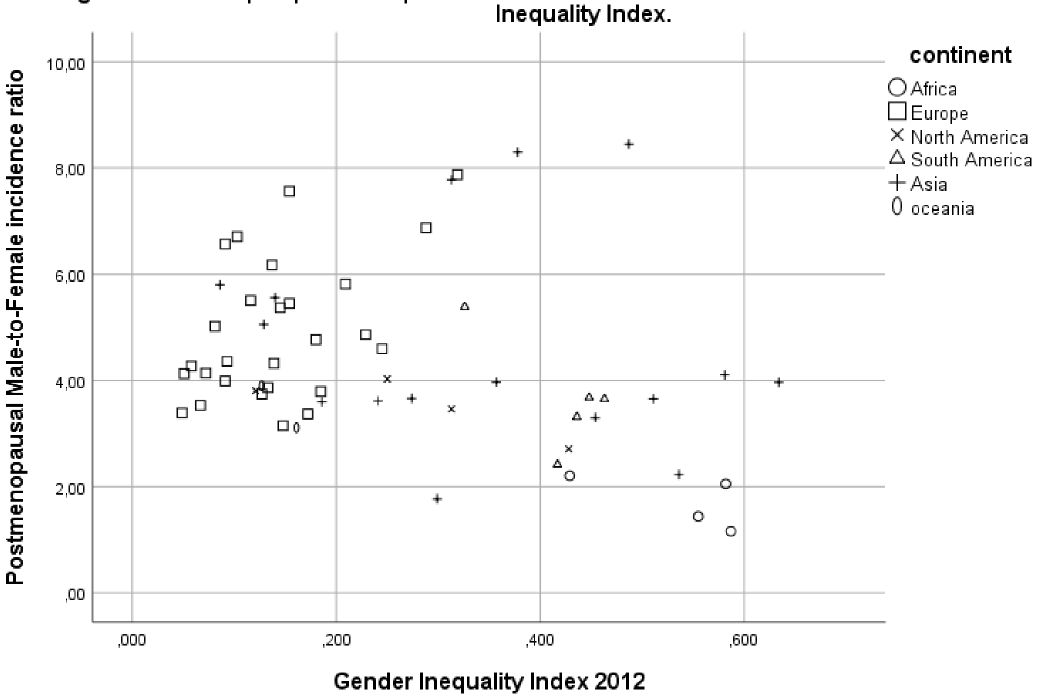


Figure 34. Scatterplot postmenopausal Male-to-Female bladder cancer incidence ratio and Human Development Index.

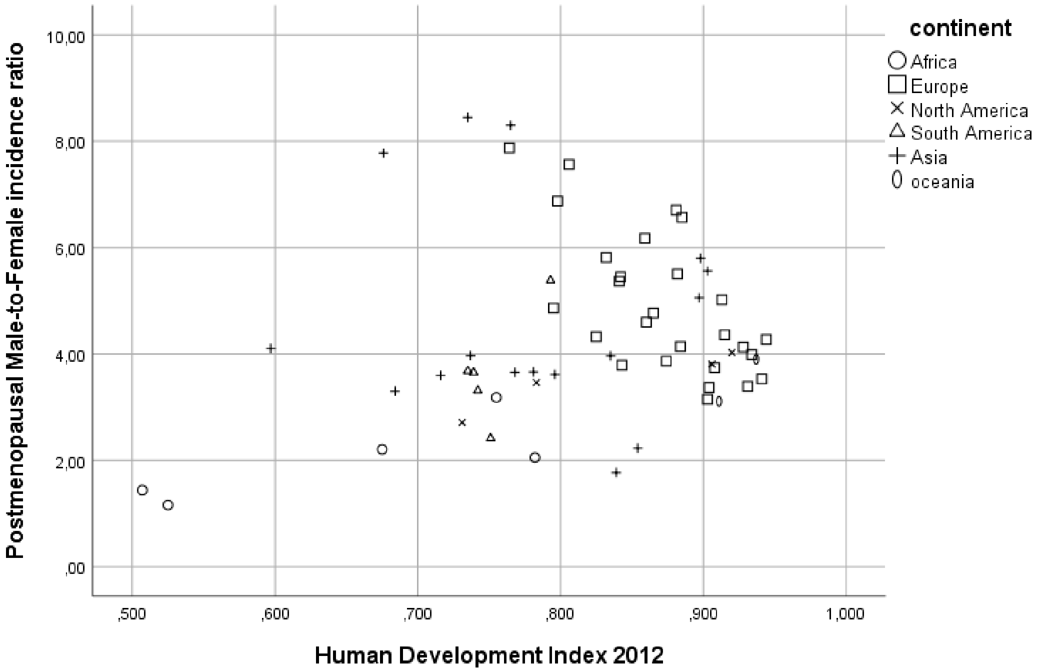


Figure 35. Scatterplot postmenopausal Male-to-Female bladder cancer incidence ratio and Gross Domestic Product per capita.

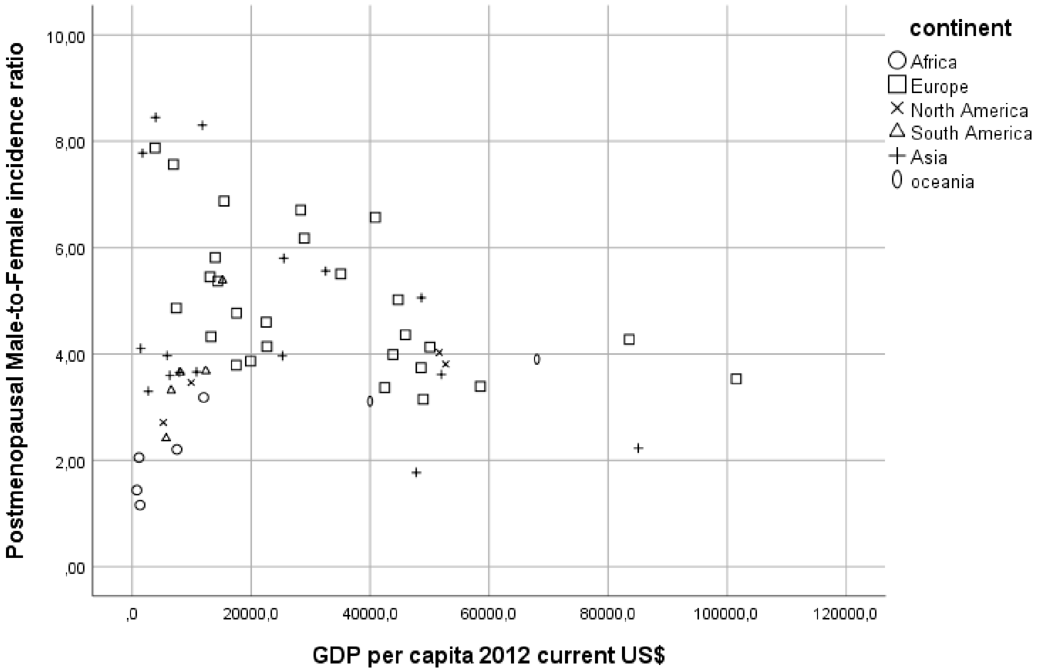


Figure 36. Scatterplot postmenopausal Male-to-Female bladder cancer incidence ratio and Gini-index.

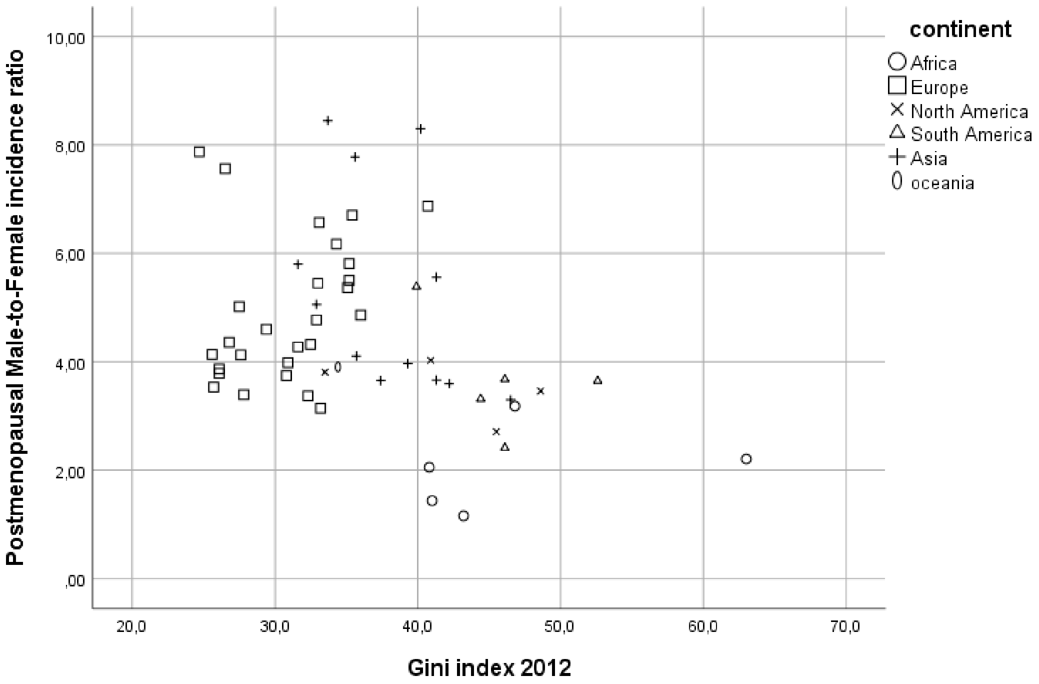


Figure 37. Scatterplot premenopausal Male-to-Female lung cancer incidence ratio and Gender Inequality Index.

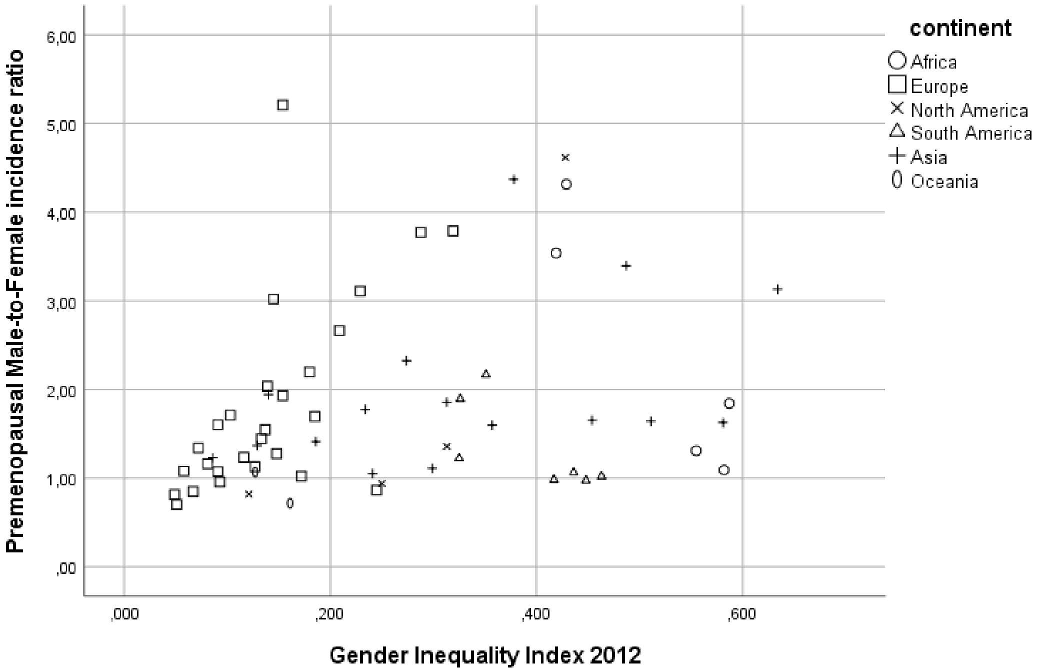


Figure 38. Scatterplot premenopausal Male-to-Female lung cancer incidence ratio and Human Development Index.

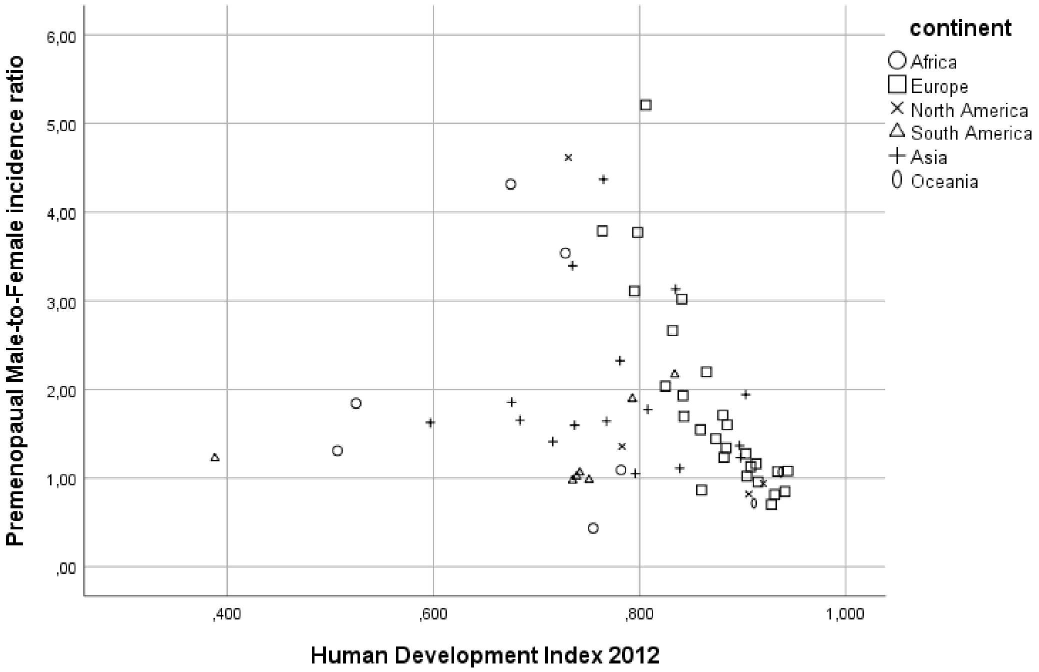


Figure 39. Scatterplot premenopausal Male-to-Female lung cancer incidence ratio and Gross Domestic Product per capita.

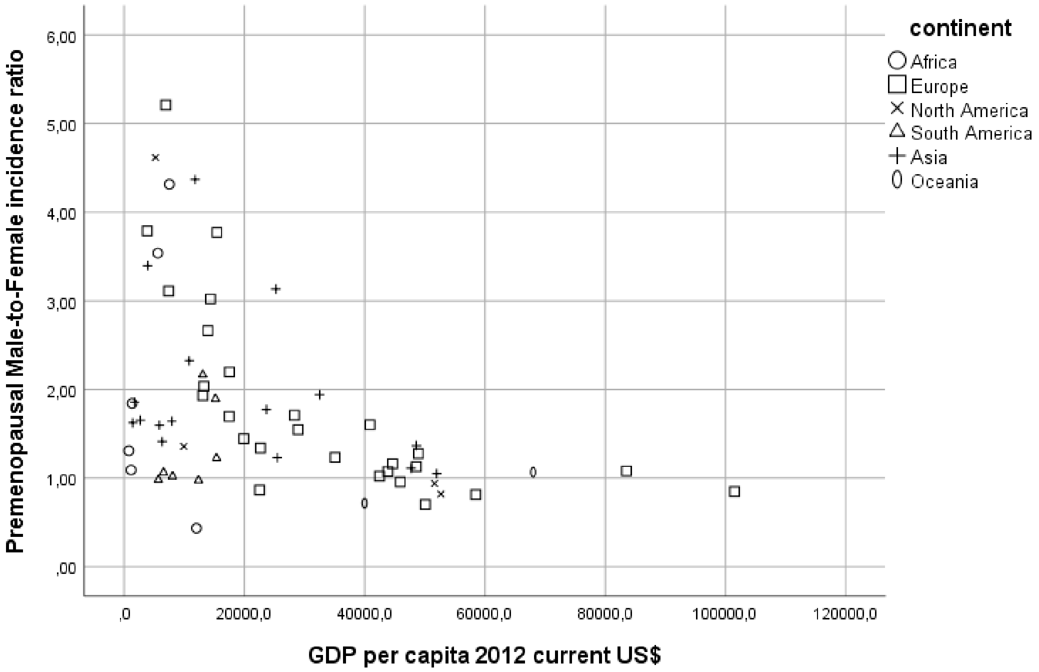


Figure 40. Scatterplot premenopausal Male-to-Female lung cancer incidence ratio and Gini-index.

