

Spatiotemporal Analysis of Mortality Rates of Major Death Causes among Men and Women in Taiwan

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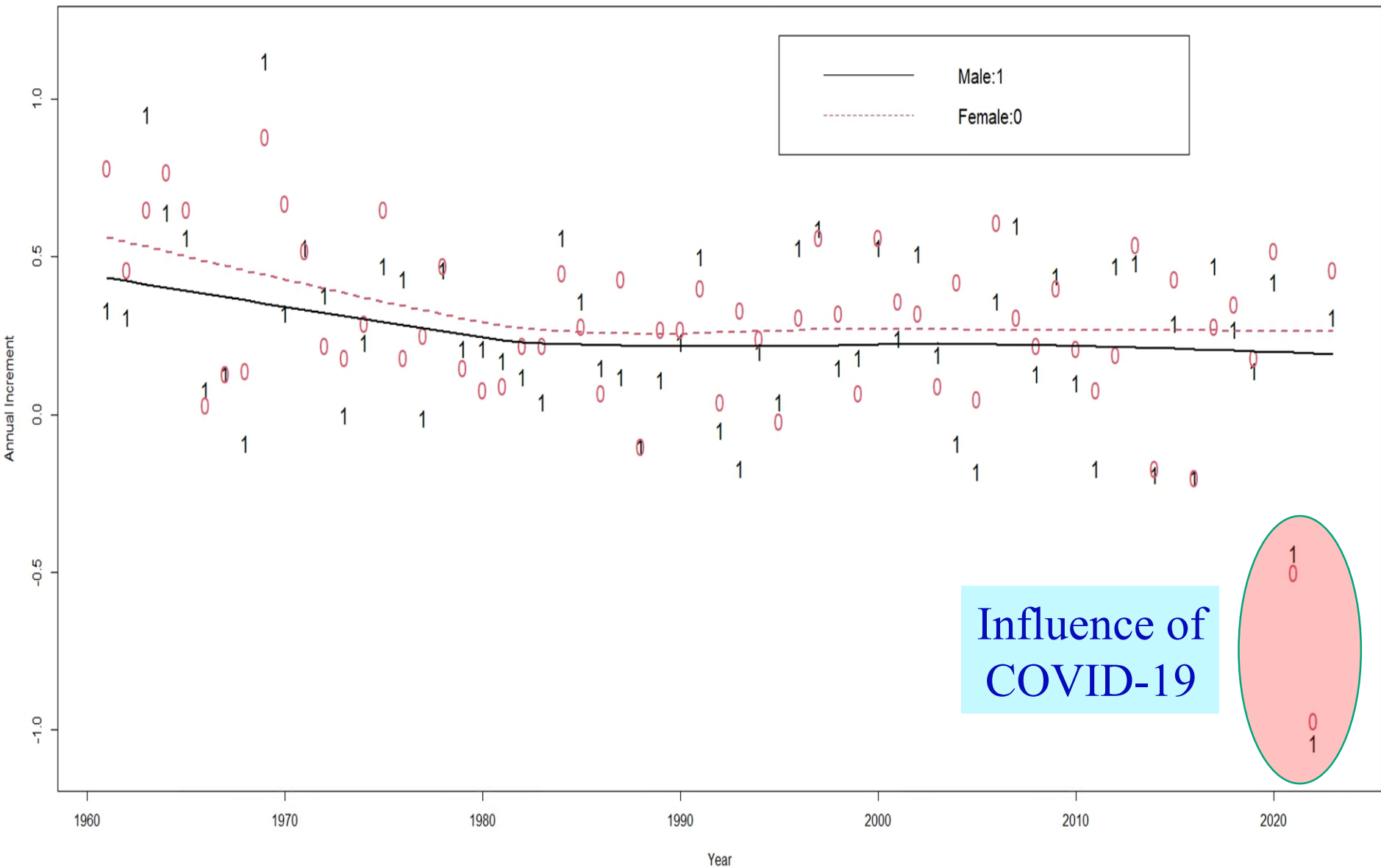


Life Expectancy Trend in Taiwan

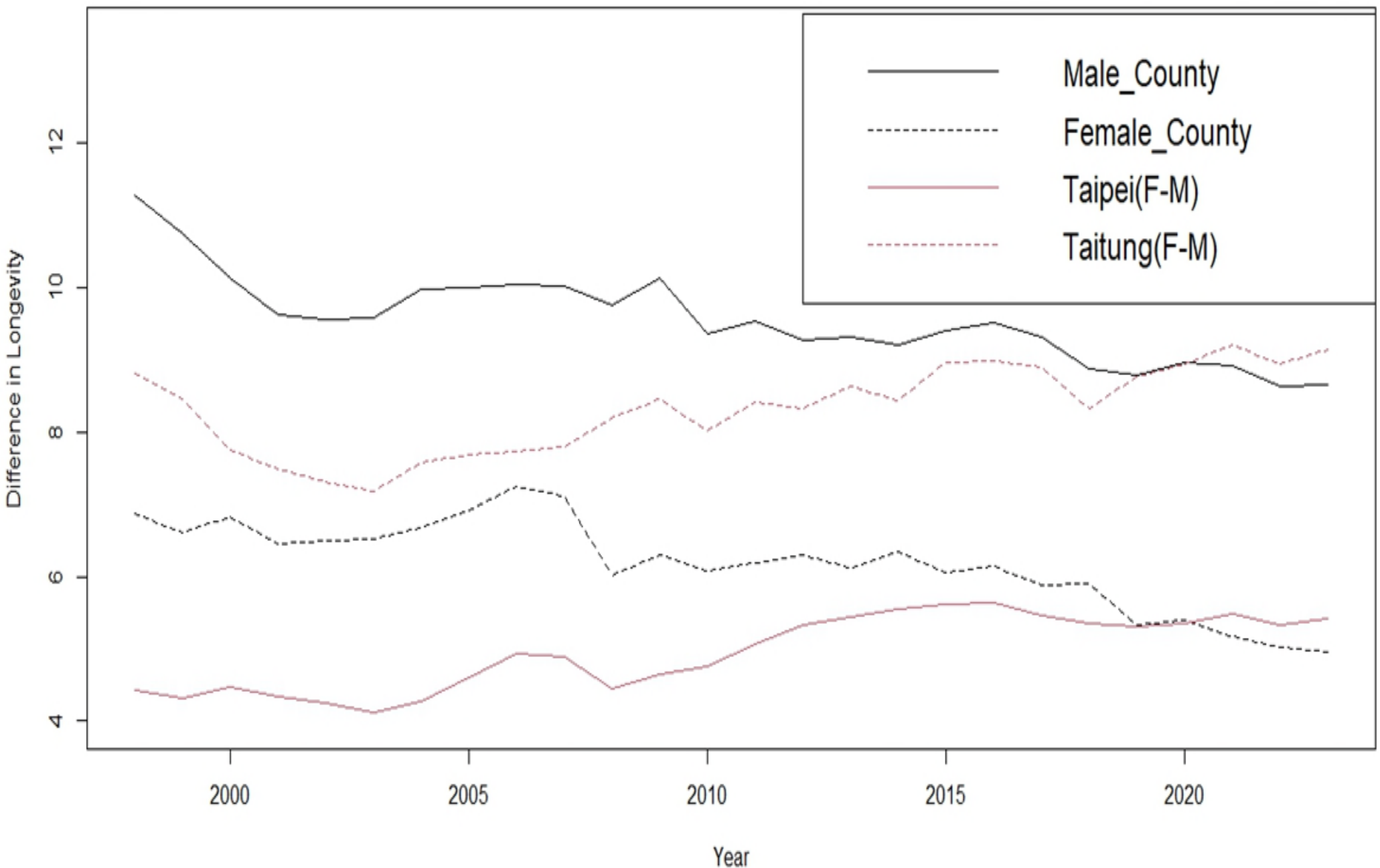
- ❑ Life expectancy in Taiwan continues to increase, but there are a large differences between men and women and between regions.
- ❑ Taipei city and Taitung county have the longest & shortest life expectancy in Taiwan, respectively.
- Difference between counties have decreased.
- Difference between men and women has widened.

Note: Trends are not affected by COVID-19.

Increment of Life Expectancy in Taiwan



Life Expectancy Gaps between Counties



Study Objective

- ❑ Investigate current status and future trends of the gender gap in life expectancy
 - Use exploratory data analysis (EDA) and the Lee-Carter model to predict trends
- ❑ Explore the difference in life expectancy between men and women and its impact
 - Compare mortality rates from all causes of death and major causes of death in men and women

