Comparison of COVID-19 incidence and mortality between rural and urban areas in Catalonia

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ABSTRACT

Background. COVID-19 has had a different impact on multiple aspects, depending on the county or region where it has been studied. Therefore, in this study we have established the differences in terms of the variables of incidence and mortality between the regions of "La Garrotxa" and "Barcelonès".

Methods. This analytical and observational study compares incidence and mortality between "La Garrotxa" and "Barcelonès" regions due to COVID-19 during the period March 1, 2020 - September 30, 2021. To this end, we have standardized the data by age and sex distribution using the direct method to calculate the cumulative incidence and the indirect method to determine the mortality ratio.

Results. The cumulative incidence of COVID-19 is higher in the region of "La Garrotxa" (139 / 1,000 inhabitants in men and 142 / 1,000 inhabitants in women) than in that of "Barcelonès" (125 / 1,000 inhabitants and 109 / 1,000 inhabitants, respectively). On the other hand, mortality ratio due to COVID-19 is higher in "Barcelonès" (1,226 in men and 1,891 in women) than in "La Garrotxa" (0.990 in men and 1,498 in women).

Conclusion. The incidence of COVID-19 is higher in "La Garrotxa" than in "Barcelonès" and the mortality due to COVID-19 is higher in "Barcelonès". For this reason, prevention

measures for the disease should be implemented taking into account the individual characteristics of each population, such as the distribution by age and sex.

Key words: COVID-19, Incidence, Mortality, Age groups, Sex

RESUM

Antecedents. La COVID-19 ha tingut un impacte diferent en diversos aspectes, segons la comarca o regió en la que ha estat estudiada. Per consegüent, en aquest estudi hem establert quines són les diferències en quant a les variables d'incidència i mortalitat entre les comarques de la Garrotxa i el Barcelonès.

Mètodes. Aquest estudi analític i observacional compara la incidència i la mortalitat entre la comarca de la Garrotxa i el Barcelonès degudes a la COVID-19 durant el període 1 març de 2020 - 30 setembre de 2021. Amb aquest objectiu, per una banda hem estandarditzat les dades per distribució d'edat i sexe utilitzant el mètode directe per calcular la incidència acumulada i el mètode indirecte, per determinar la raó de mortalitat.

Resultats. La incidència acumulada de COVID-19 és major en la comarca de la Garrotxa (139/1.000 habitants en homes i 142/1.000 habitants en dones) que en la del Barcelonès (125/ 1.000 habitants i 109/1.000 habitants, respectivament). Per contra, la raó de mortalitat deguda a la COVID-19 és major al Barcelonès (1,226 en homes i 1,891 en dones) que a la Garrotxa (0,990 en homes i 1,498 en dones).

Conclusions. La incidència de COVID-19 és major a la Garrotxa que al Barcelonès i la mortalitat deguda a la COVID-19 és major al Barcelonès. Per aquest motiu, les mesures

de prevenció de la malaltia s'haurien d'implantar tenint en compte les característiques individuals de cada població, com serien la distribució per edat i sexe.

INTRODUCTION

COVID-19 is an acute respiratory disease caused by SARS-CoV-2, a virus that belongs to the coronavirus family. This family of viruses cause various diseases that range from a common cold to, in worse cases, pneumonia. In late December 2019, a new coronavirus was identified in Wuhan: SARS-CoV-2, however, it was not until March 2020 that the WHO (World Health Organization) declared the current state of pandemic. Over the last two years, it has been established a recurrent, wave-like pattern to the virus presence in our society.

After having done some research, we have found that several authors have suggested a possible relation between higher density areas and greater cases of COVID-19 (Ref. 1,2). Nevertheless, other studies show a different conclusion (Ref. 3) as they state that rural areas have higher incidence. As there is no clarifying conclusion, we propose such a study.

Since its breakout, in Catalonia there have been over two million confirmed cases and close to thirty thousand deaths. Even though raw data of cases are available, there are no studies analysing them. In order to solve the scarcity of treated data available linking incidence with population density in Catalonia, we have found ourselves with another motive to proceed with this research. Another reason for this study is the lack of knowledge on how COVID-19 has influenced rural and urban areas.

“La Garrotxa” is a rural region in the province of Girona, in northeast Catalonia. It has a population of 59.163 as of 2021 and a population density of 80,5 inhabitants/km^2. In “La Garrotxa”, 20,35% of the total population is >65 years old and the ageing index is 130,12 (Ref. 4). On the other hand, “Barcelonès” is an urban region where almost half the Catalan population live there, about 2.280.967 inhabitants, resulting in a population density of 15.649,9 inhabitants/km^2. In “Barcelonès”, 20,81% of the total population is >65 years old and the ageing index is 149,02 (Ref. 5).

We theorize that “Barcelonès”, being the area that has a greater population density, will have a larger incidence of COVID-19 due to the increased difficulty of maintaining enough social distancing. As for the mortality, we believe it to be higher in “Barcelonès” because it has an elder population than “La Garrotxa".

Regarding our secondary objectives, we do not think there are any differences in terms of incidence or mortality between sex groups in the regions analysed. When it comes to age-distribution groups, we believe the group of 80+ will have the highest mortality in both regions.