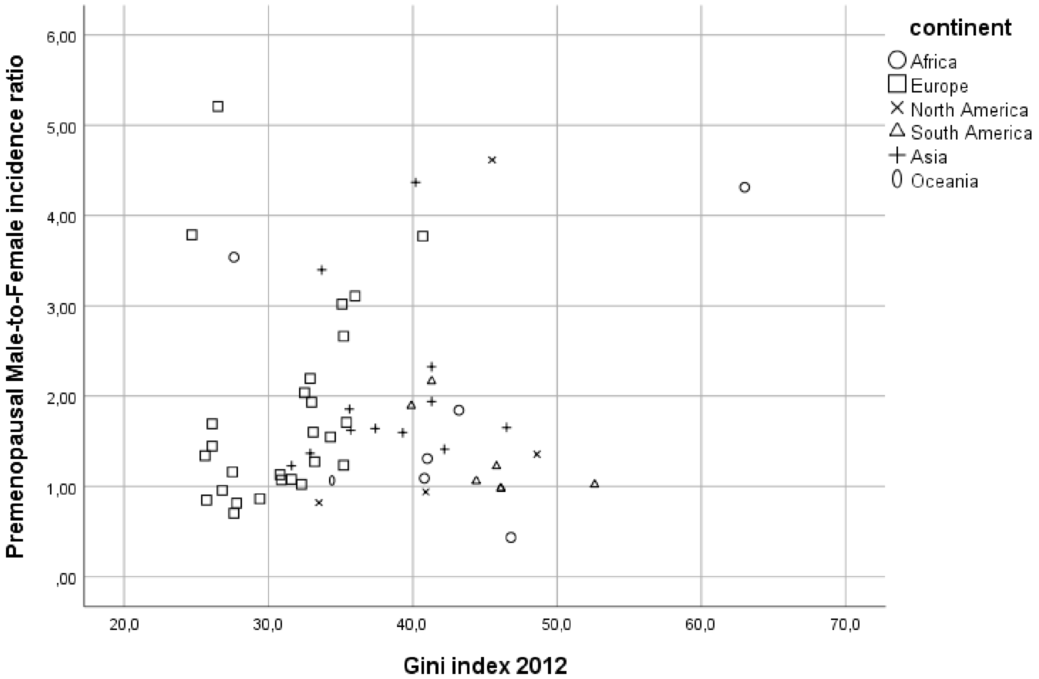


Figure 41. Scatterplot postmenopausal Male-to-Female lung cancer incidence ratio and Gender Inequality Index.

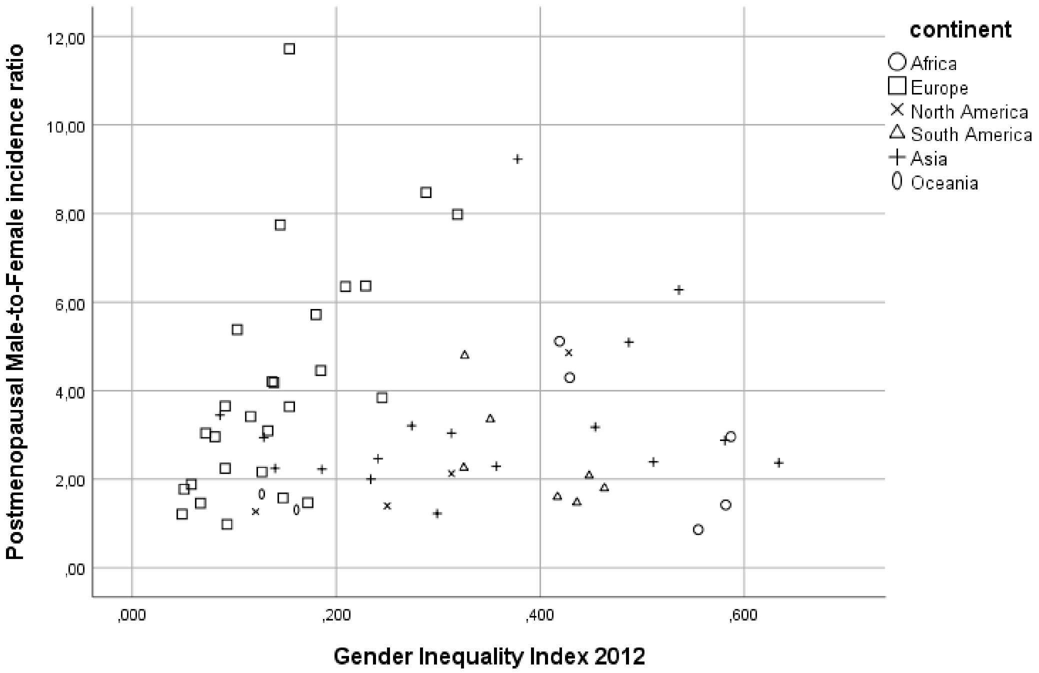


Figure 42. Scatterplot postmenopausal Male-to-Female lung cancer incidence ratio and Human Development Index.

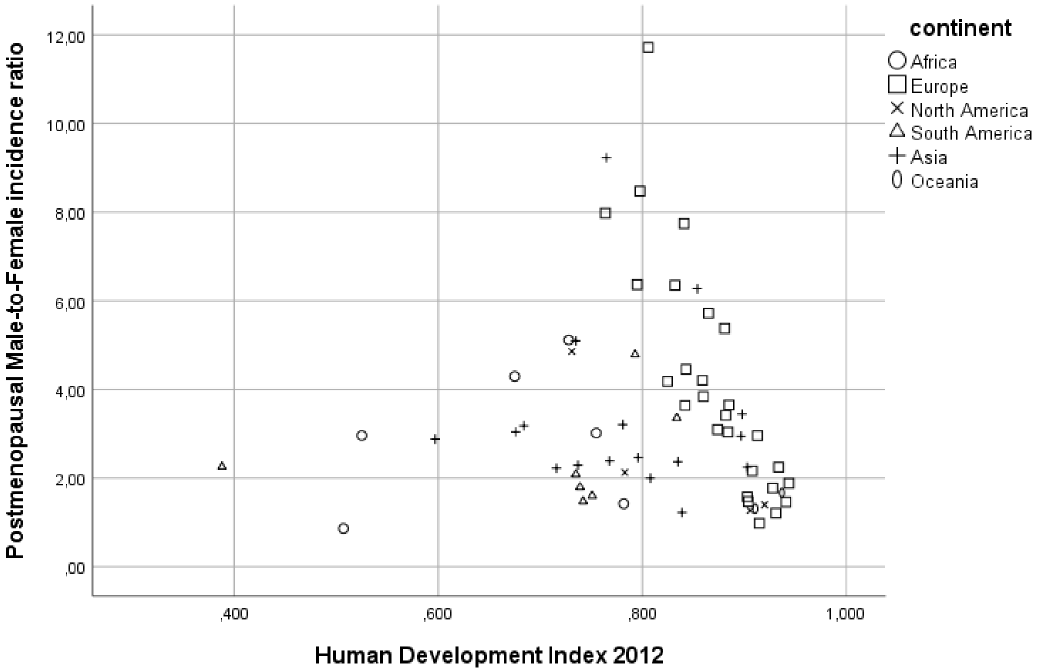


Figure 43. Scatterplot postmenopausal Male-to-Female lung cancer incidence ratio and Gross Domestic Product per capita.

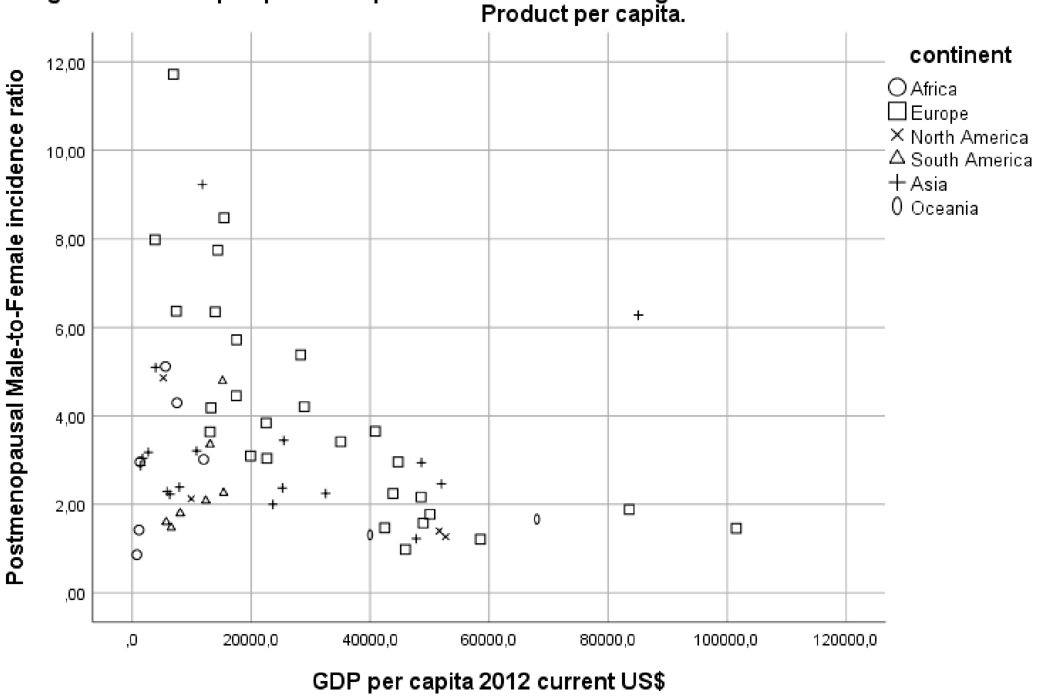
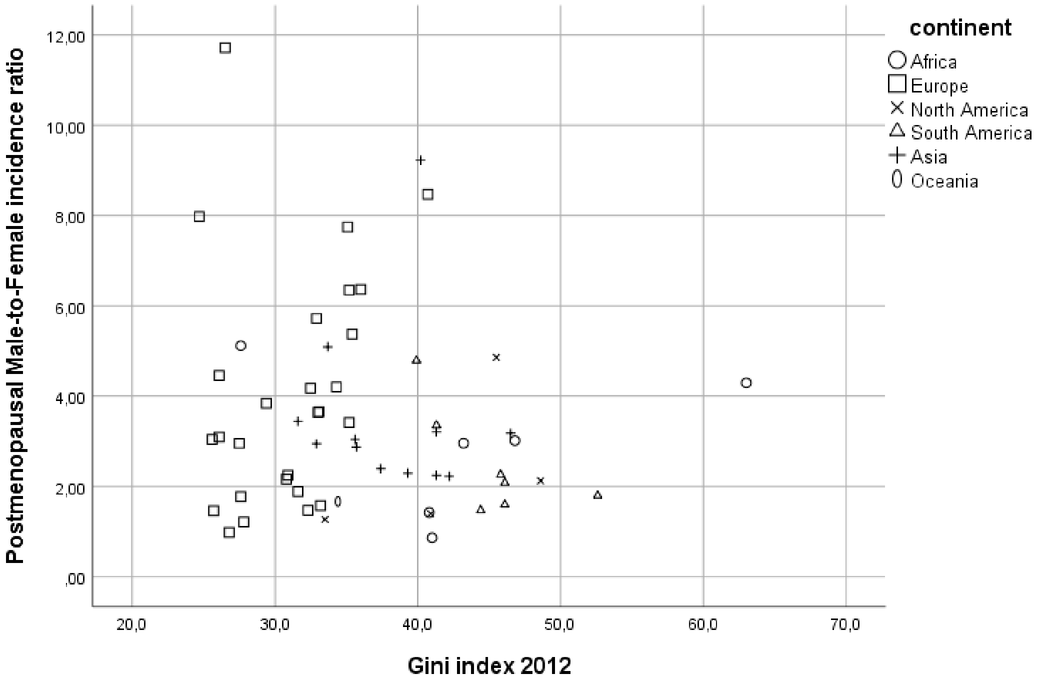


Figure 44. Scatterplot postmenopausal Male-to-Female lung cancer incidence ratio and Gini-index.



Appendix 3. Scatterplots Male-to-Female mortality ratios

Below are the scatterplots showing the Male-to-Female mortality ratios against the socioeconomic variables. The dots are shaped to distinguish continents.

Figure 1. Scatterplot postmenopausal Male-to-Female oesophagus cancer mortality ratio and Gender Inequality Index.

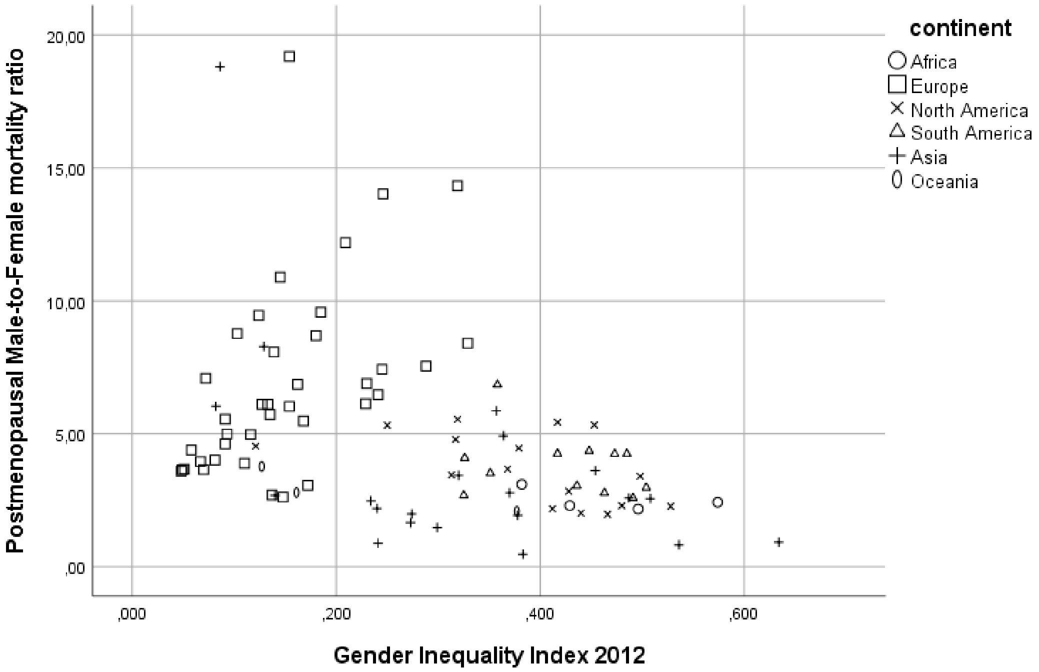


Figure 2. Scatterplot postmenopausal Male-to-Female oesophagus cancer mortality ratio and Human Development Index.

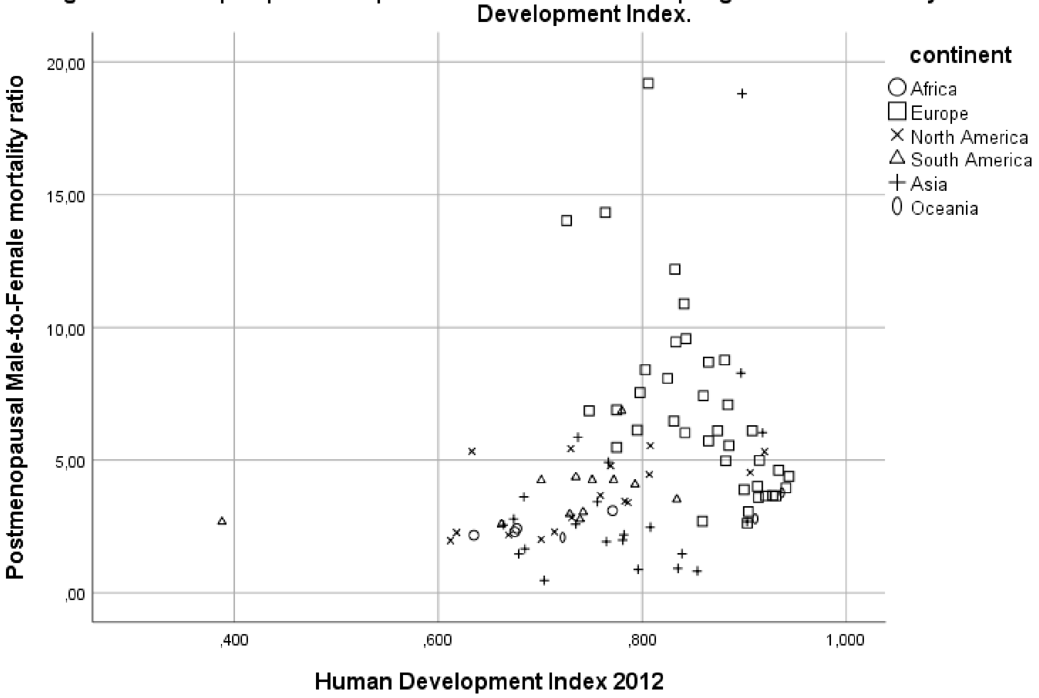


Figure 3. Scatterplot postmenopausal Male-to-Female oesophagus cancer mortality ratio and Gross Domestic Product per capita.