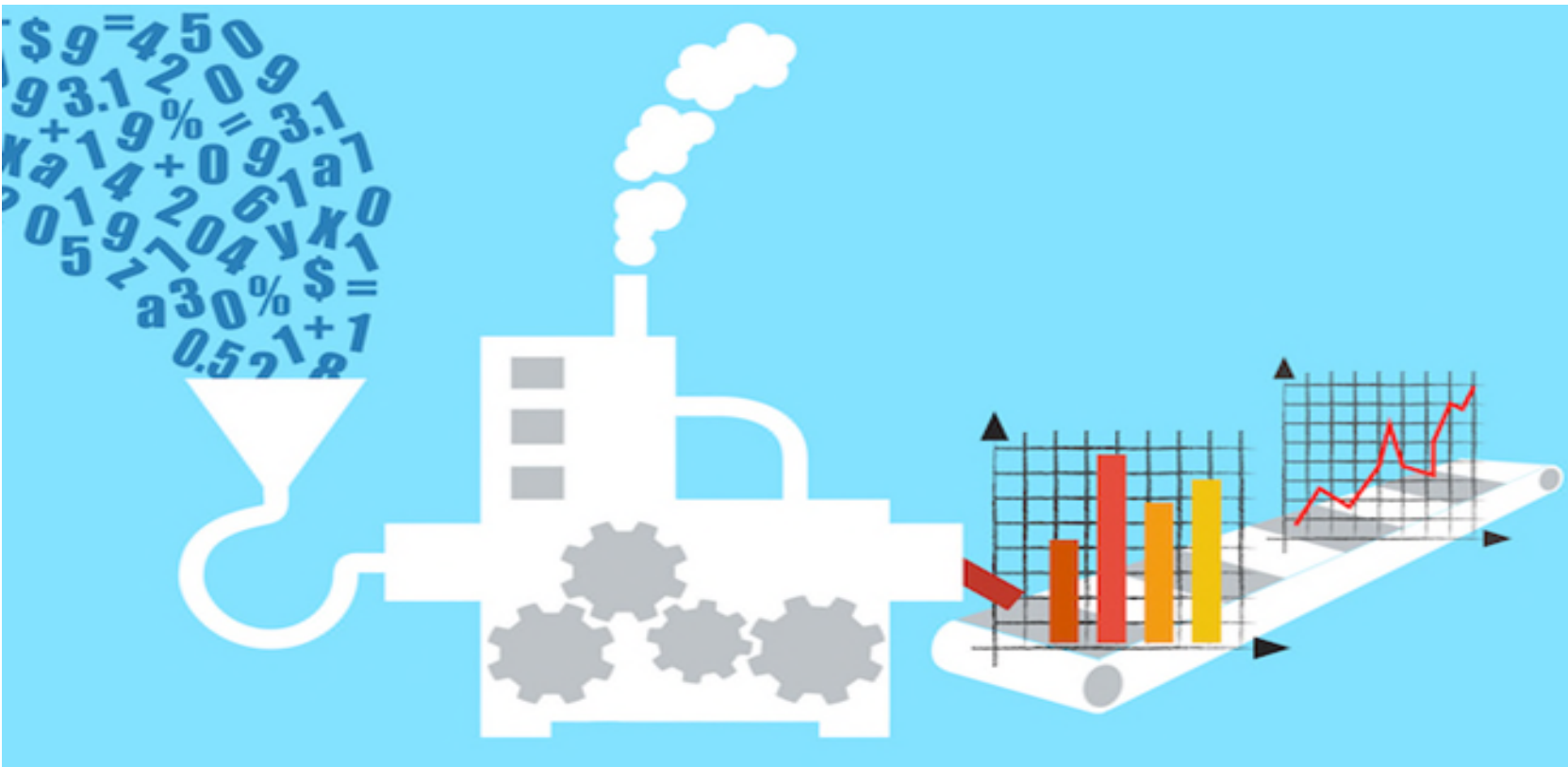


EDA and CDA

- Data Analysis can be separated into two parts:
 - Exploratory Data Analysis (EDA) and Confirmatory Data Analysis (CDA)
 - EDA (or data driven) is to **learn** from the data:
Indices & Graphical tools:
 - CDA (or formal modeling) is to **confirm** the observed findings: Lee-Carter model

EDA & Data Visualization

❑ Exploratory data analysis (EDA) is an approach to analyzing data sets to summarize their main characteristics ... EDA is for seeing what the data can tell us beyond the formal modeling. ---Wikipedia



https://www.google.com/url?sa=i&url=https%3A%2F%2Fwww.aiche.org%2Facademy%2Fwebinars%2Fapplied-statistics-exploratory-data-analysis&psig=AOvVaw36ZuxAJqz27dLqU5IFzBMO&ust=1570108849384000&source=images&cd=vfe&ved=0CAIQjRxqFwoTCJC1qLXV_eQCFQAAAAAAdAAAAAJ

Methodology

- Standardized mortality ratio (SMR) can be used to assess the mortality level of populations with different age structures, and the mortality trend in the same region.
- SMR measures overall mortality level w.r.t. to standard population (i.e., mortality index).

$$\mathbf{SMR} = \frac{\sum_x d_x}{\sum_x e_x} = \frac{\sum_x d_x}{\sum_x n_x u_x} = \frac{\text{\textit{\# of observed deaths}}}{\text{\textit{\# of expected deaths}}}$$

Lee-Carter Model

- Lee and Carter (1992) proposed a mortality model for forecasting (central) mortality rates

$$\ln(m_{xt}) = \alpha_x + \beta_x \kappa_t + \varepsilon_{xt}$$

where $\kappa_t \rightarrow$ mortality index in the year t

$\alpha_x \rightarrow$ average age-specific mortality.

$\beta_x \rightarrow$ deviation in changes of mortality index

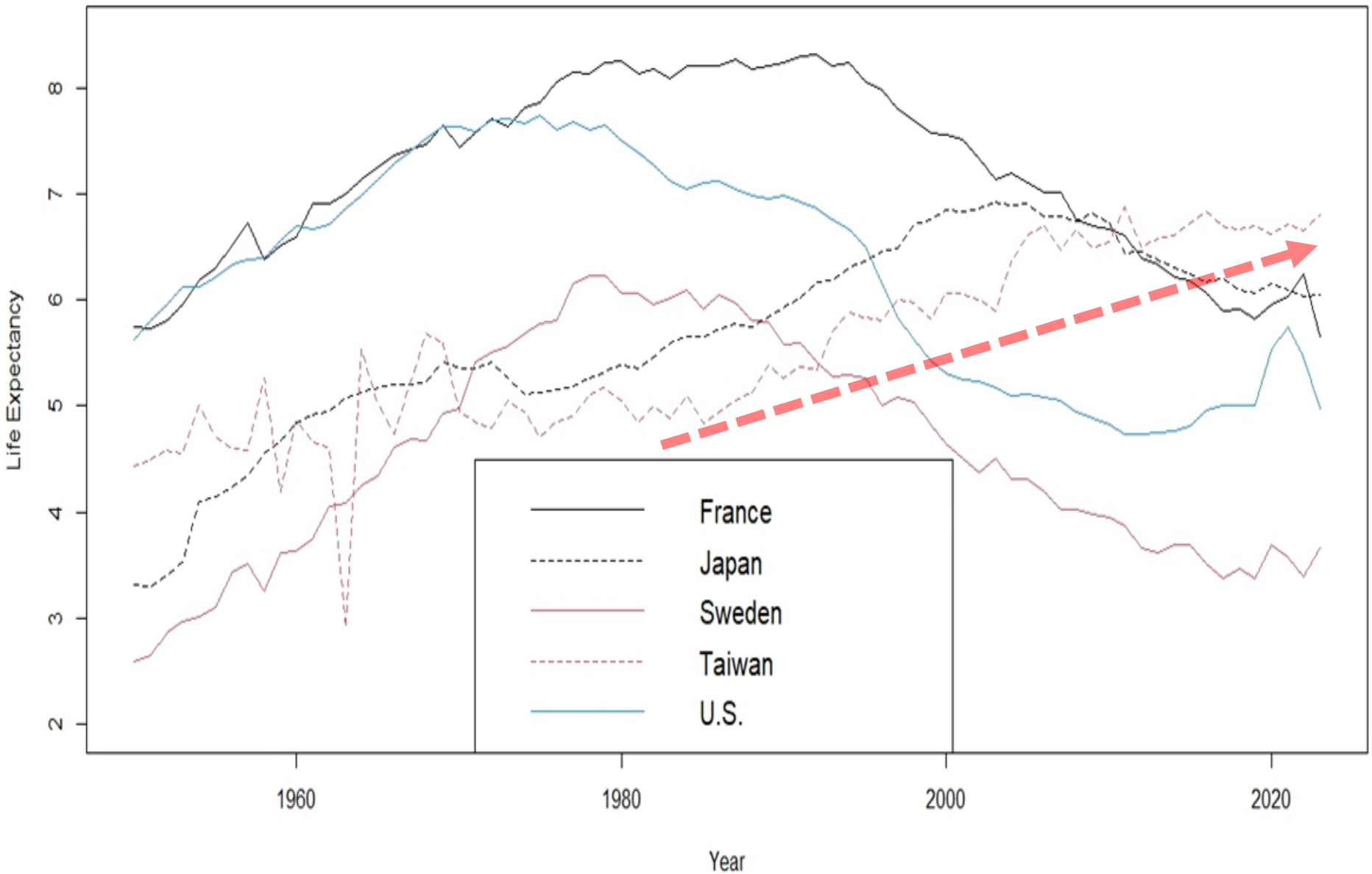
Note: $\beta_x \times \kappa_t$ can be used to measure annual change.

Gender Gap in Life Expectancy

- Gender gap in life expectancy varies a lot between countries and is usually not constant over time.
 - In general, women live longer than men.
- Gender gap is mostly inverted U-shaped but the maximum value varies from country to country.
 - Gender gap in Taiwan has been steadily increasing since 1980 (not U-shaped yet).