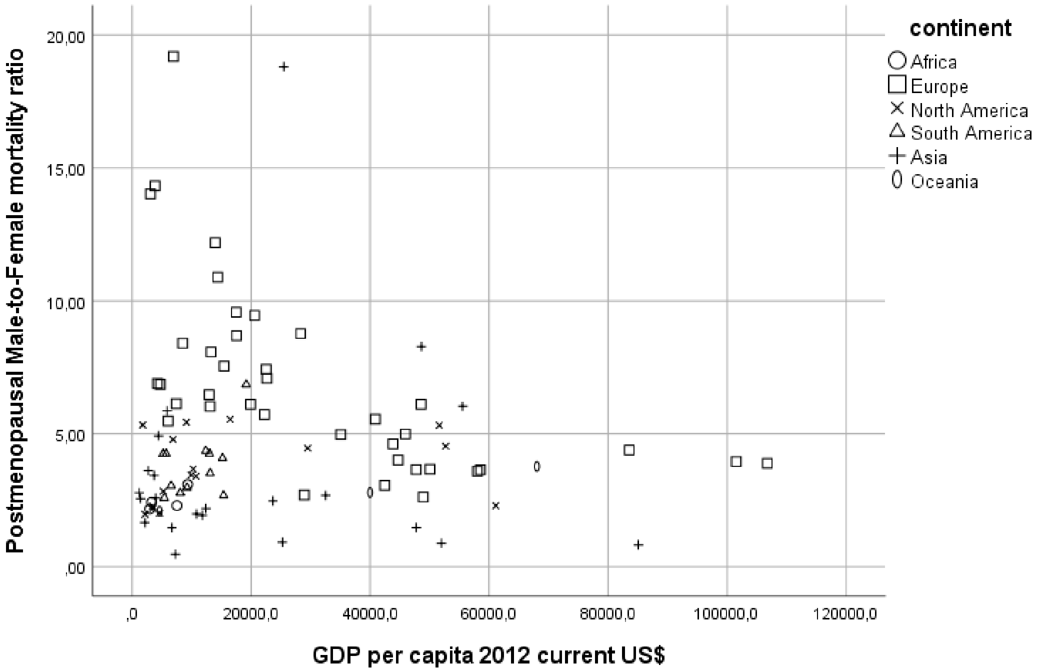


Figure 4. Scatterplot postmenopausal Male-to-Female oesophagus cancer mortality ratio and Gini-index.

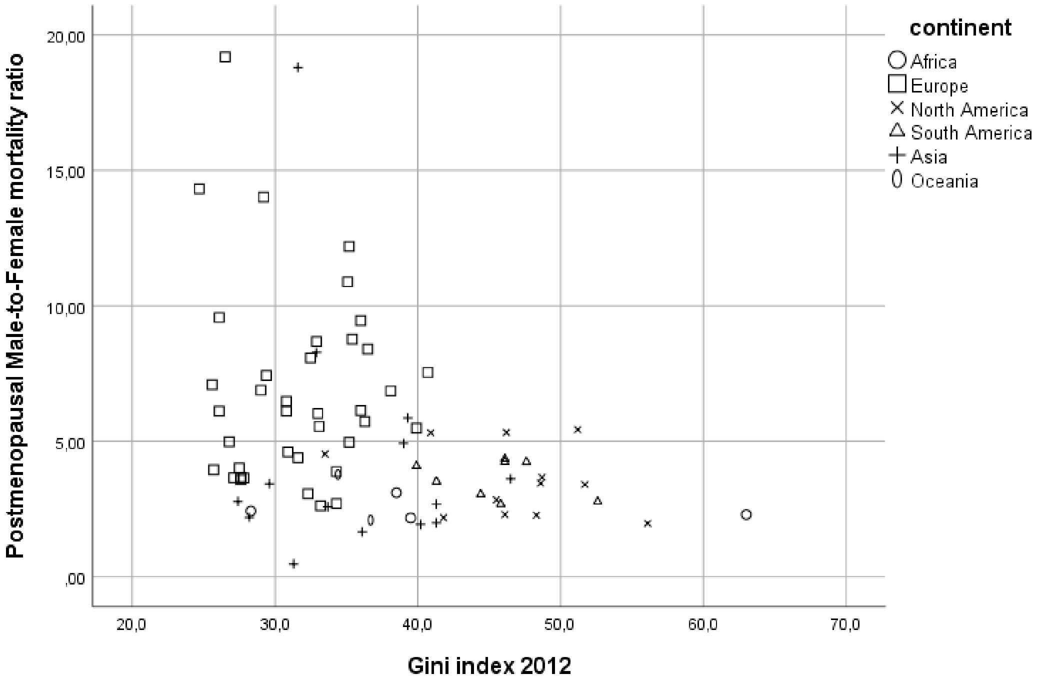


Figure 5. Scatterplot premenopausal Male-to-Female stomach cancer mortality ratio and Gender Inequality Index.

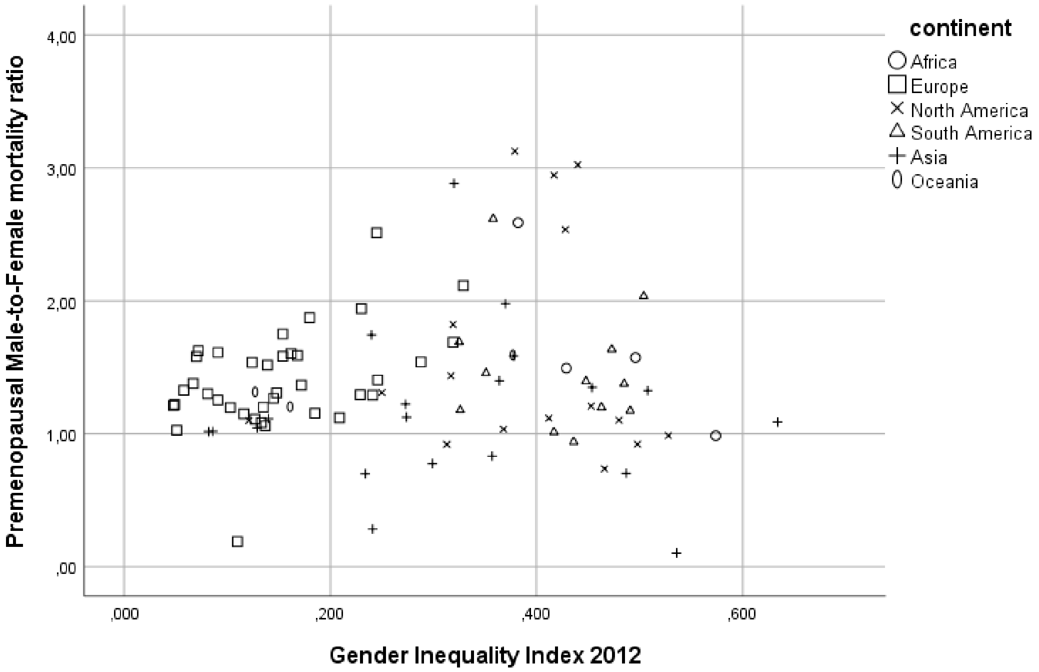


Figure 6. Scatterplot premenopausal Male-to-Female stomach cancer mortality ratio and Human Development Index.

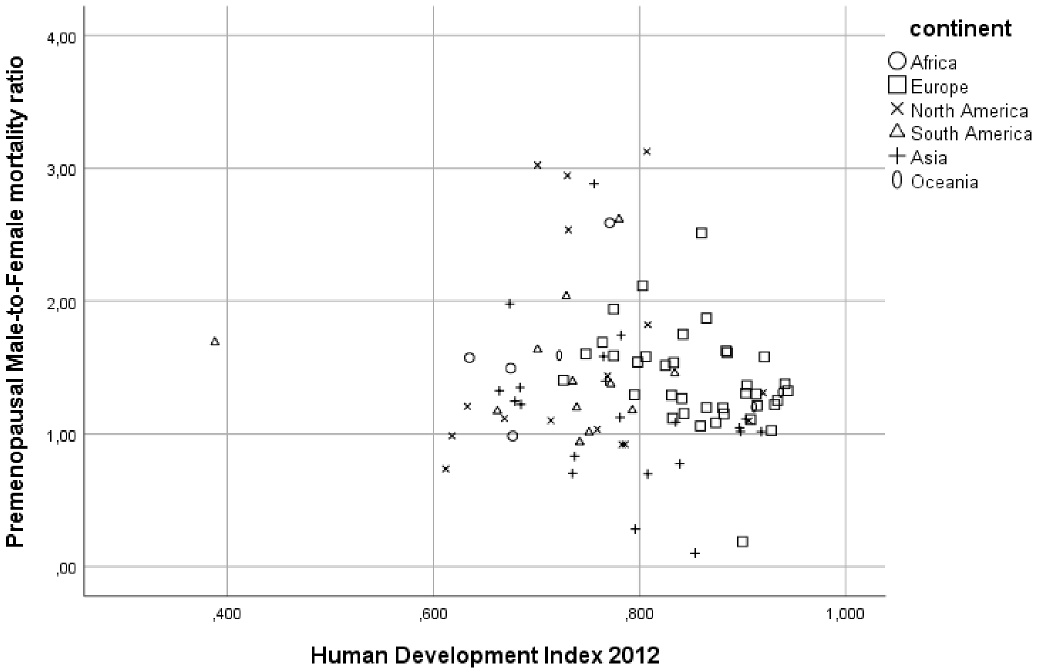


Figure 7. Scatterplot premenopausal Male-to-Female stomach cancer mortality ratio and Gross Domestic Product per capita.

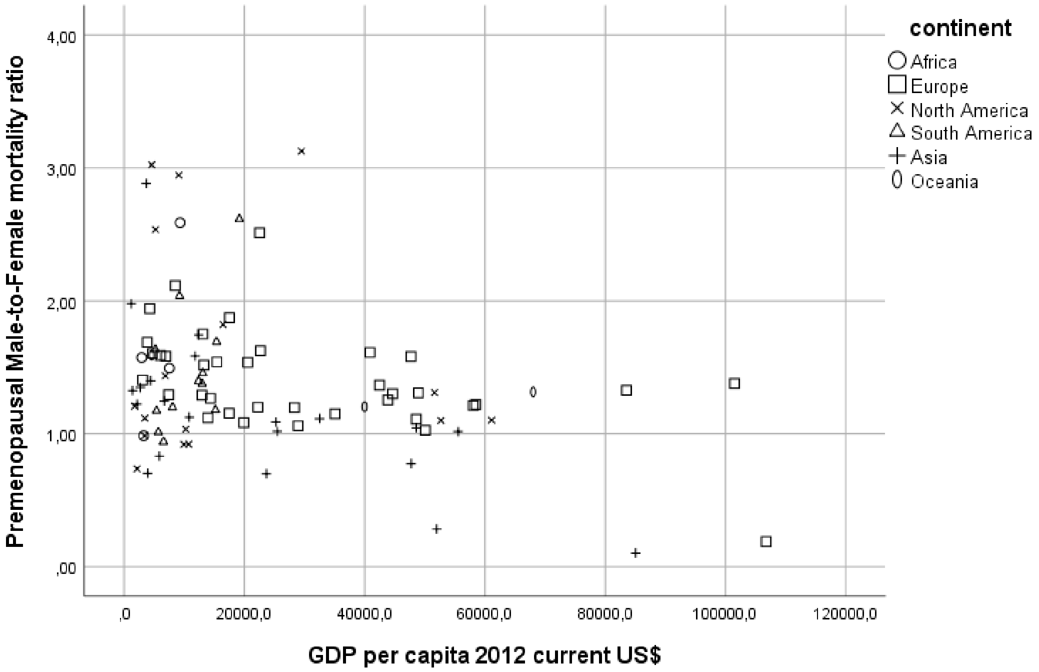


Figure 8. Scatterplot premenopausal Male-to-Female stomach cancer mortality ratio and Gini-index.

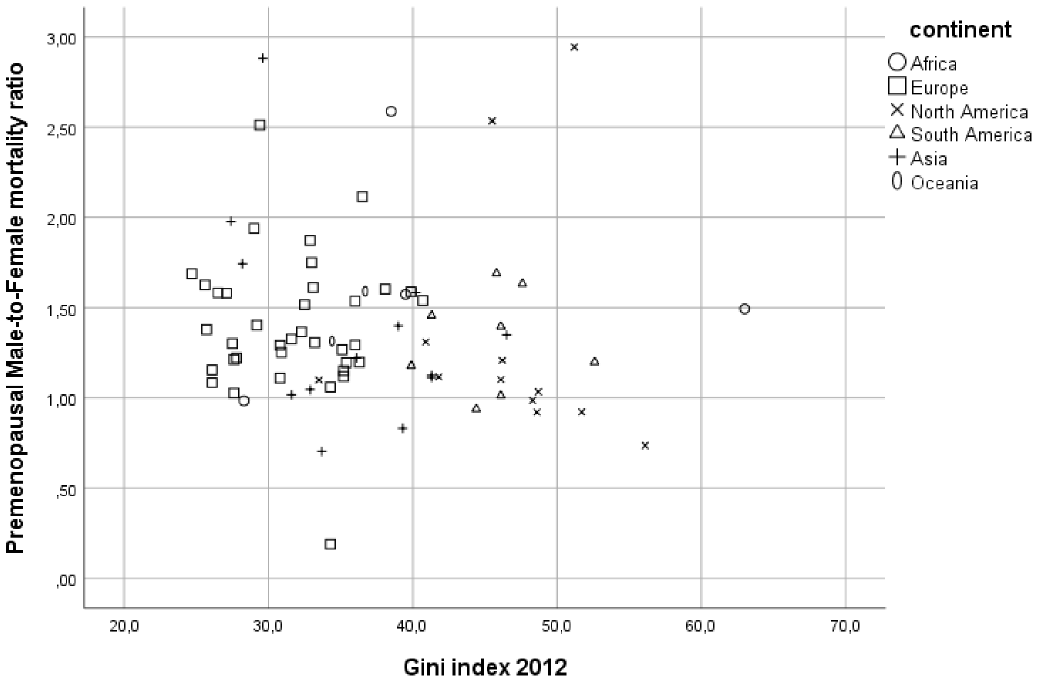


Figure 9. Scatterplot postmenopausal Male-to-Female stomach cancer mortality ratio and Gender Inequality Index.

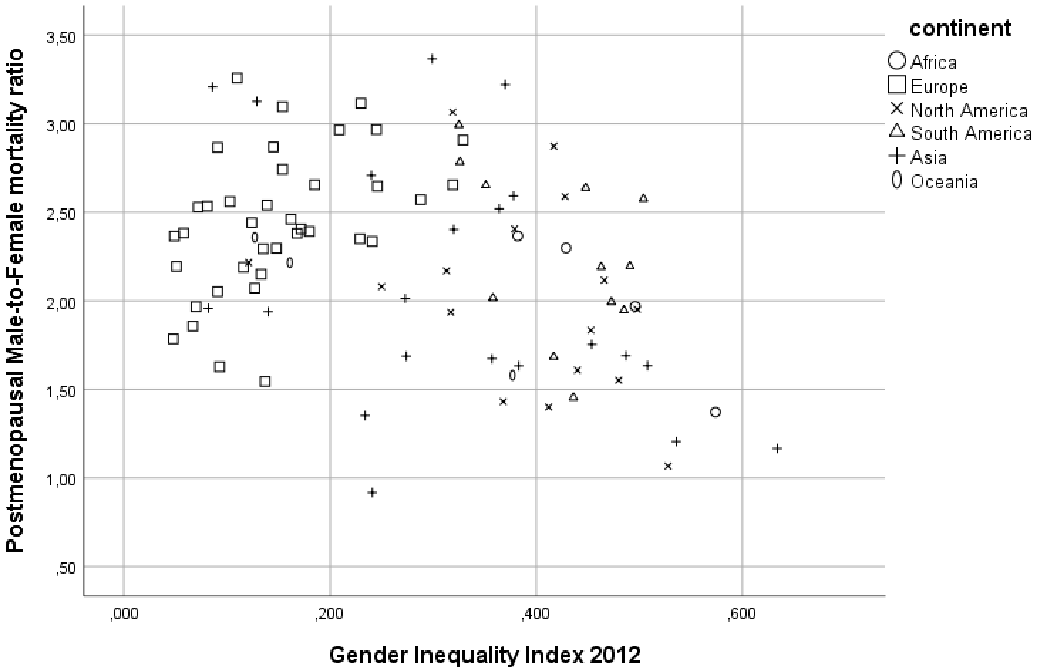


Figure 10. Scatterplot postmenopausal Male-to-Female stomach cancer mortality ratio and Human Development Index.

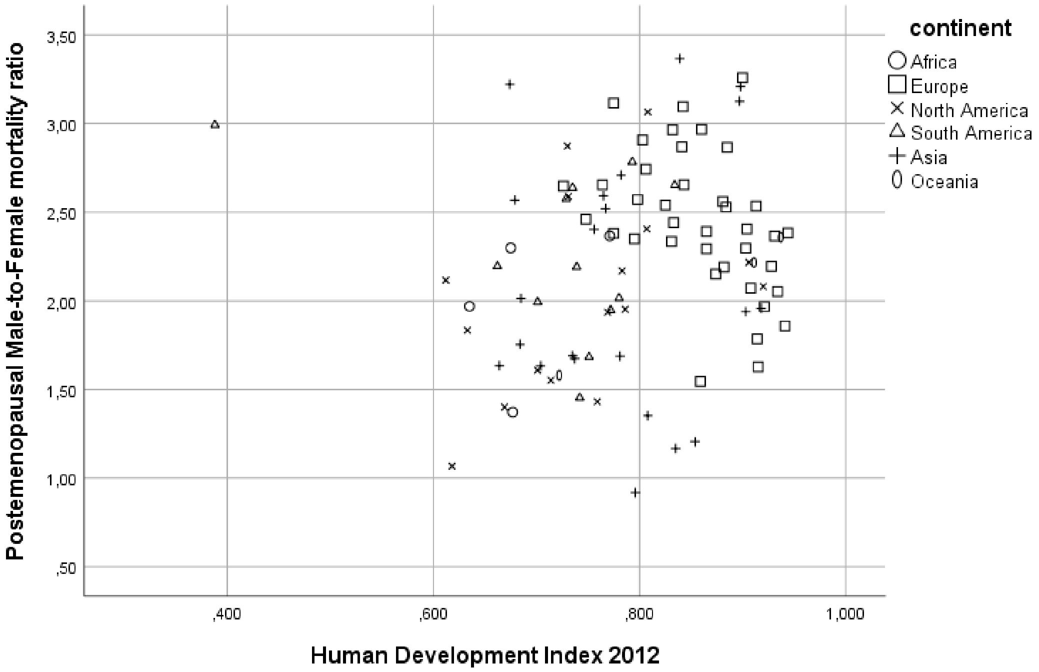


Figure 11. Scatterplot postmenopausal Male-to-Female stomach cancer mortality ratio and Gross Domestic Product per capita.

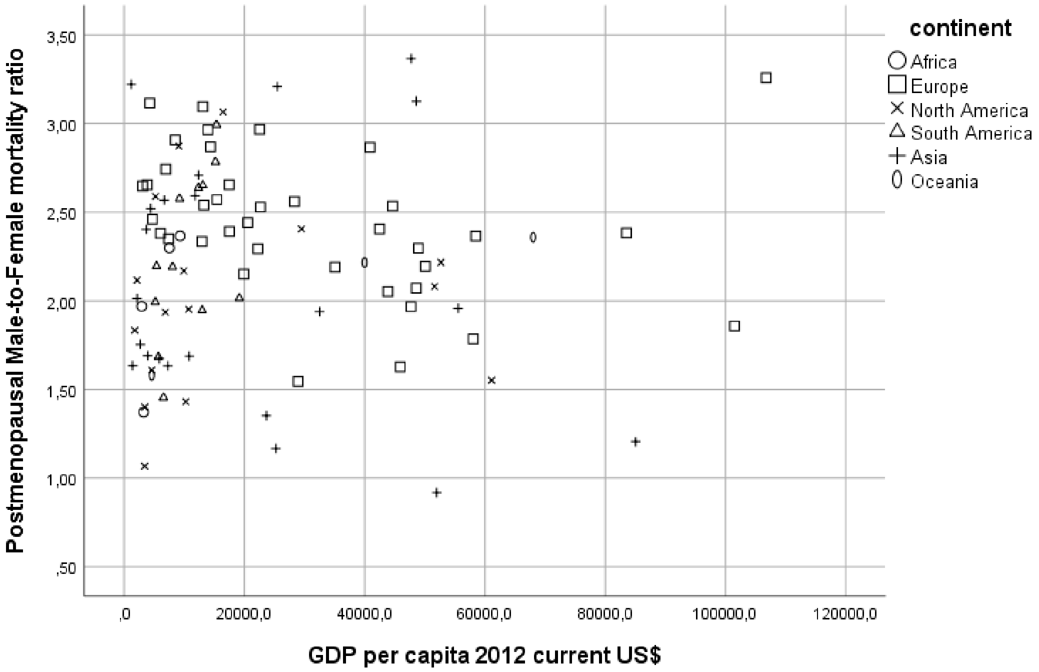


Figure 12. Scatterplot postmenopausal Male-to-Female stomach cancer mortality ratio and Gini-index.

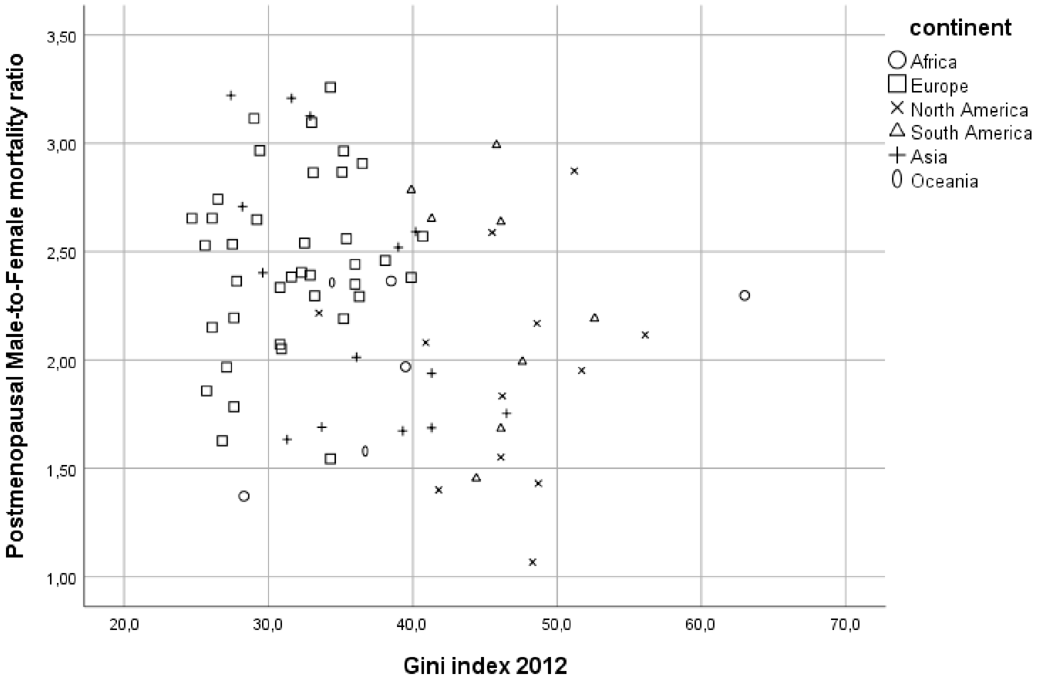


Figure 13. Scatterplot premenopausal Male-to-Female liver cancer mortality ratio and Gender Inequality Index.

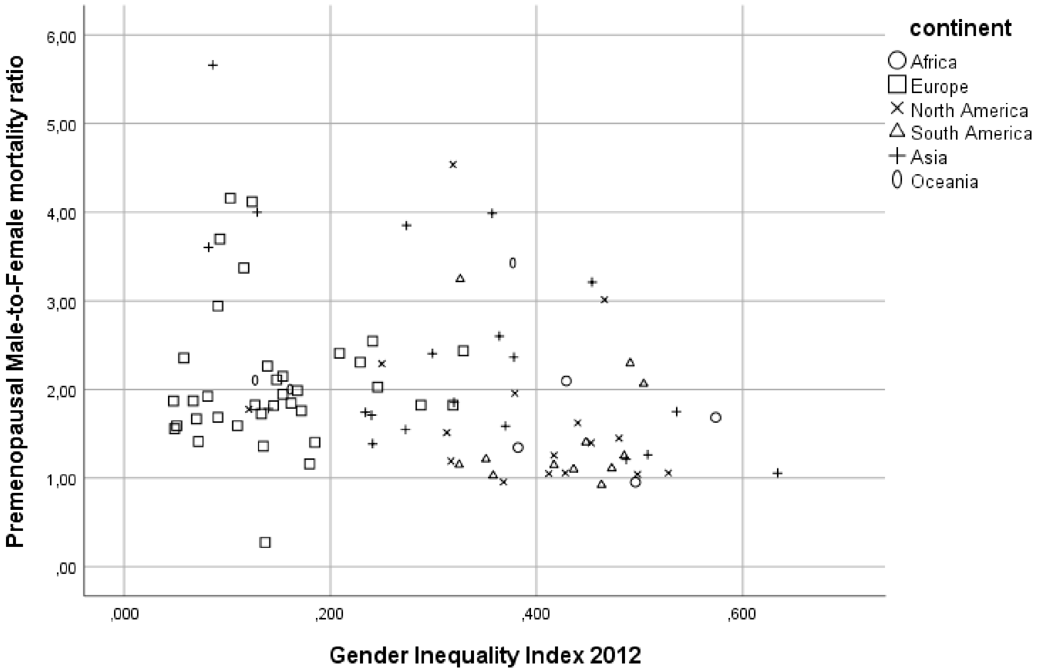


Figure 14. Scatterplot premenopausal Male-to-Female liver cancer mortality ratio and Human Development Index.

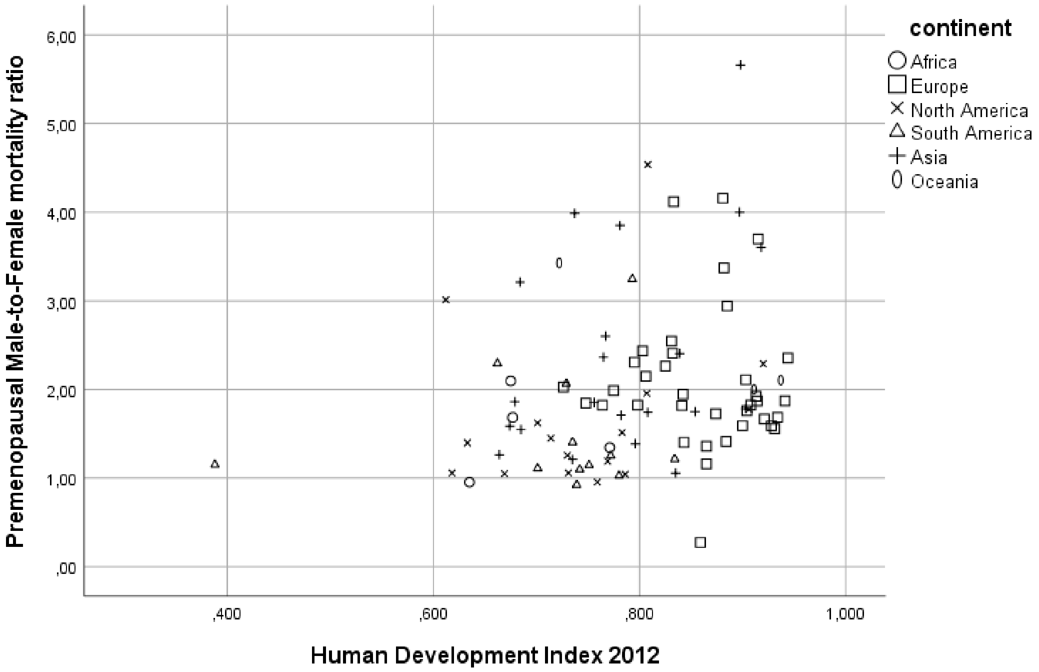


Figure 15. Scatterplot Male-to-Female liver cancer mortality ratio and Gross Domestic Product per capita.

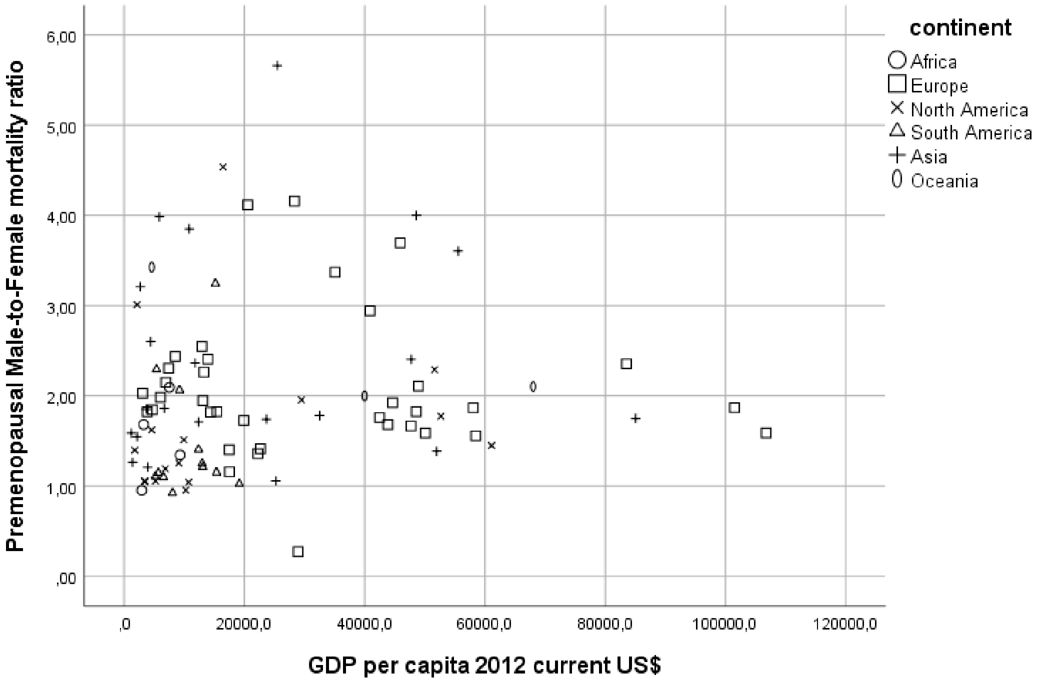


Figure 16. Scatterplot premenopausal Male-to-Female liver cancer mortality ratio and Gini-index.