Gender Longevity Gaps in Selected Countries

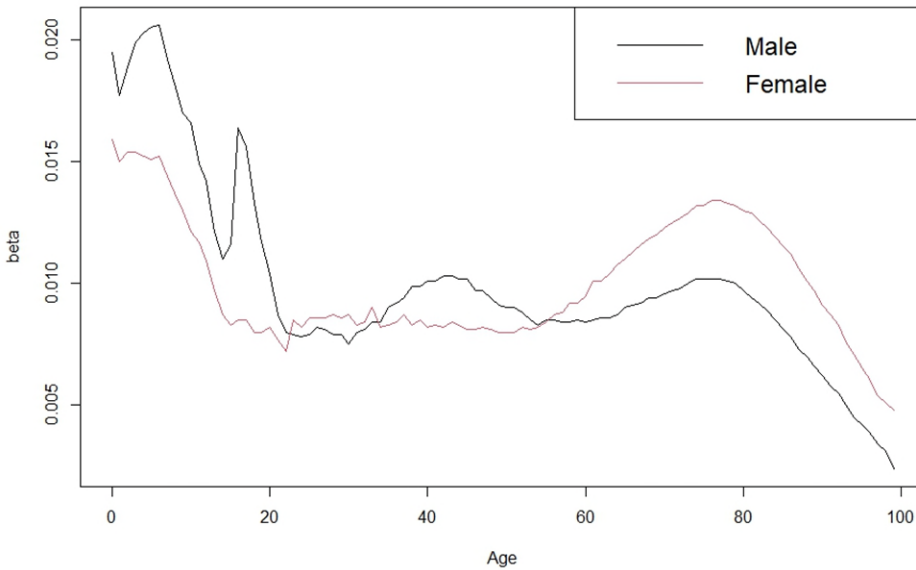


Mortality Trend via LC Model

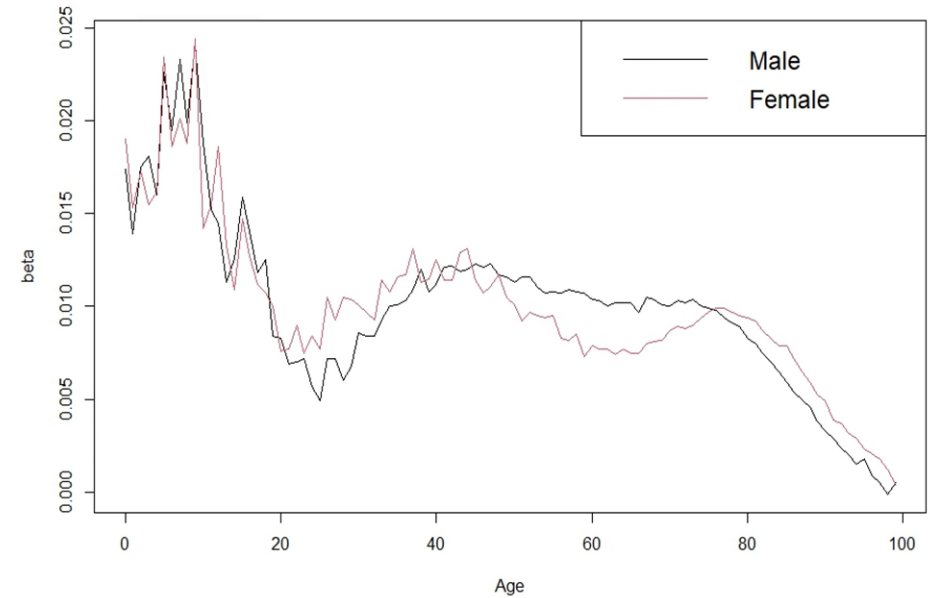
- Applying age-specific mortality rates to Lee-Carter model to assess life expectancy trends.
 - Examine improvement across sexes & age groups.
- We can use β_x estimates to roughly evaluate the gender gap trends of various countries.
 - Mortality improvement for women in Taiwan is significantly higher, while that in France, Japan, Sweden & U.S. is slightly lower than that for men.

β_x of Japan, Sweden, Taiwan, and U.S.