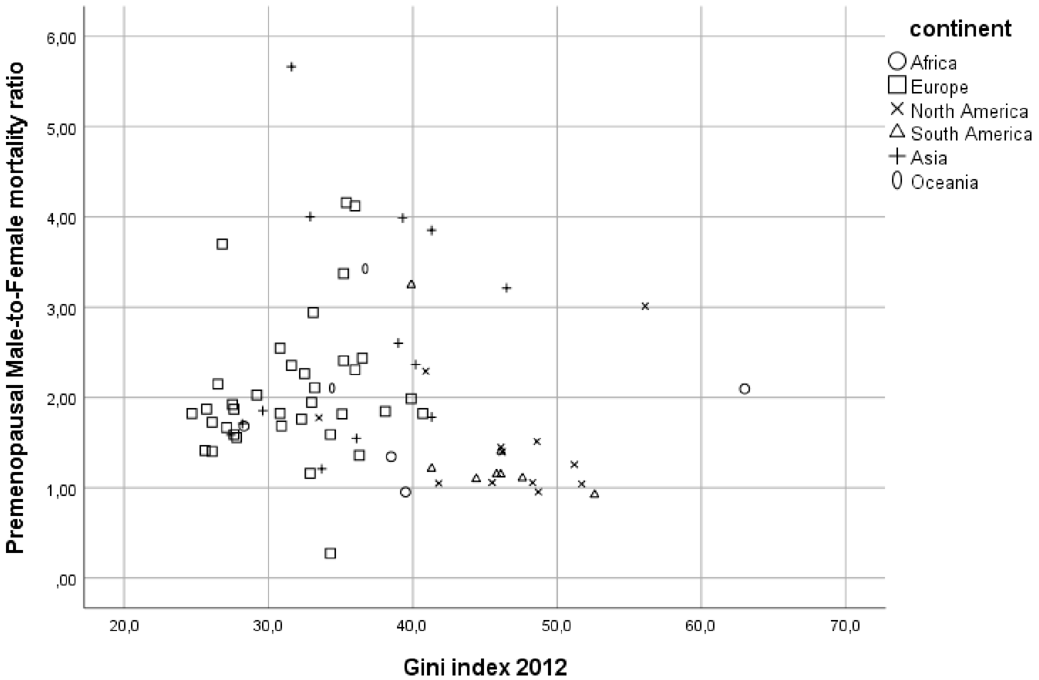


Figure 17. Scatterplot postmenopausal Male-to-Female liver cancer mortality ratio and Gender Inequality Index.

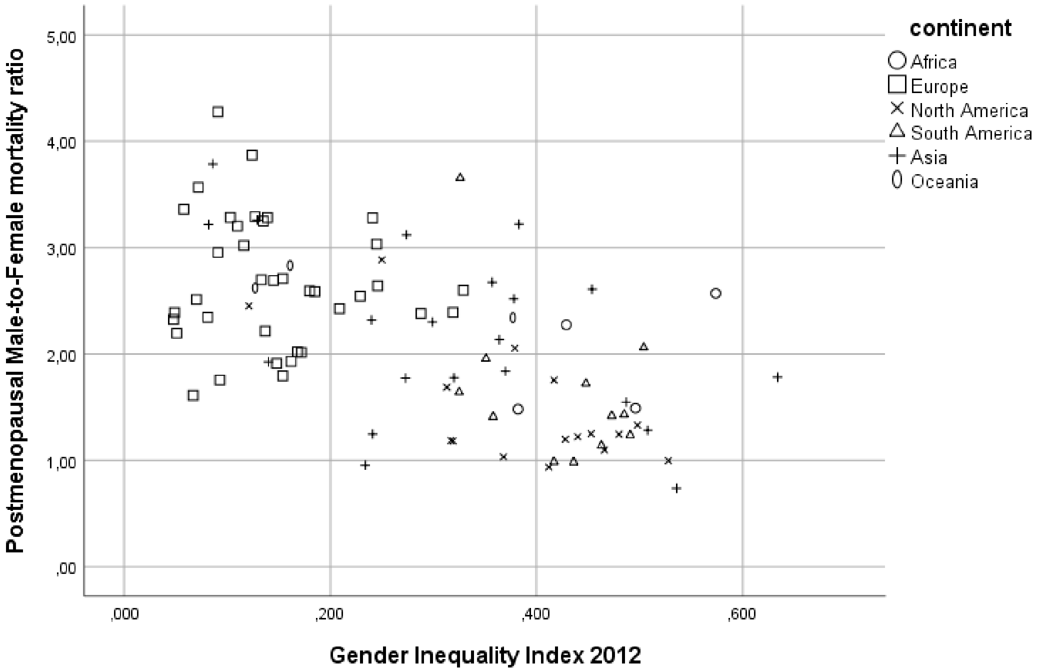


Figure 18. Scatterplot postmenopausal Male-to-Female liver cancer mortality ratio and Human Development Index.

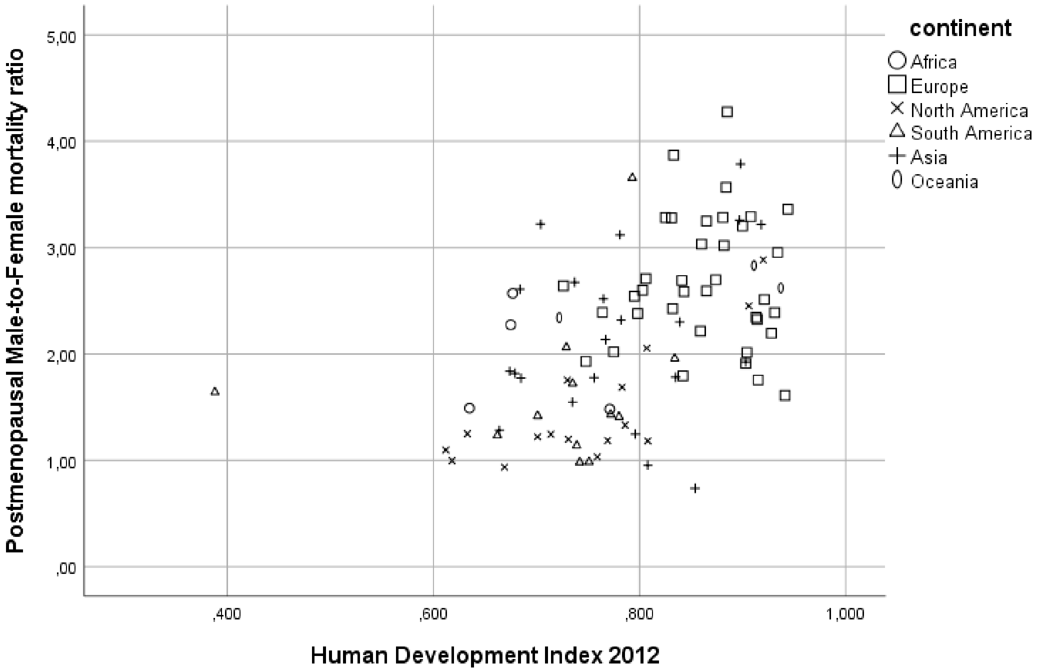


Figure 19. Scatterplot postmenopausal Male-to-Female liver cancer mortality ratio and Gross Domestic Product per capita.

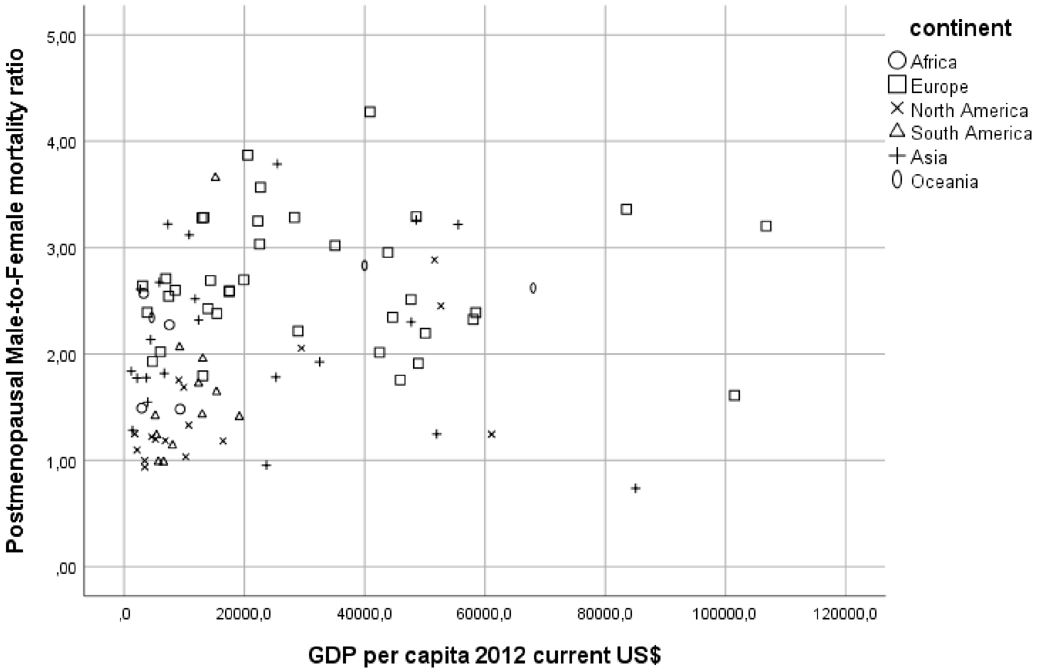


Figure 20. Scatterplot postmenopausal Male-to-Female liver cancer mortality ratio and Gini-index.

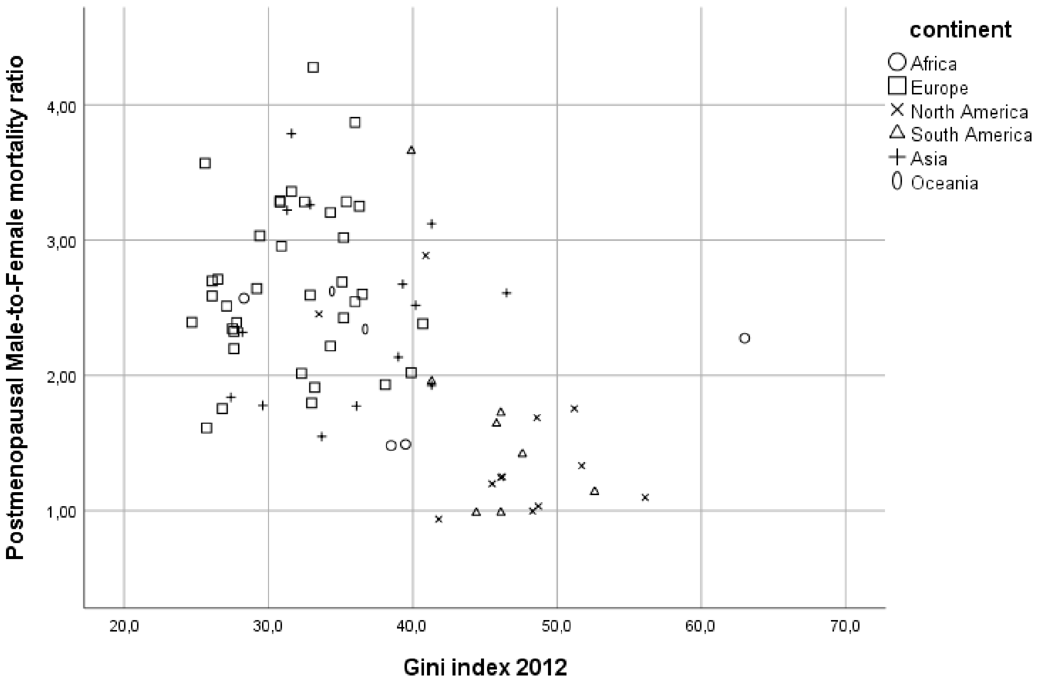


Figure 21. Scatterplot postmenopausal Male-to-Female pancreas cancer mortality ratio and Gender Inequality index.

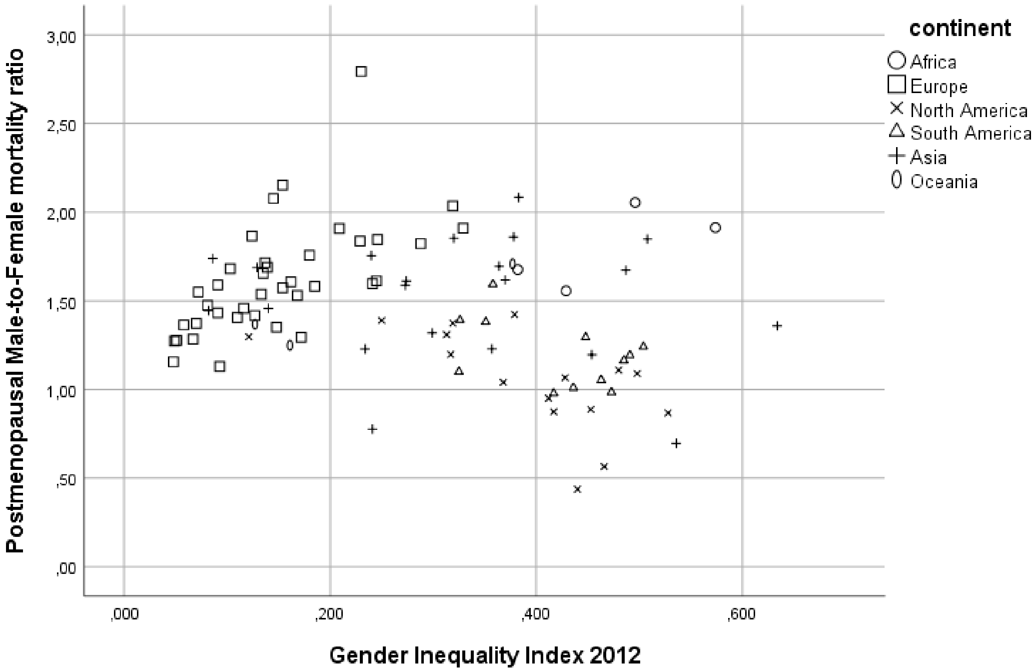


Figure 22. Scatterplot postmenopausal Male-to-Female pancreas cancer mortality ratio and Human Development Index.

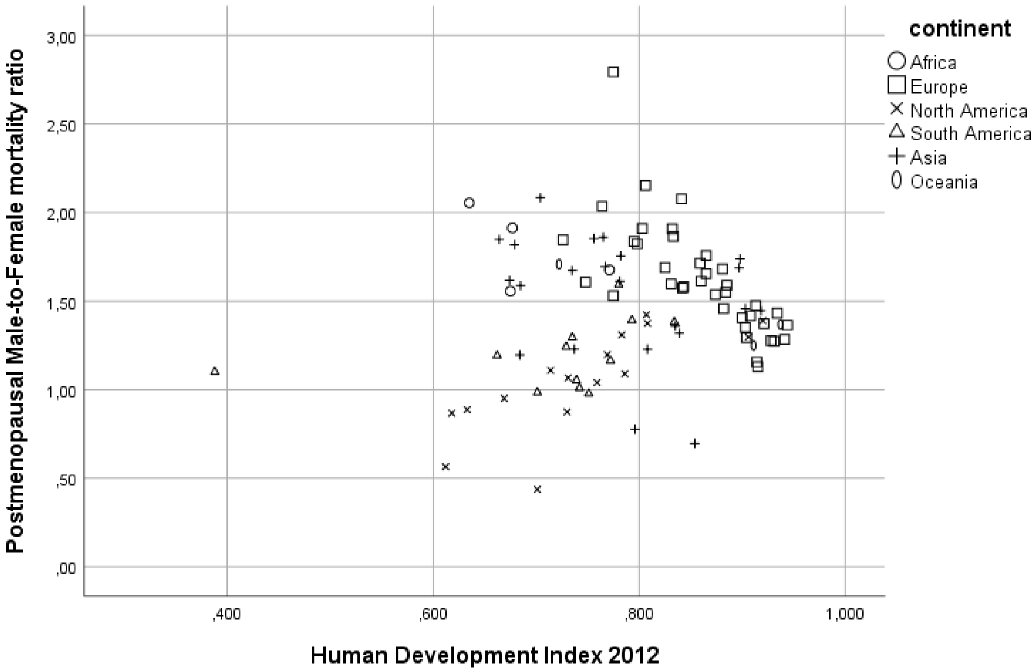


Figure 23. Scatterplot postmenopausal Male-to-Female pancreas cancer mortality ratio and Gross Domestic Product per capita.