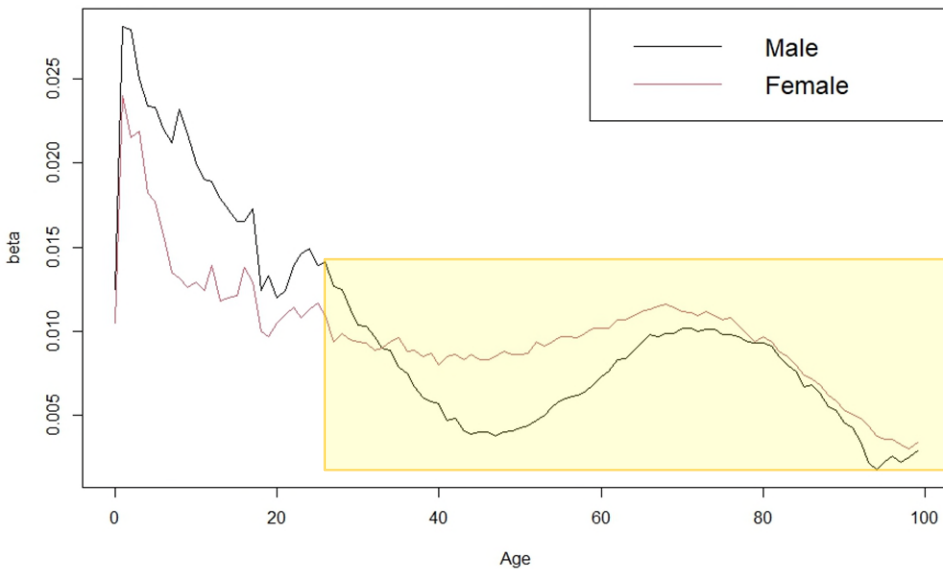
Japan



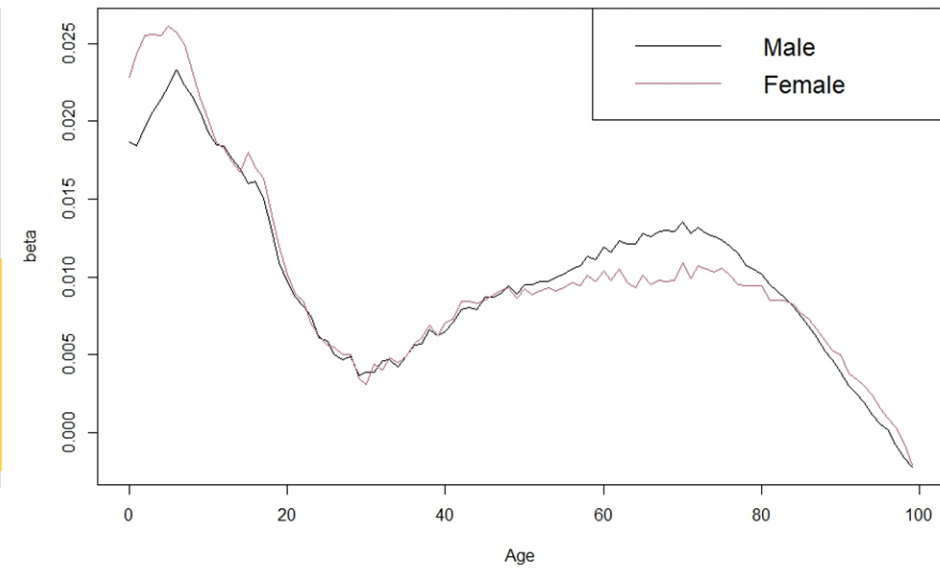
Sweden



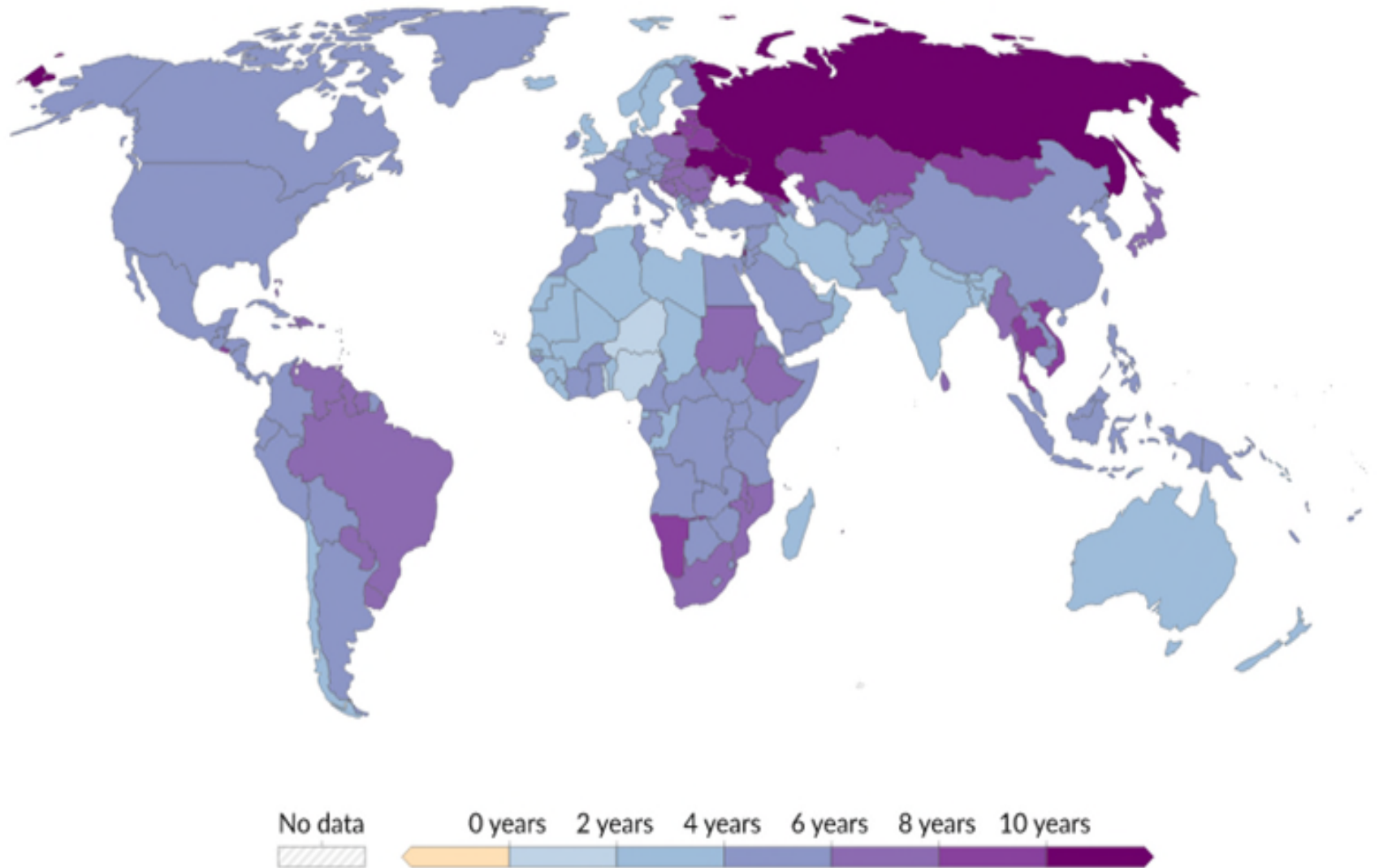
Taiwan



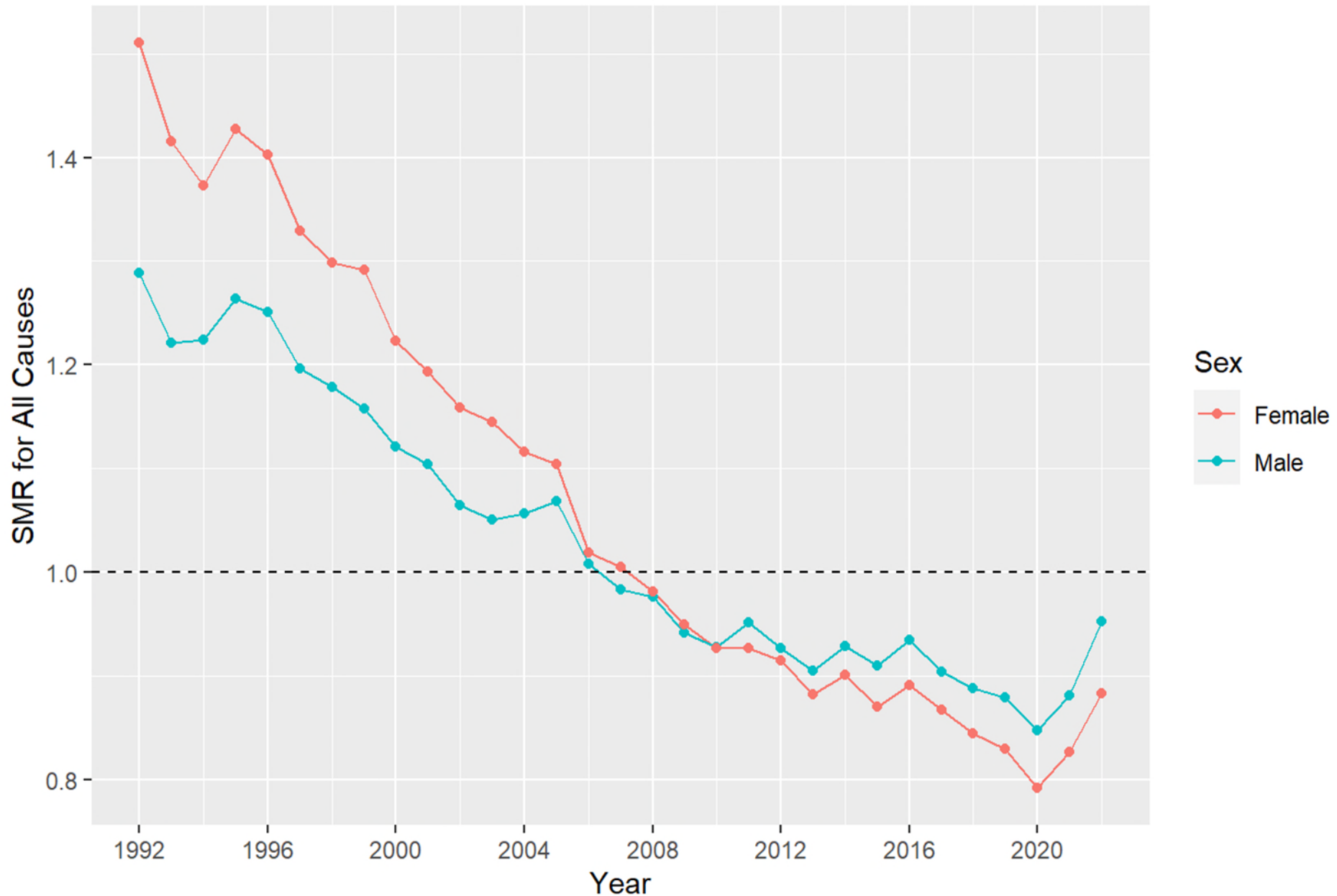
U.S.



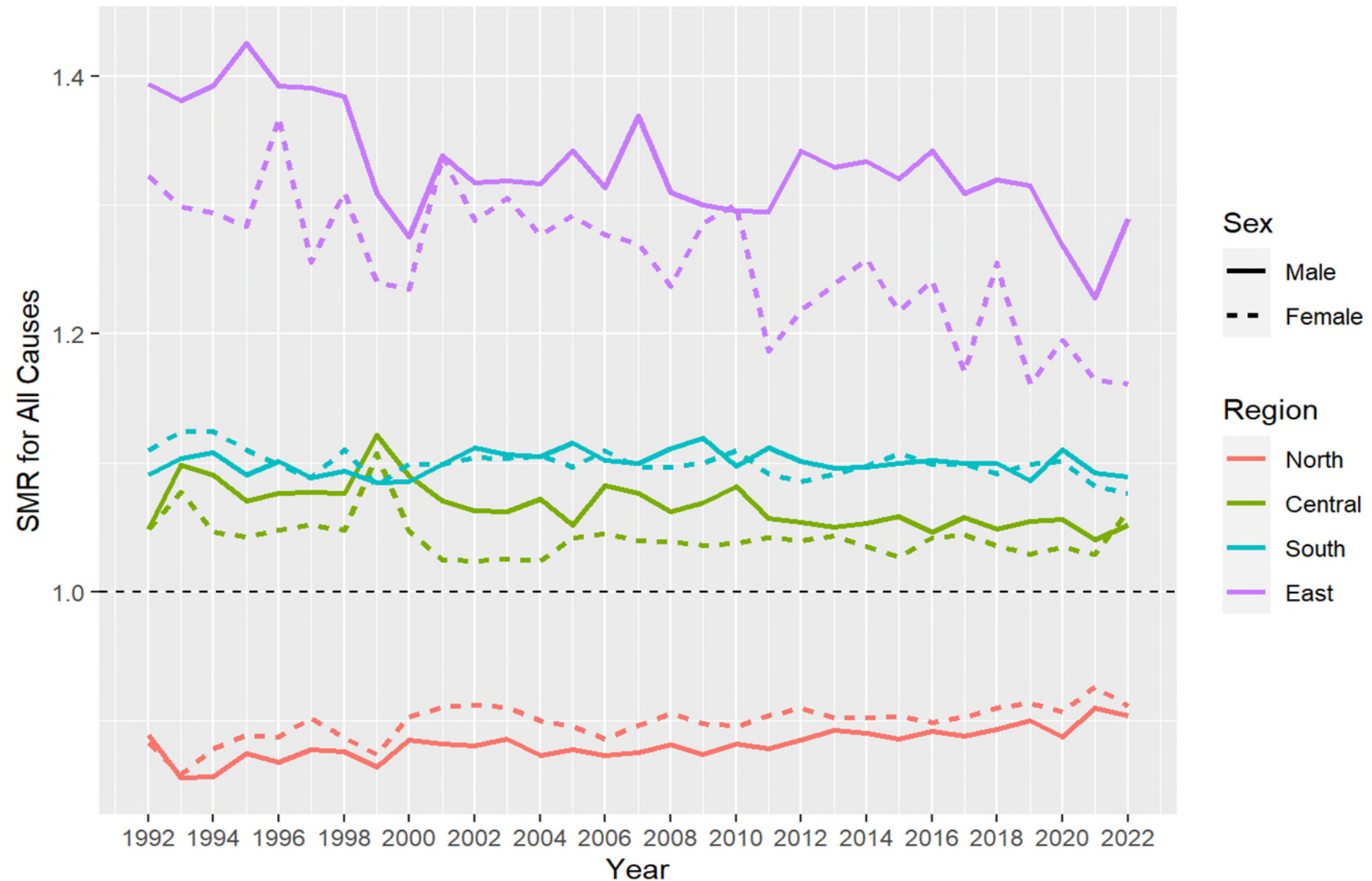
Spatiotemporal Analysis of Life Span Differences between Men and Women



Decrease in all-cause mortality (SMR)



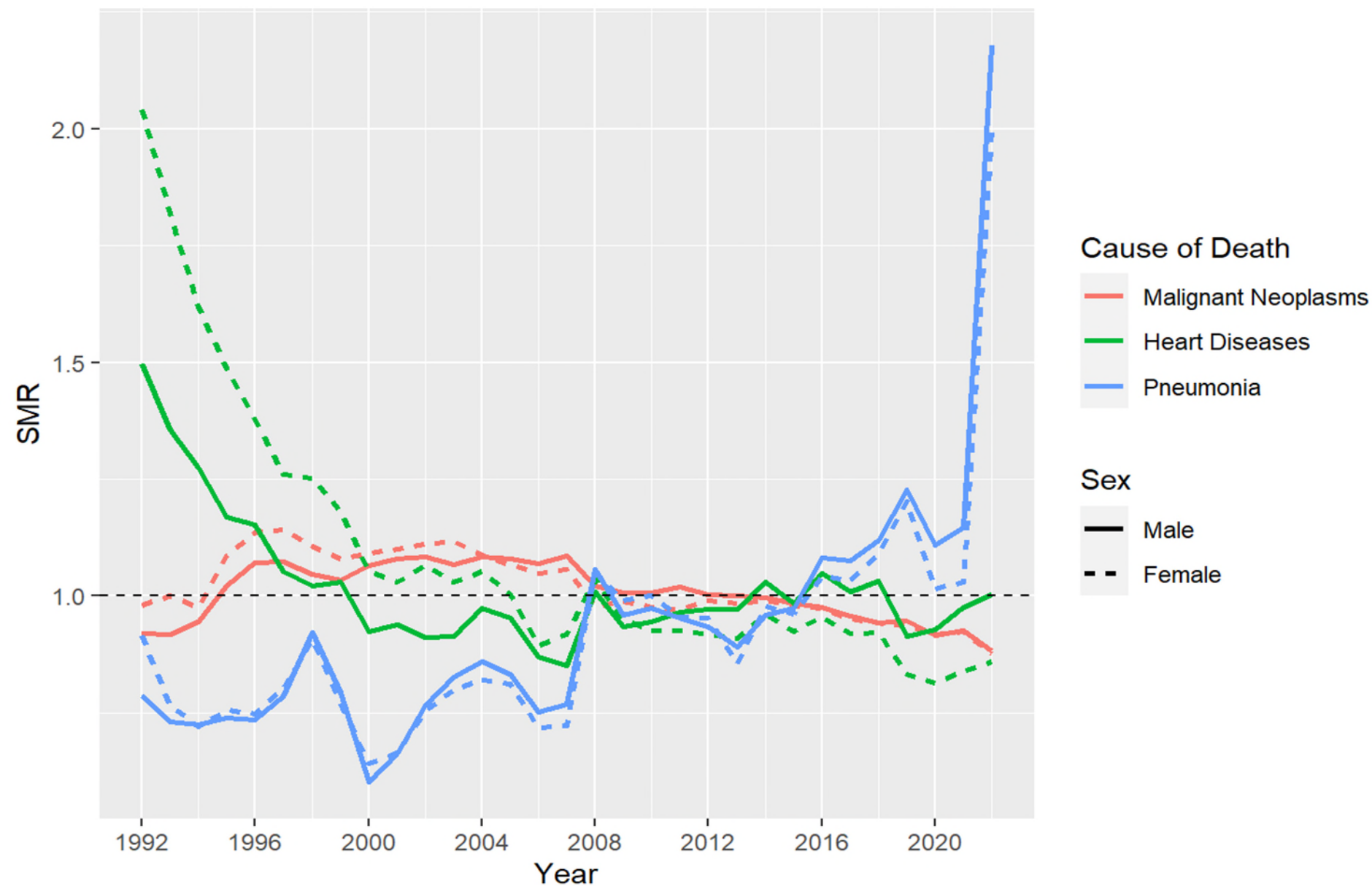
Decline in mortality Varies across Regions



County-wise Mortality in Taiwan

- ❑ Mortality rates increase from north to south and are inversely proportional to the population size.
→ Similar patterns were observed for all-cause mortality and major cause mortality.
- ❑ Time trends in all-cause and major-cause mortality rates were different.
→ Pneumonia-related mortality rates were rising before COVID-19.

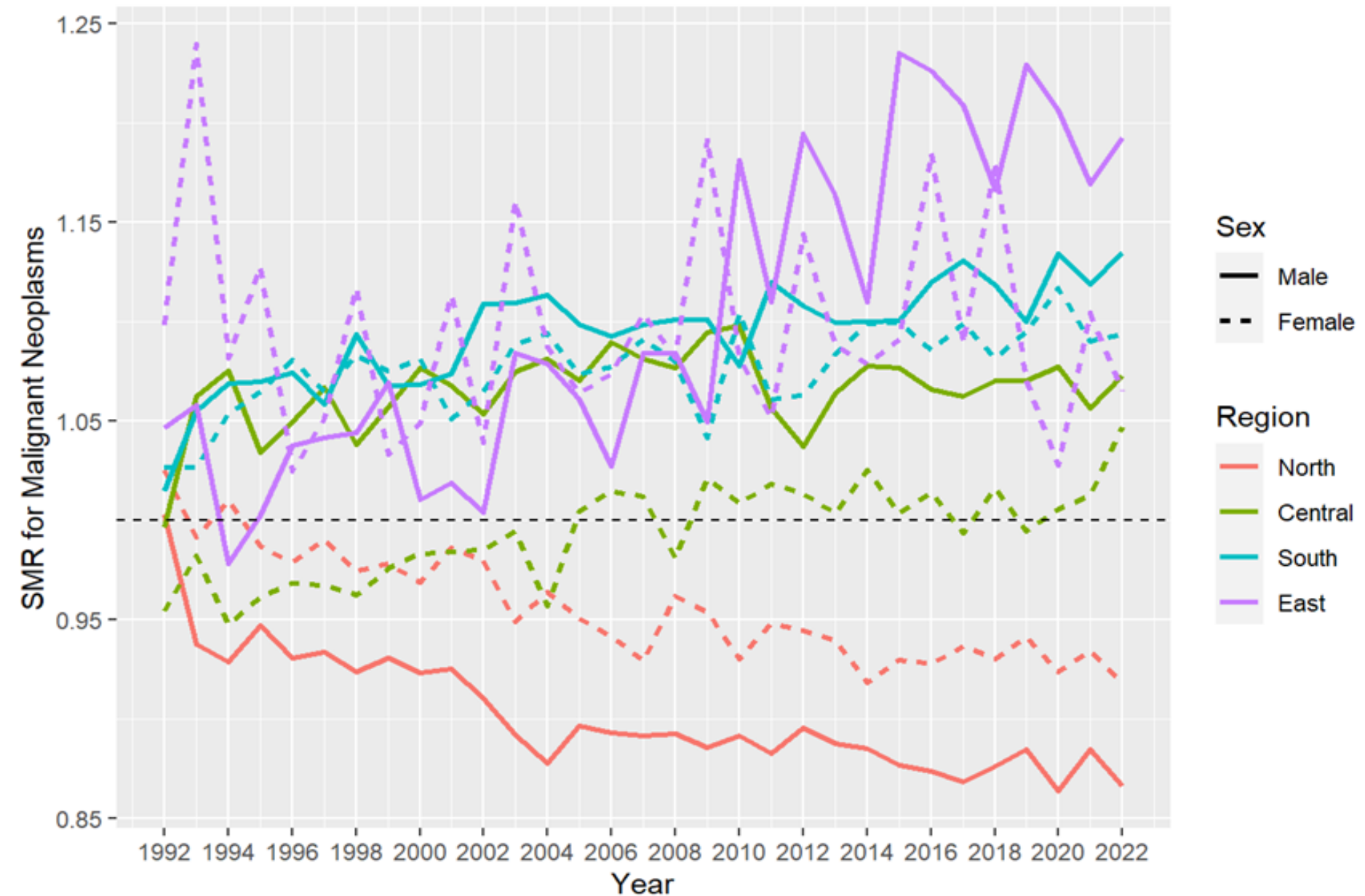
Trends for Three Major Death Causes



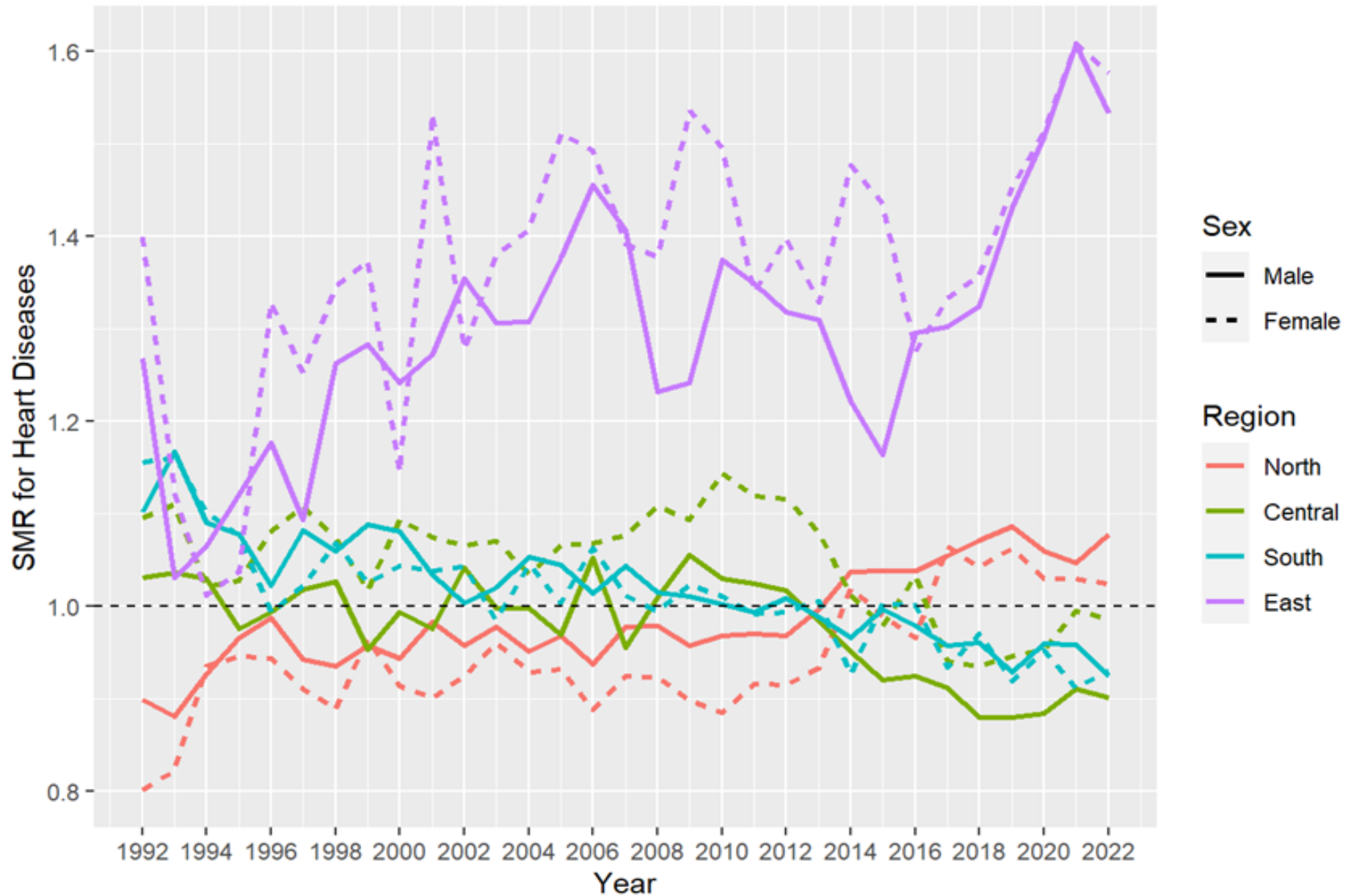
Regional Trends for Men and Women

- ❑ Trends in leading causes of death differed between men and women and between regions.
 - Only northern counties saw an obvious decline in cancer mortality rates.
 - Cardiovascular-related mortality rates increased significantly in eastern counties.
 - Pneumonia mortality rates in northern counties have gradually increased in recent years.