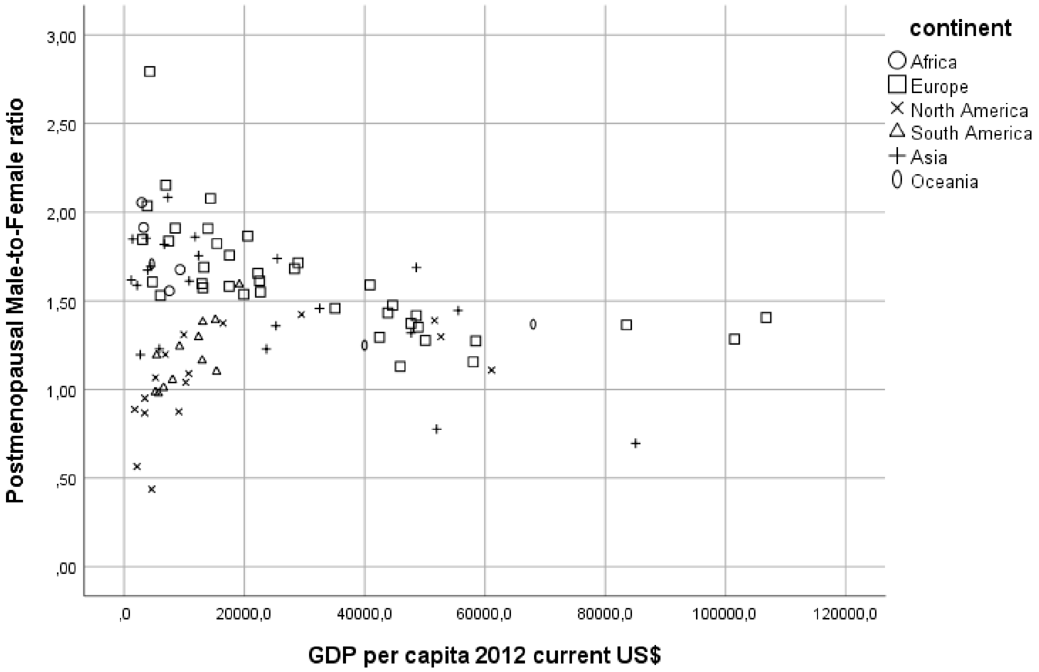


Figure 24. Scatterplot postmenopausal Male-to-Female pancreas cancer mortality ratio and Gini-index.

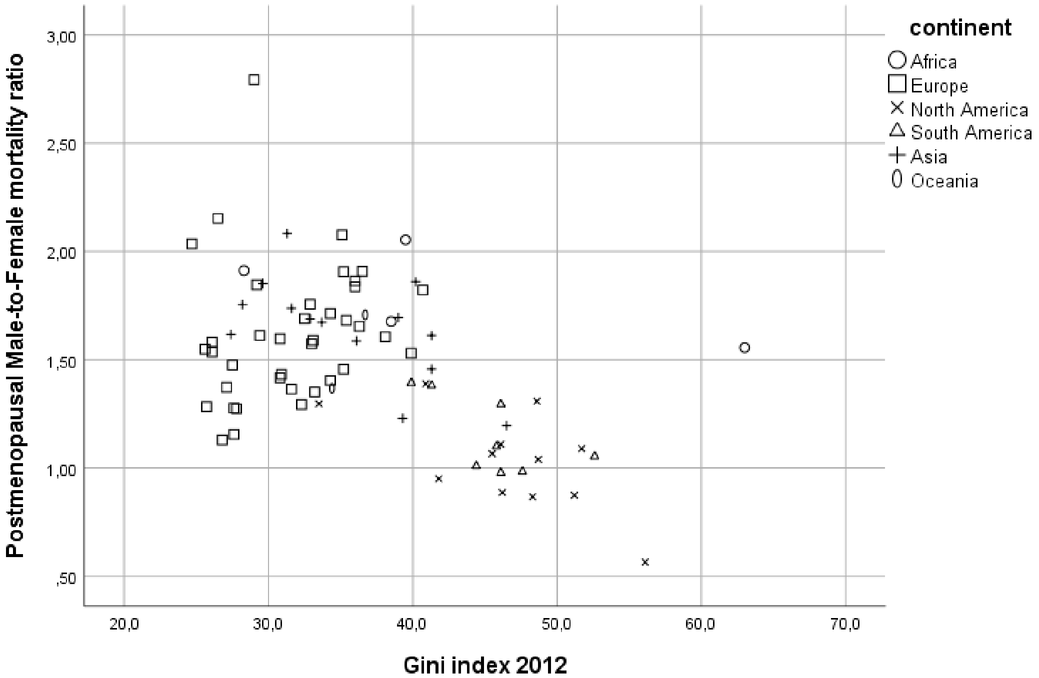


Figure 25. Scatterplot premenopausal Male-to-Female colorectum cancer mortality ratio and Gender Inequality Index.

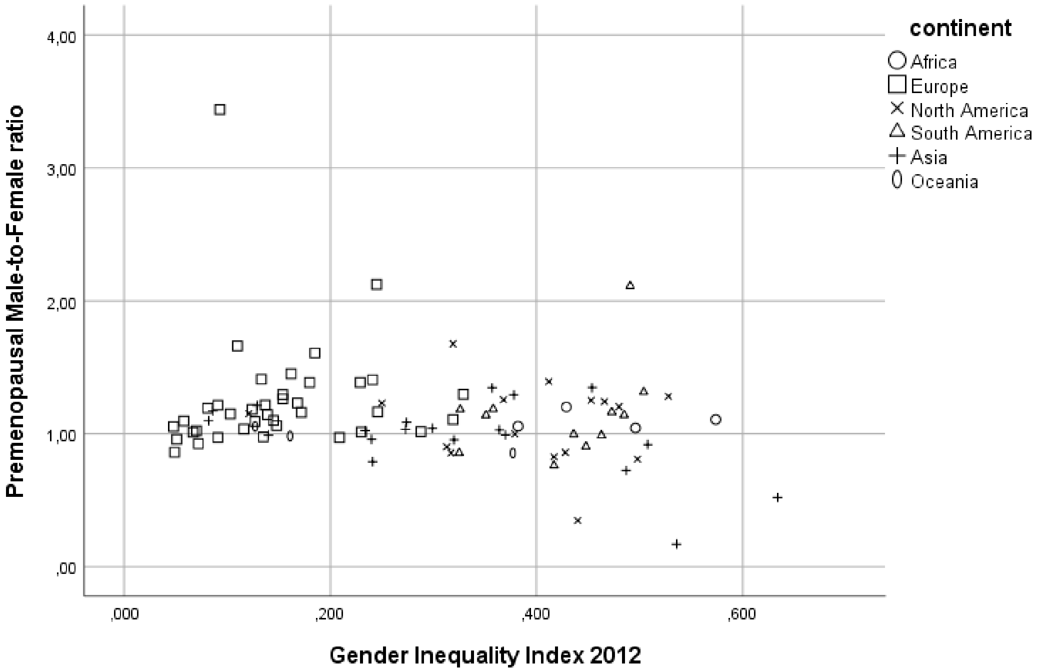


Figure 26. Scatterplot premenopausal Male-to-Female colorectum cancer mortality ratio and Human Development Index.

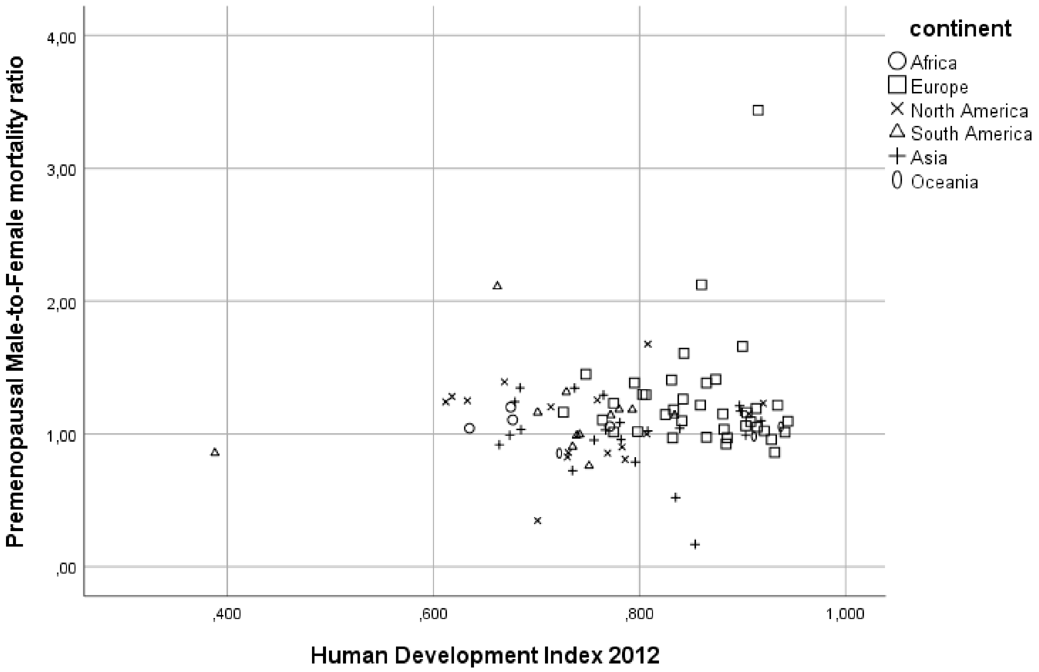


Figure 27. Scatterplot premenopausal Male-to-Female colorectum cancer mortality ratio and Gross Domestic Product per capita.

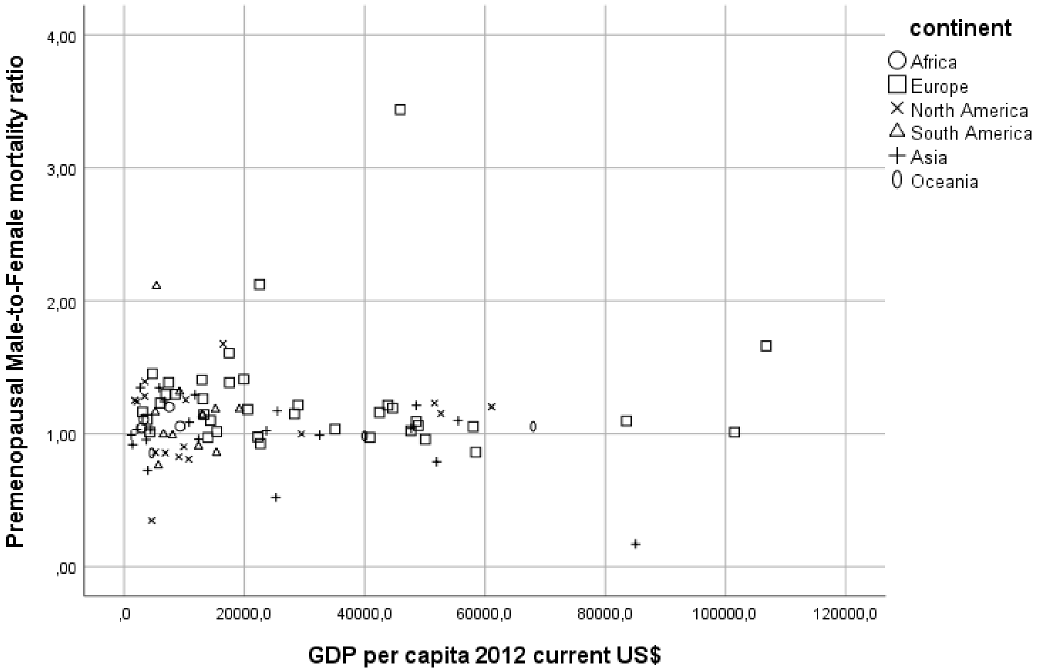


Figure 28. Scatterplot premenopausal Male-to-Female colorectum cancer mortality ratio and Gini-index.

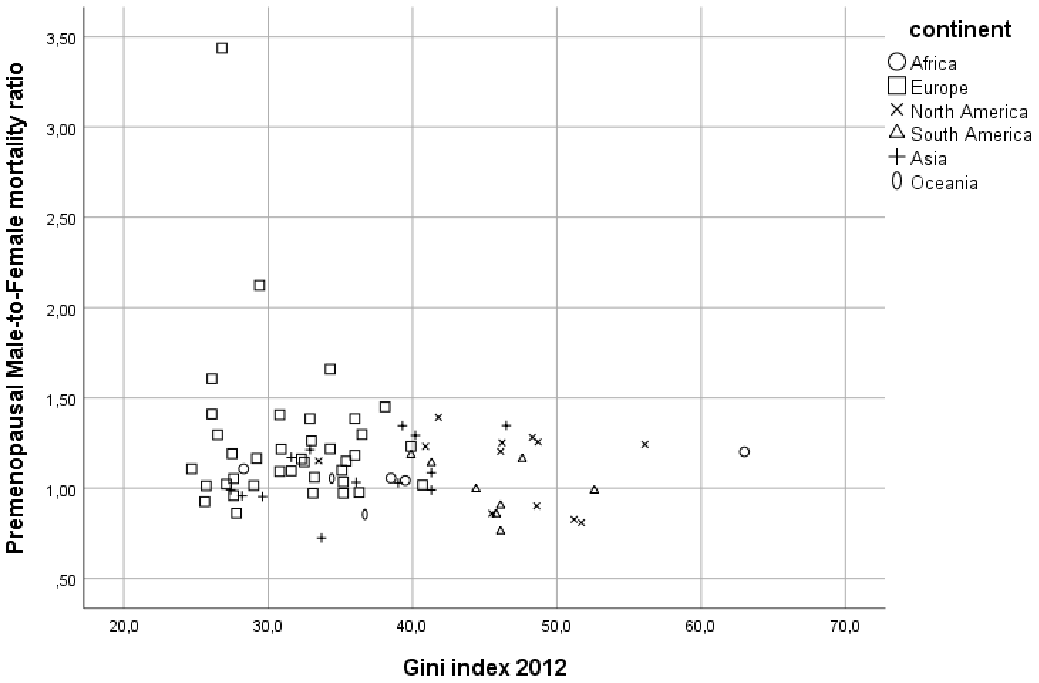


Figure 29. Scatterplot postmenopausal Male-to-Female colorectum cancer mortality ratio and Gender Inequality Index.

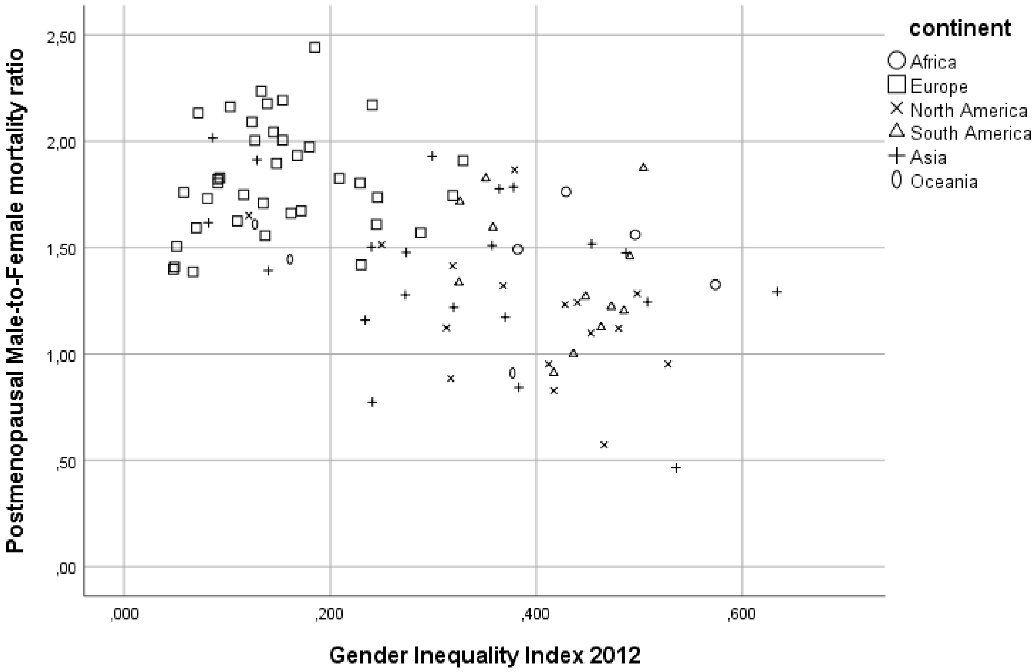


Figure 30. Scatterplot postmenopausal Male-to-Female colorectum cancer mortality ratio and Human Development Index.