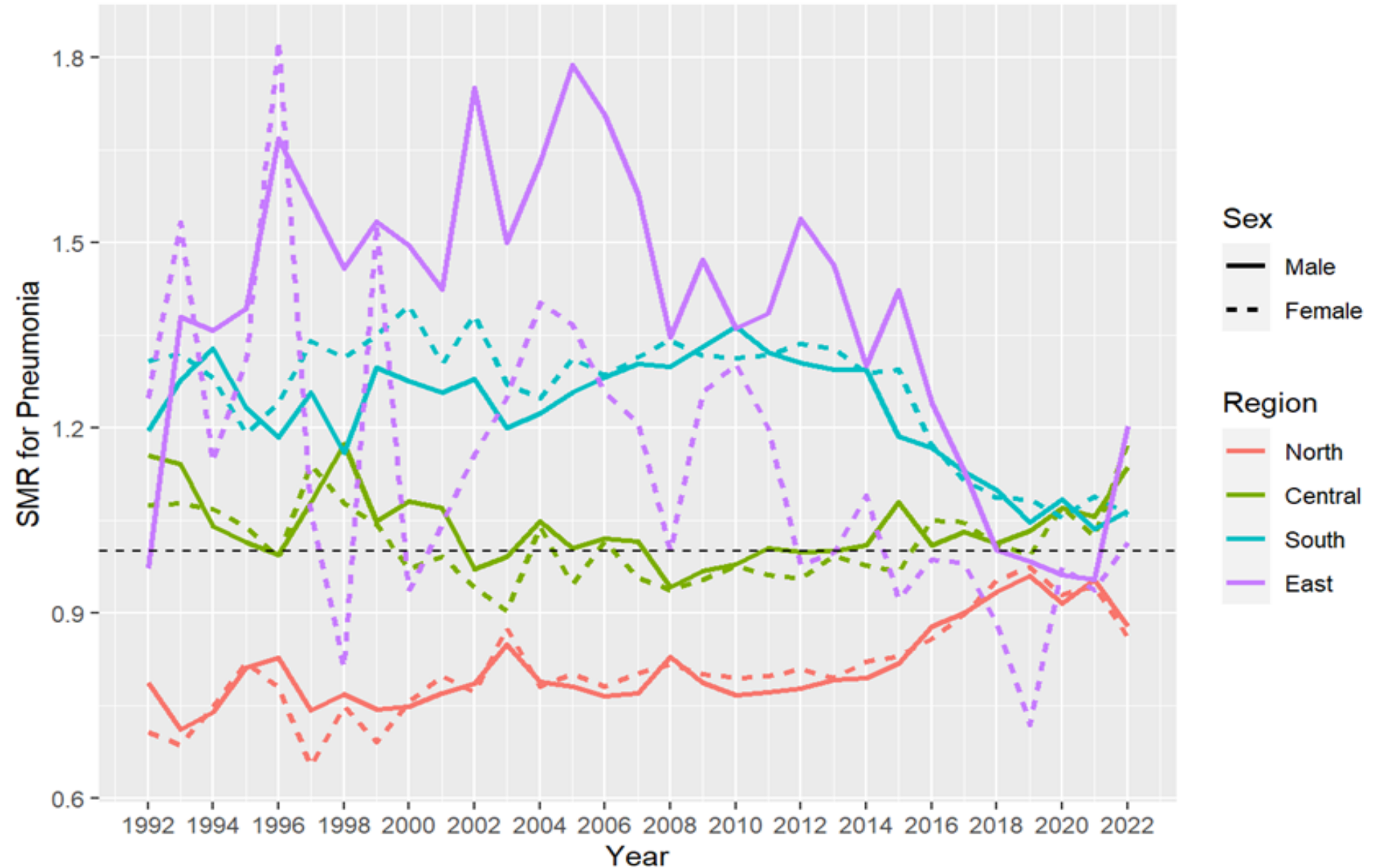
Cancer Mortality Trend (Gender & Region)



Heart Disease Trend (Gender & Region)



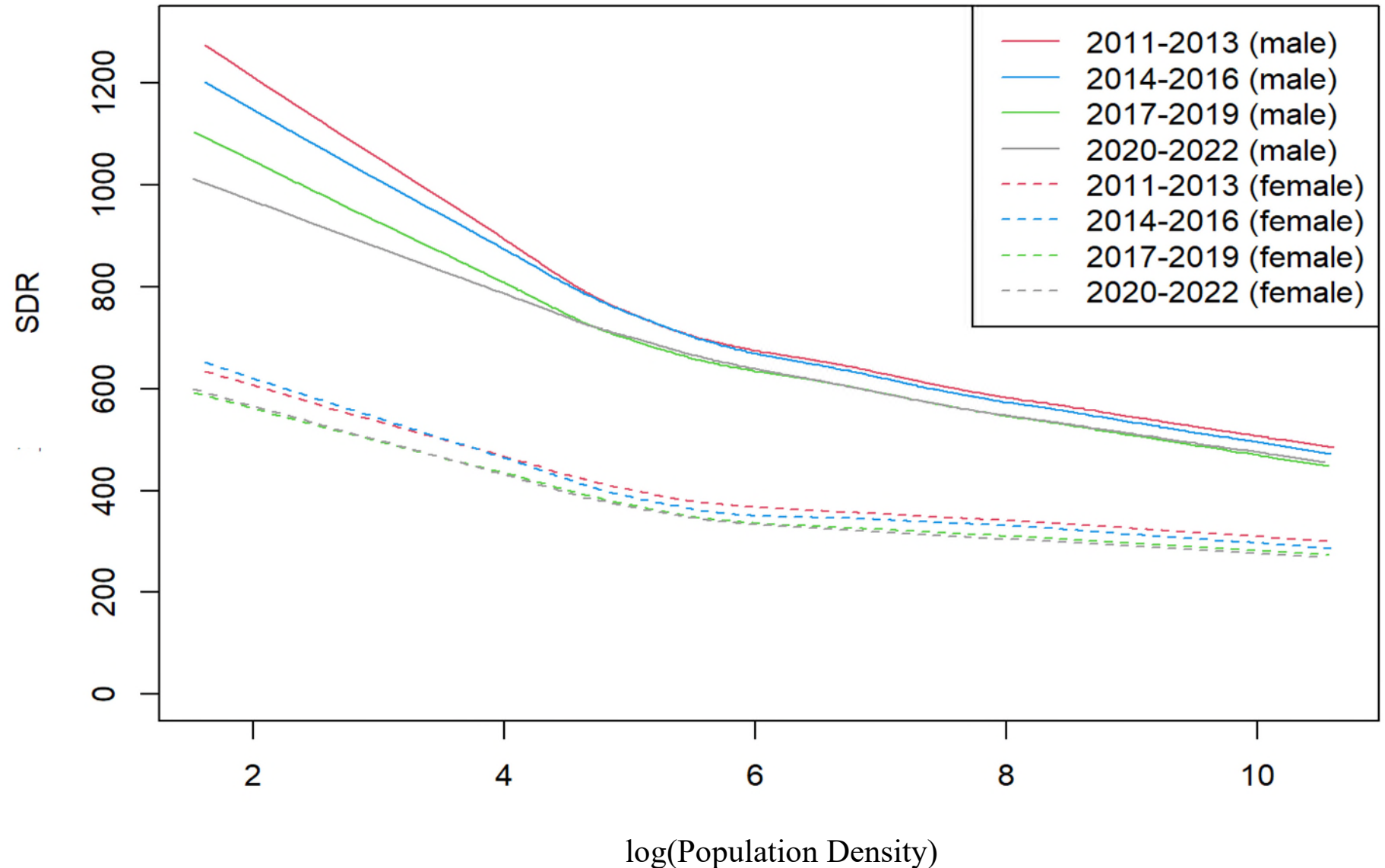
Pneumonia Trend (Gender & Region)



Standardized Death Rate (SDR)

- ❑ We can also use SDR to explore mortality trend.
 - SDR is to compare mortality rates between populations with different age structures, also known as age-standardized mortality rates
- ❑ We calculate the SDR of each region and then arrange them according to population density.
 - The most significant improvement in mortality rates was seen in less densely populated areas.

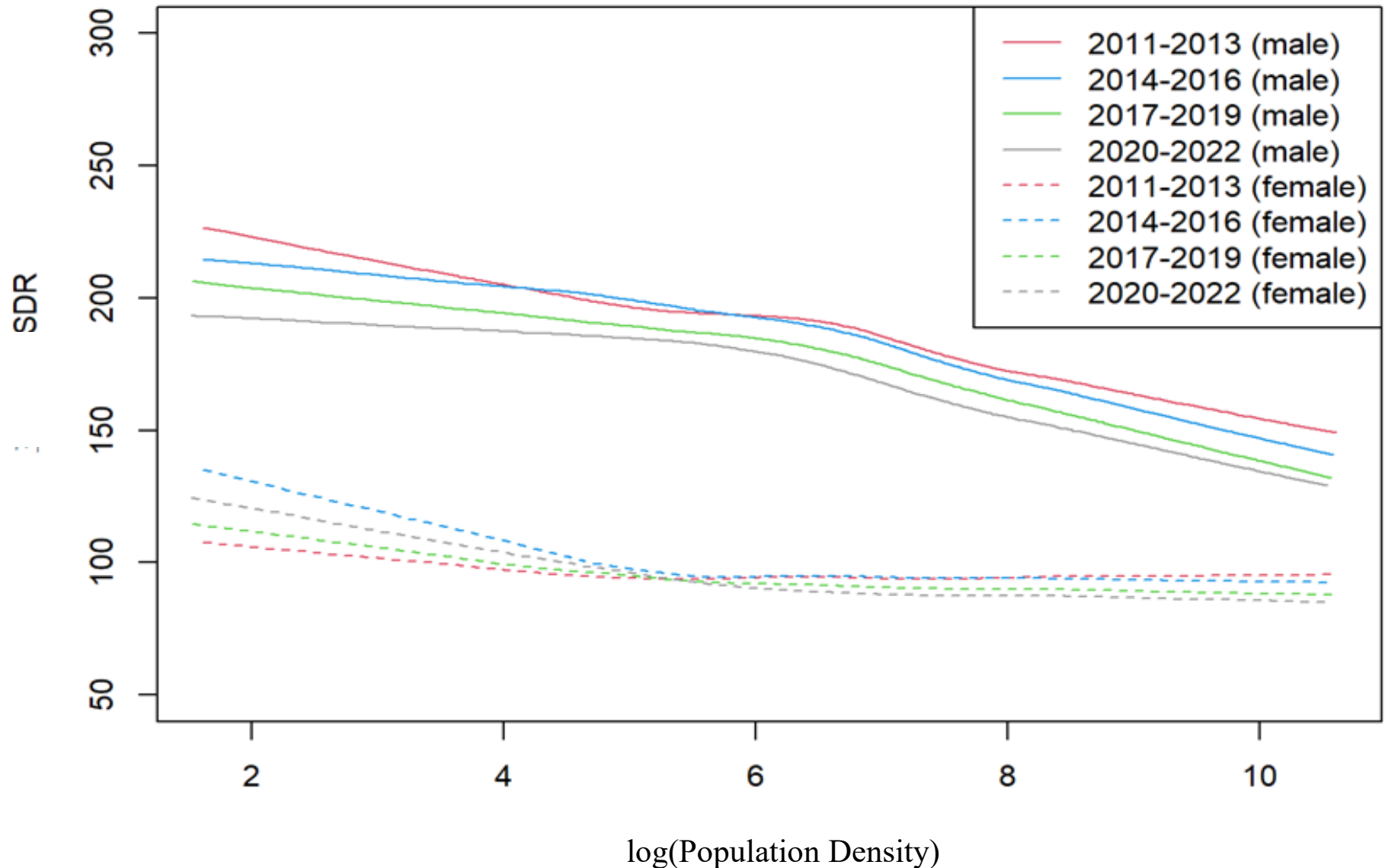
Regional Trend of All-cause Mortality (SDR)



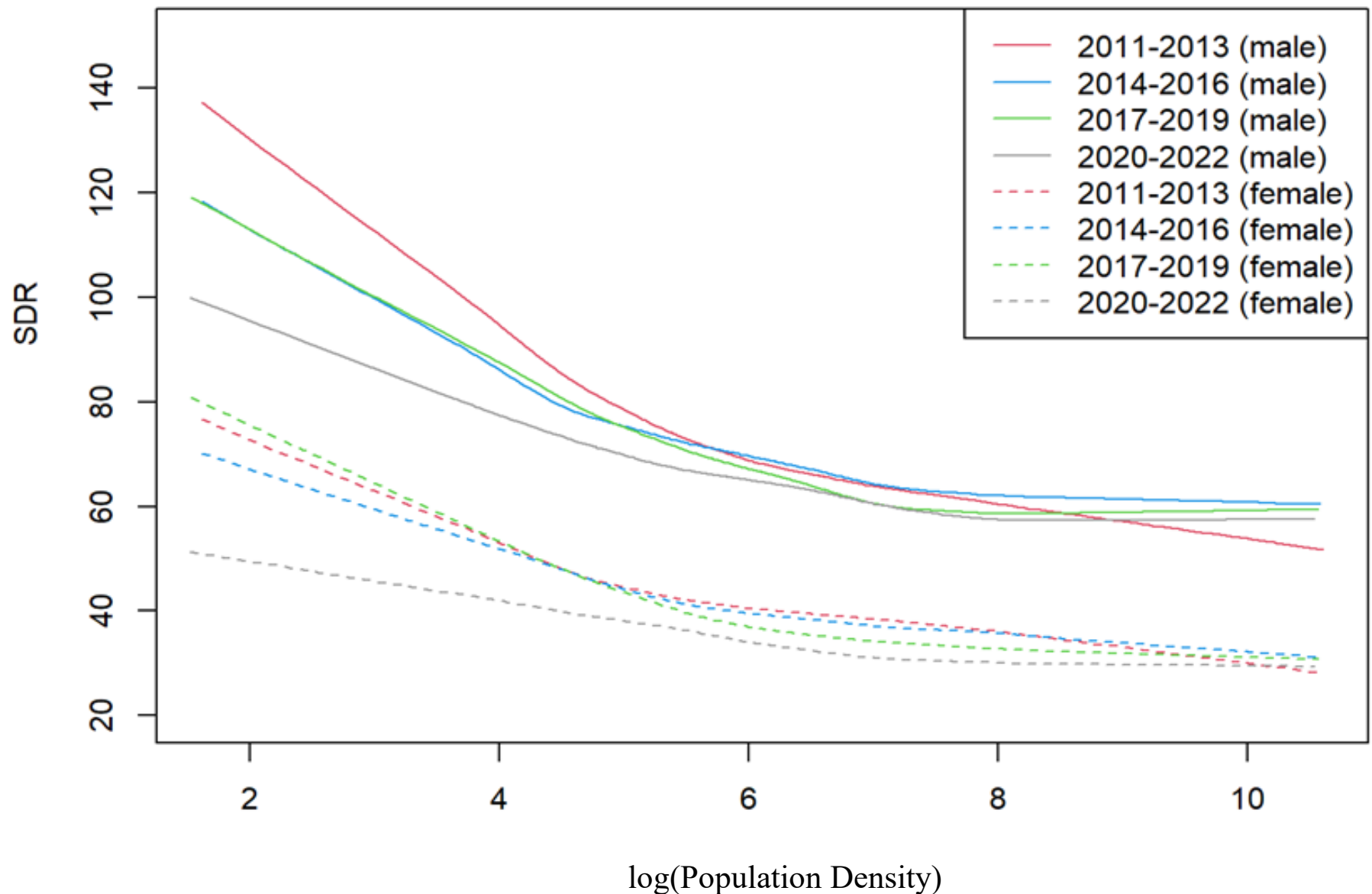
2020 Township-level SDR of Men and Women

	Men		Women	
	Moran' I	p-value	Moran' I	p-value
All-cause	0.5755	< 0.001***	0.3974	< 0.001***
Cancer	0.2486	< 0.001***	0.1826	< 0.001***
Heart Disease	0.4006	< 0.001***	0.2151	< 0.001***
Pneumonia	0.0487	< 0.001***	0.0667	< 0.001***

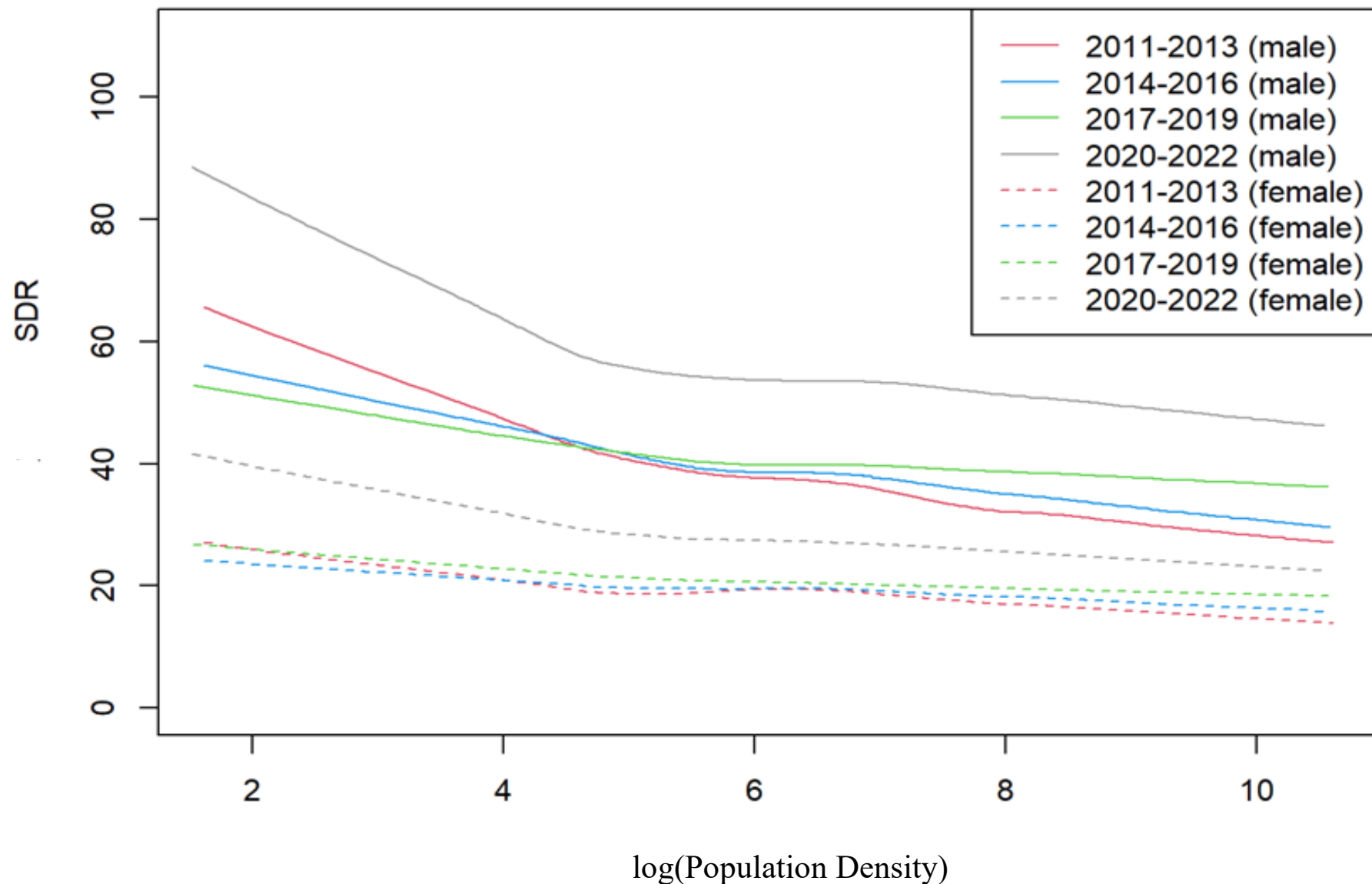
Regional Trend of Cancer (SDR)