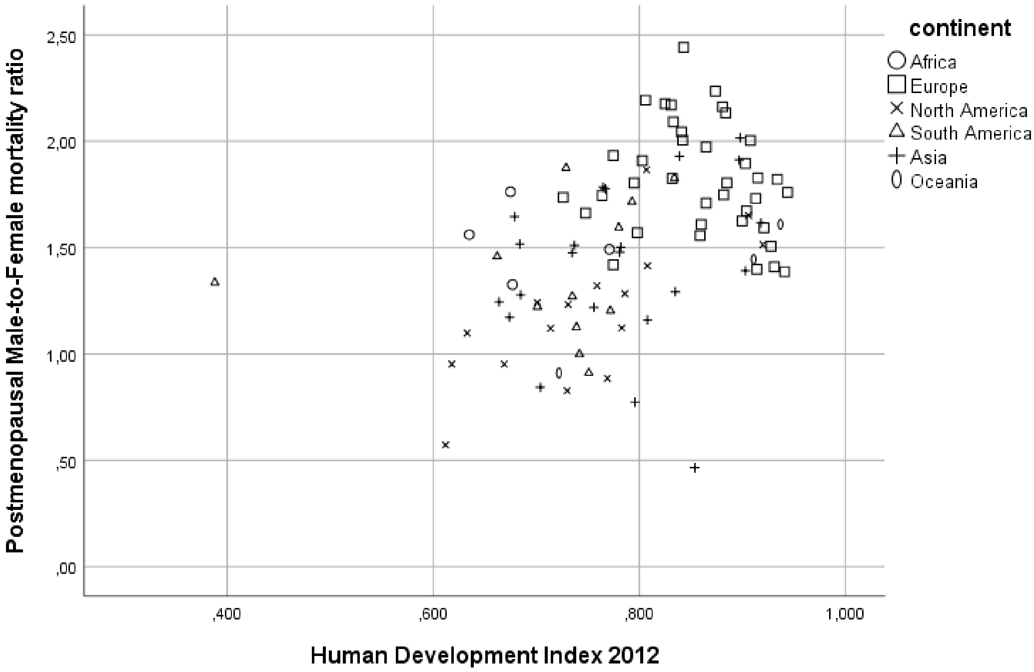


Figure 31. Scatterplot postmenopausal Male-to-Female colorectum cancer mortality ratio and Gross Domestic Product per capita.

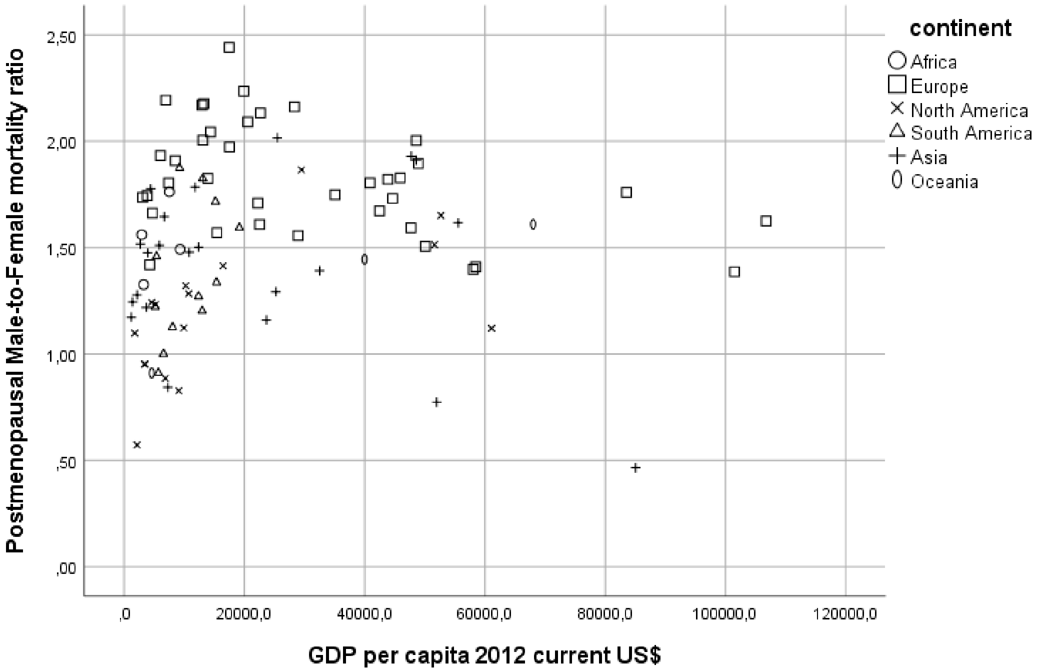


Figure 32. Scatterplot postmenopausal Male-to-Female colorectum cancer mortality ratio and Gini-index.

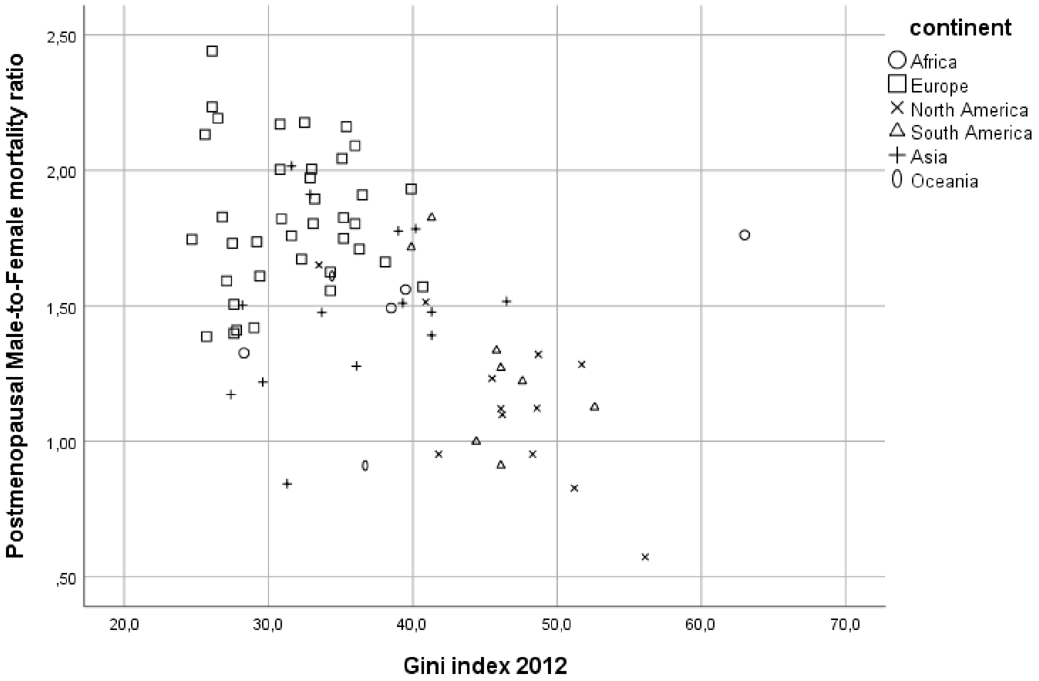


Figure 33. Scatterplot premenopausal Male-to-Female lung cancer mortality ratio and Gender Inequality Index.

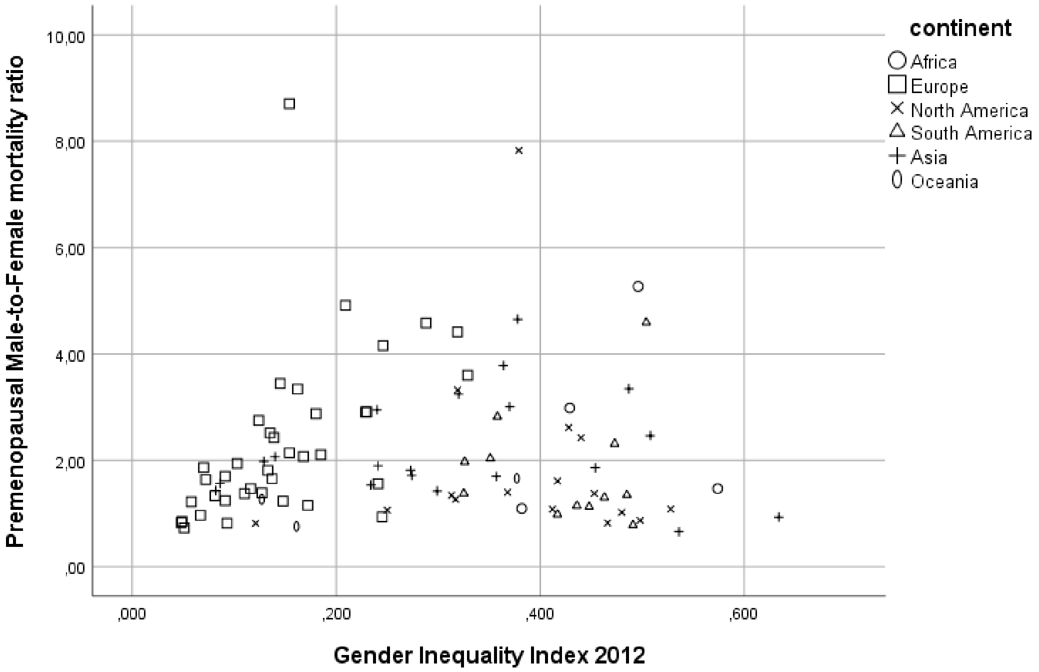


Figure 34. Scatterplot premenopausal Male-to-Female lung cancer mortality ratio and Human Development Index.

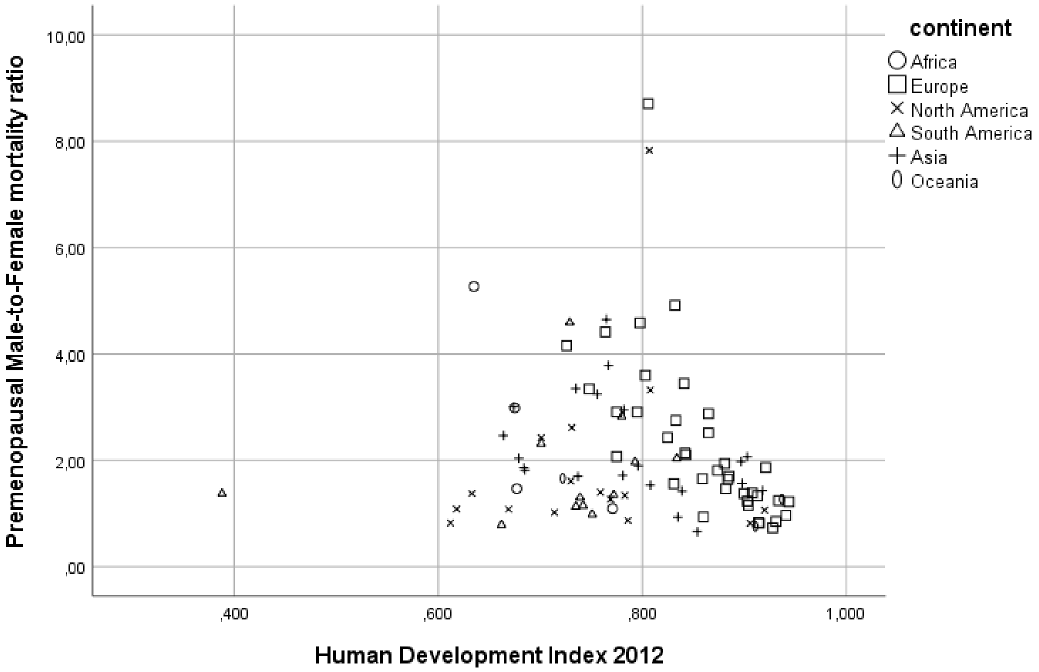


Figure 35. Scatterplot premenopausal Male-to-Female lung cancer mortality ratio and Gross Domestic Product per capita.

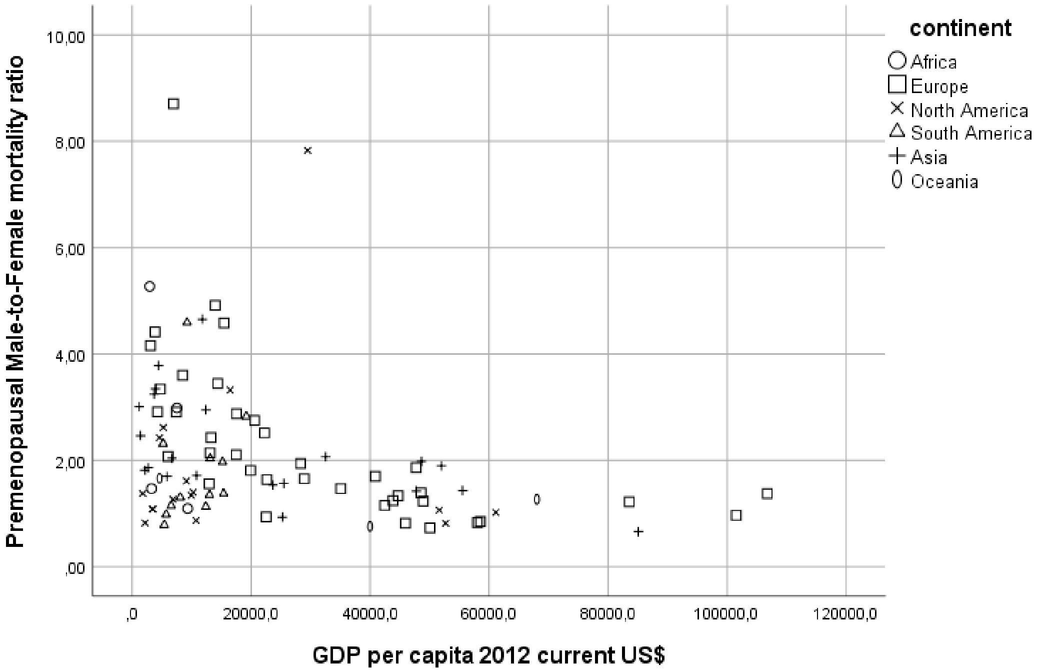


Figure 36. Scatterplot premenopausal Male-to-Female lung cancer mortality ratio and Gini-index.

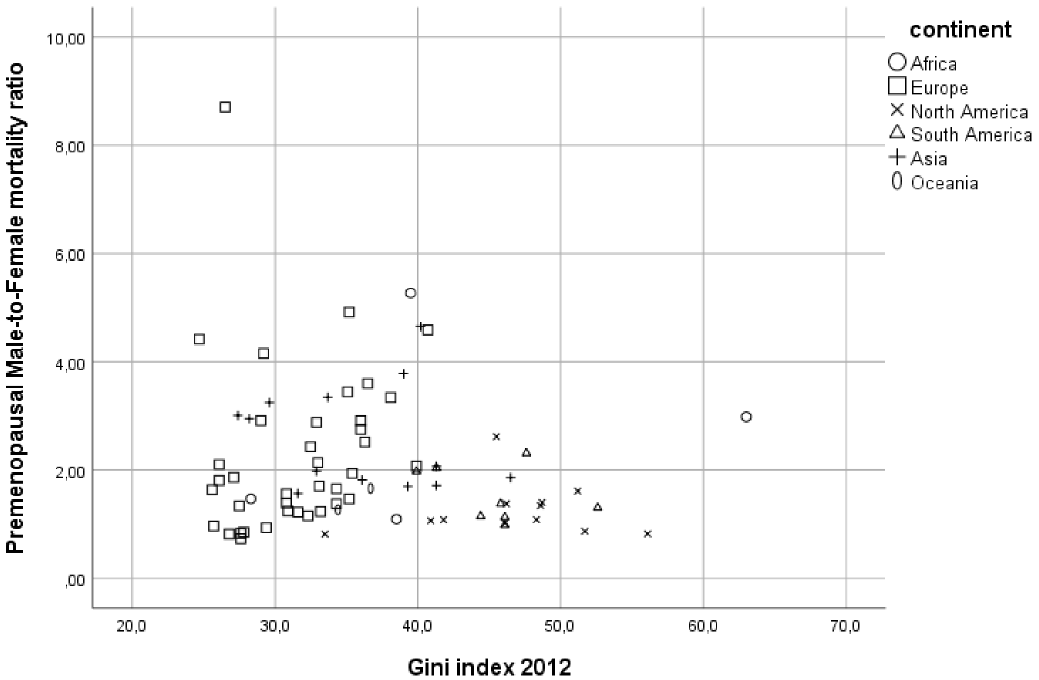


Figure 36. Scatterplot premenopausal Male-to-Female lung cancer mortality ratio and Gini-index.

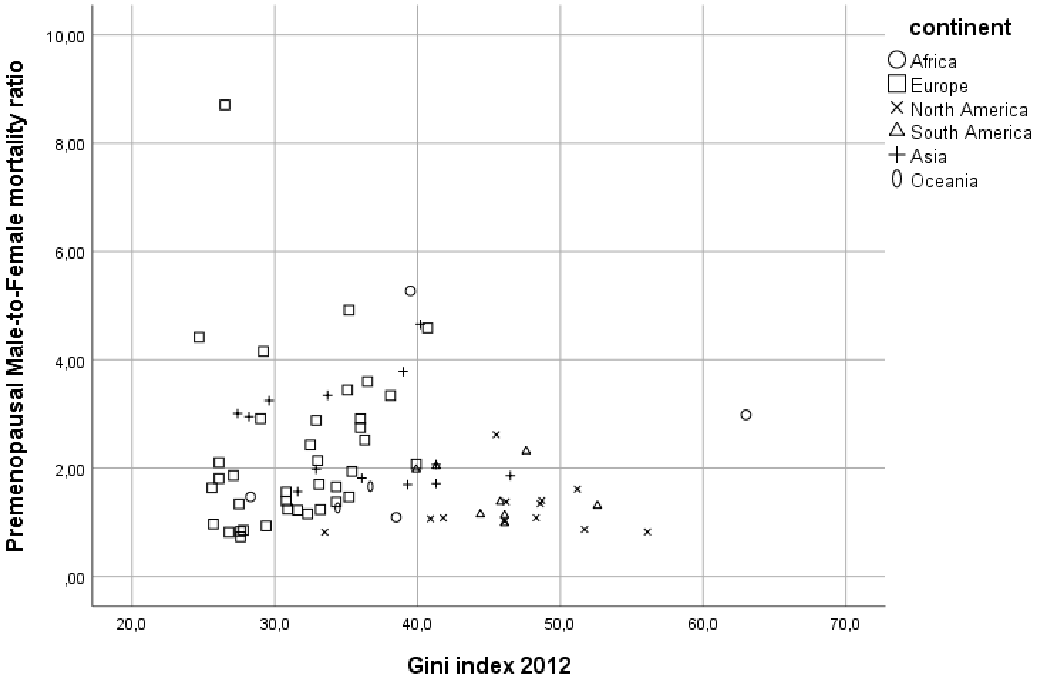


Figure 38. Scatterplot postmenopausal Male-to-Female lung cancer mortality ratio and Human Development Index.

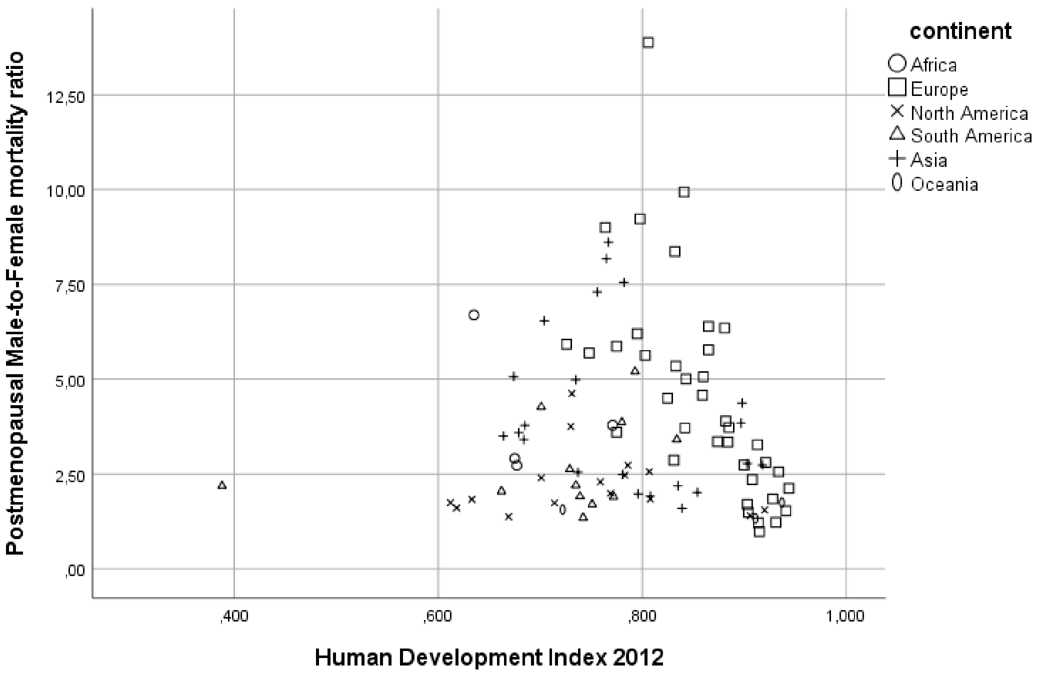


Figure 39. Scatterplot postmenopausal Male-to-Female lung cancer mortality ratio and Gross Domestic Product per capita.

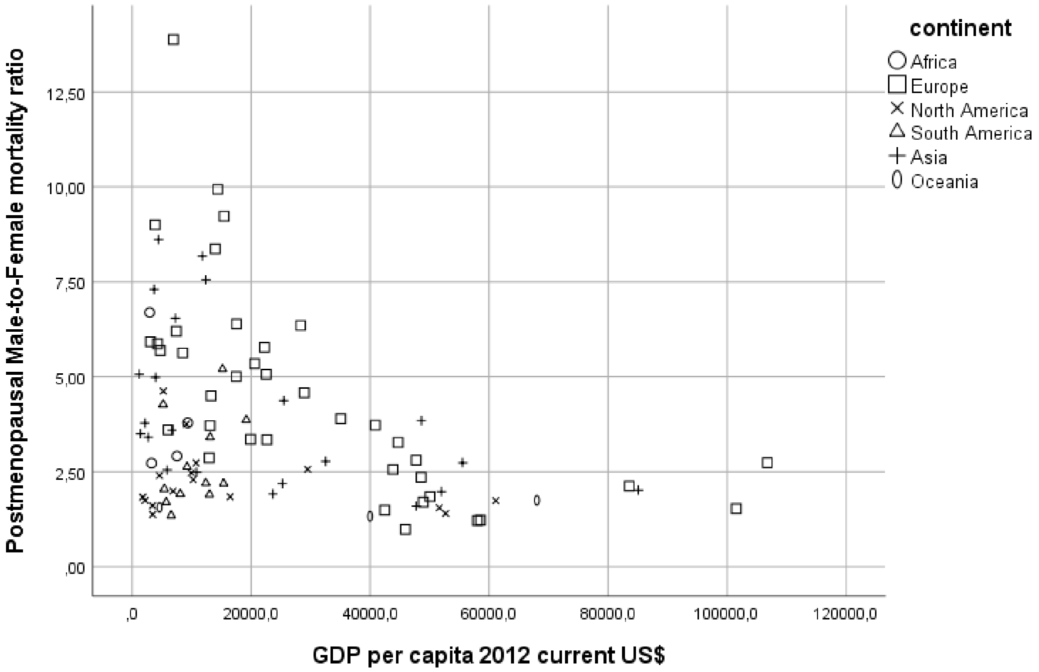


Figure 40. Scatterplot postmenopausal Male-to-Female lung cancer mortality ratio and Gini-index.

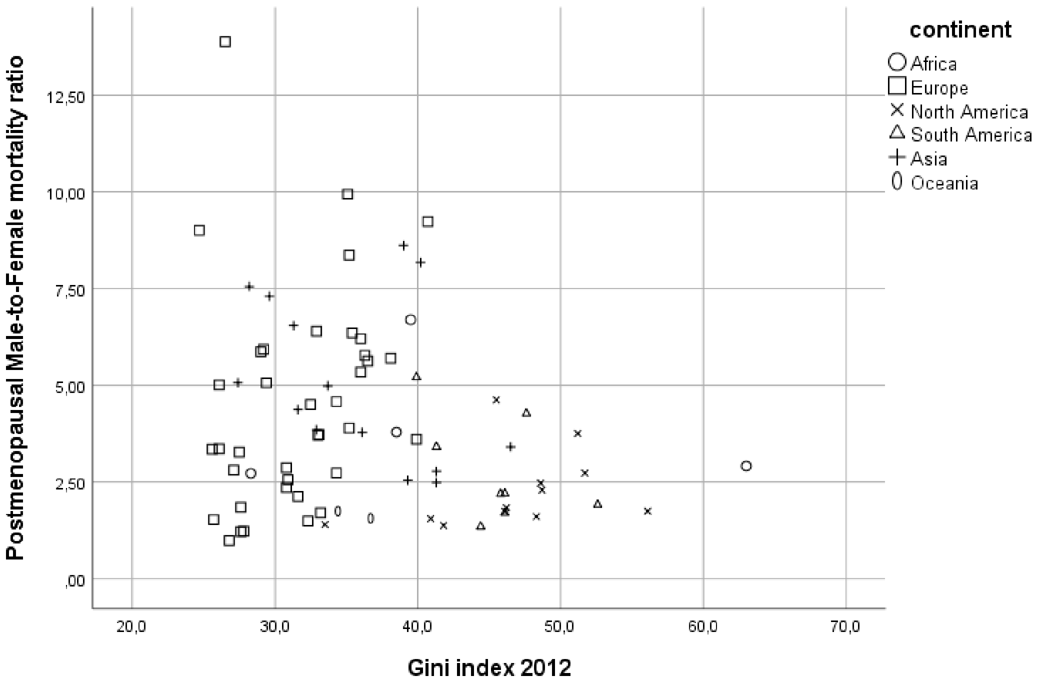


Figure 41. Scatterplot postmenopausal Male-to-Female bladder cancer mortality ratio and Gender Inequality Index.

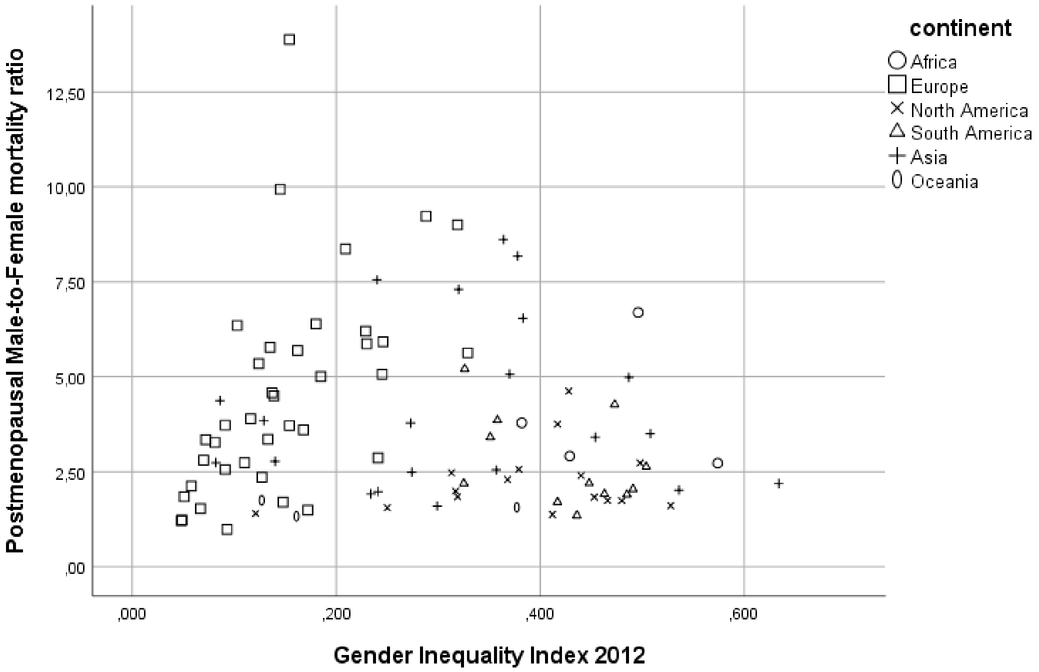


Figure 42. Scatterplot postmenopausal Male-to-Female bladder cancer mortality ratio and Human Development Index.

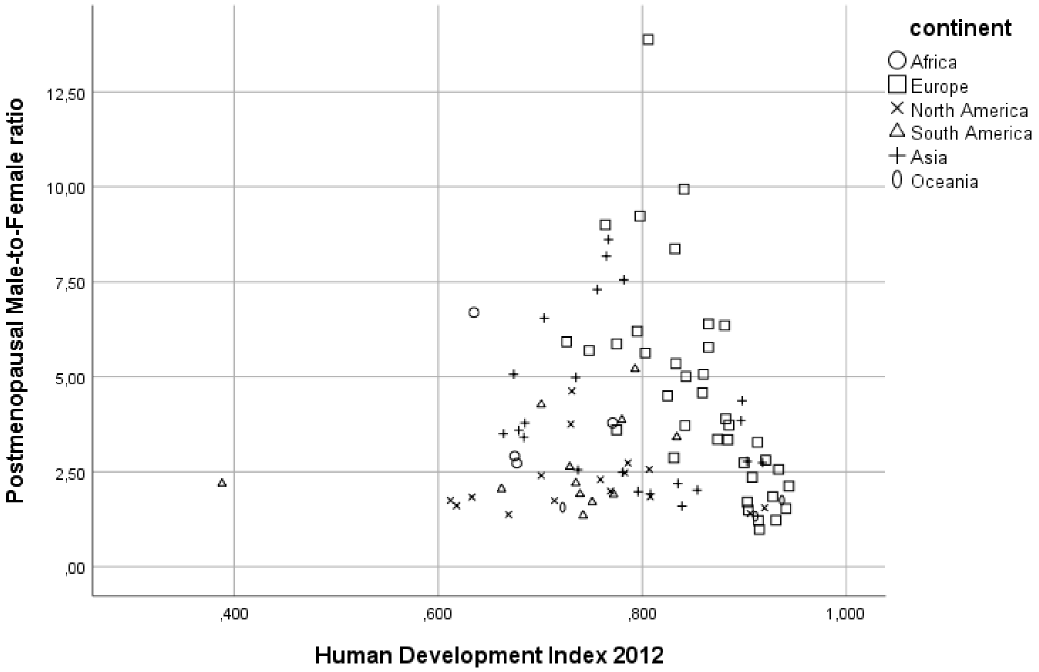


Figure 43. Scatterplot postmenopausal Male-to-Female bladder cancer mortality ratio and Gross Domestic Product per capita.

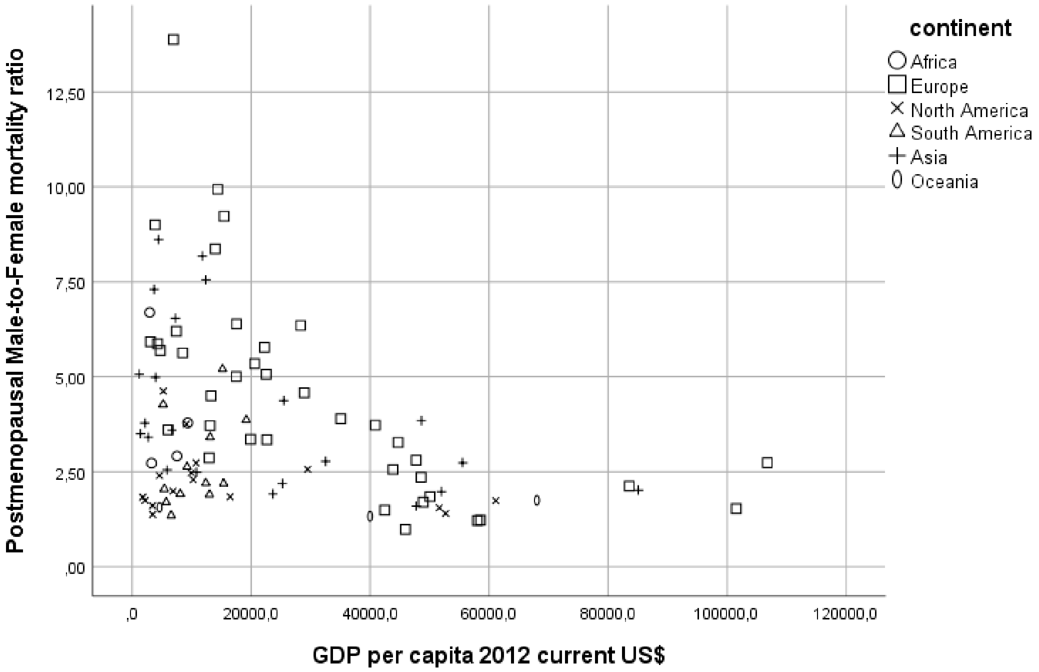


Figure 44. Scatterplot postmenopausal Male-to-Female bladder cancer mortality ratio and Gini-index.