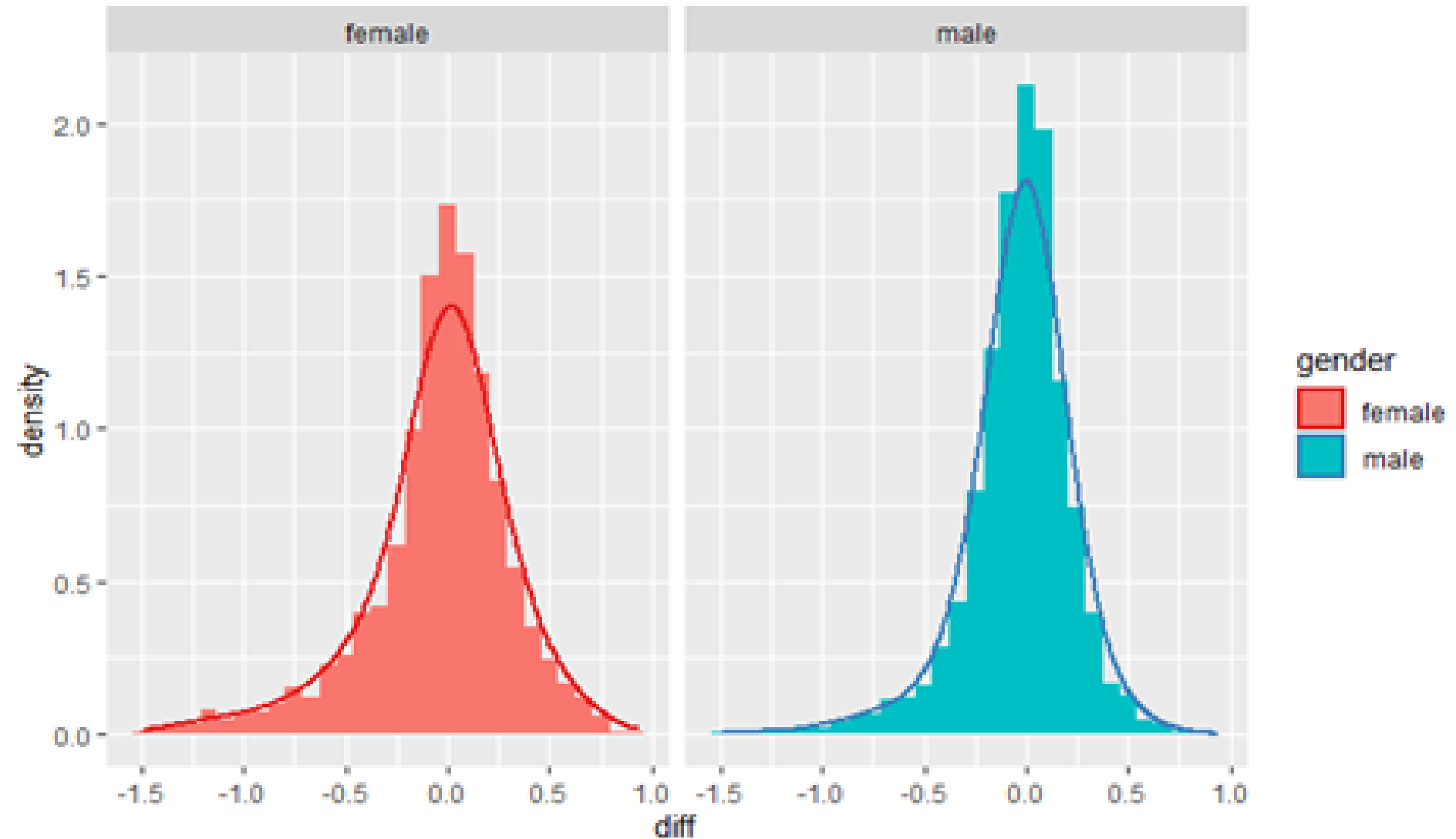
Regional Trend of Heart Disease (SDR)



Regional Trend of Pneumonia (SDR)

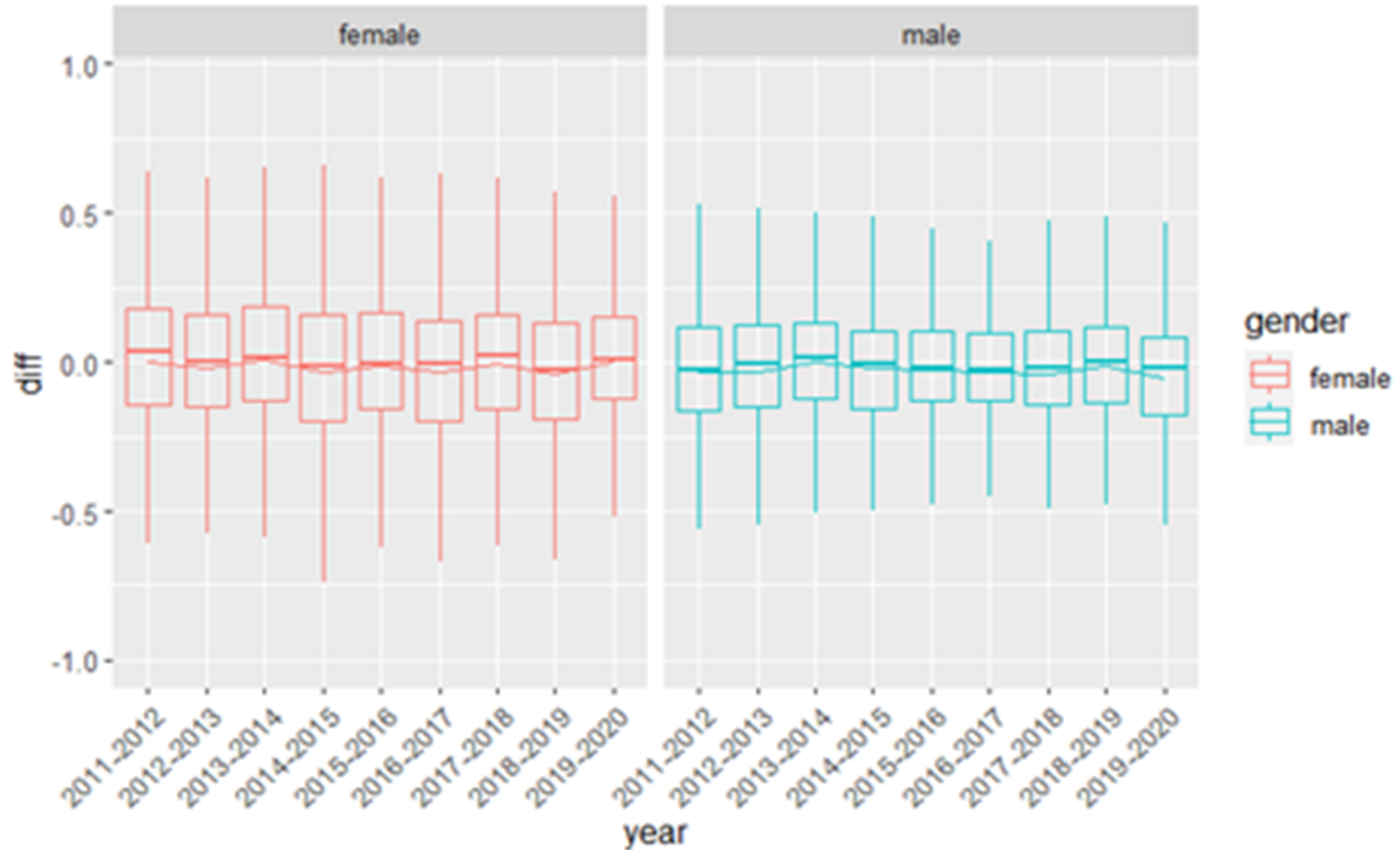


Cancer SDR Changes in adjacent years



Note: Apply Moran's I to check the spatial homogeneity of changes of cancer SDR in adjacent years.

Cancer SDR changes in adjacent years are spatially homogeneous!!





Conclusion

- ❑ Taiwan's life expectancy continues to rise, but at different rates across regions.
 - Life span gap between regions is narrowing, and the SDR changes in adjacent years across regions are spatially homogeneous.
- ❑ Men and women had similar changes in mortality, but the improvement was slightly greater in women.
 - Gender gap in Taiwan's life expectancy widens.



Limitations

- Results are based on national data and may not apply to those purchasing life insurance.
 - Marital status mortality rates may vary in different regions.
- Other possibilities of including marital status
 - Health insurance, joint-life insurance
 - Mortality models

Thank you
for your Attention!