Our main objective is to determine incidence comparative index and mortality ratio in the region of “La Garrotxa” compared to “Barcelonès”. Furthermore, we have also sought to compare results between sex groups and age-distribution groups inside each region.

MATERIAL AND METHODS

This is a descriptive study that has regions, age and sex as independent variables and cumulative mortality and cumulative incidence of COVID-19 as dependent variables.

For this study, all cases of COVID-19 were extracted from IDESCAT (Statistical Institute of Catalonia) (Ref. 6) and the "*Portal dades obertes de Catalunya*" (Ref. 7).

From all the data available, we established that the inclusion criteria for our study were: having had or died from COVID-19, region ("La Garrotxa" & "El Barcelonès"), period of time (from 01/03/2020 to 30/09/2021) and age distribution (0-9, 10-19, 20-29, 30-39, 40-49, 50-59, 60-69, 70-79, 80+).

To carry out the calculations, we need the number of deaths in Catalonia over the period of time studied and the total population of "La Garrotxa", "Barcelonès" and Catalonia as of 1st January 2020.

Amongst all the data available, we have encountered some that are not correctly indexed in the data banks and do not have the independent variables studied specified. Since we can discern neither sex nor age-group from such data, we have excluded them from our calculations.

From the collected data it has been calculated the cumulative incidence and cumulative mortality of COVID-19 for "La Garrotxa" and "Barcelonès" for each group of sex and age distribution using the following formulas:

$$Cumulative\ incidence = \frac{New\ cases\ of\ COVID-19}{Total\ number\ of\ individuals\ in\ the\ population\ at\ risk\ at\ the\ beginning\ of\ the\ period}$$

$$Cumulative\ mortality = \frac{Number\ of\ deaths\ by\ COVID-19}{Total\ population}$$

In order to compare the results obtained, we standardized the data as the population of both regions highly differ in numbers of inhabitants and age distribution.

By using the direct standardization approach to compare COVID-19 incidence we calculated the age-standardized cumulative incidence for the two regions within both sex groups considering the population of Catalonia as the standard. Firstly, we calculated the expected cases of COVID-19 at "La Garrotxa" and "Barcelonès" for either age distribution and sex group.

Later, we calculated the age-standardized cumulative incidence:

$$\text{Age standardized cumulative incidence} = \frac{\sum \text{Expected cases in all age groups}}{\text{Total catalan population (1st january 2020)}}$$

Finally, an incidence comparative index has been established:

$$\text{Incidence comparative index} = \frac{\text{Age} - \text{standardized cumulative incidence in "La Garrotxa"}}{\text{Age} - \text{standardized cumulative incidence in "Barcelonès"}}$$

Due to low death numbers in our region (<50), we used the indirect standardization method to determine the mortality ratio of both sex separately using the cumulative mortality of Catalonia as the standard.

$$\text{Cumulative mortality} = \frac{\text{Catalonia deaths by COVID} - 19}{\text{Total catalan population (1st january 2020)}}$$

We have also calculated the expected deaths for age distribution and sex groups for "La Garrotxa" and "Barcelonès".

Finally, by using the expected deaths calculated, we can determine the mortality ratio:

$$\text{Mortality ratio} = \frac{\sum \text{Observed deaths for age distribution}}{\sum \text{Expected deaths for age distribution}}$$

In order to justify the differences that we might encounter between age-groups when analysing the results, we have decided to calculate the Sundbärg Index to see the ageing pattern of both regions. This index is calculated by dividing the population in three age groups: youth (0-19 years old), adults (20-49 years old), elderly (50-80+ years old).

With the above-mentioned distribution, we proceeded to calculate the Sundbärg indexes and their relation:

$$\text{Index 1} = \frac{\text{Youth}}{\text{Adults}} \qquad \text{Index 2} = \frac{\text{Elderly}}{\text{Adults}}$$

$$\text{Relation Sundbärg indexes} = \frac{\frac{Youth}{Adults}}{\frac{Elderly}{Adults}}$$

The Sundbärg Indexes are calculated with the youth group being between 0-15 years old and the adults between 16-49 years old. In our study we have had to change the age-group distributions to adapt to the available data, which was organized every 10 years.

RESULTS

The cumulative incidence, mortality ratio and cumulative mortality results are expressed per 1000 inhabitants in order to facilitate the comparison of the values.

Our estimates showed an age-standardized cumulative incidence in “La Garrotxa" of 140 for men, and 142 for women between March 2020 until September 2021. As for the cumulative incidence of “Barcelonès”: 125 for men, and 109 for women (Figure 1). Apropos the comparative index, we determined that the cumulative incidence for “La Garrotxa” is 1,115 times greater for men and 1,298 for women when compared to Barcelona. However, when looking at mortality ratio results, for “La Garrotxa” we have obtained 0,989 for men and 1,498 for women. Whilst for “Barcelonès”, mortality ratio is 1,226 for men and 1,891 for women (Figure 2).

Additionally, we compared the cumulative incidence and cumulative mortality between men and women within each region by using non-standardized data. In reference to “La Garrotxa”, the cumulative incidence is 139 for men and 140 for women and cumulative mortality is 2,1 for men and 1,1 for women. Whereas in “Barcelonès”, the cumulative incidence is 126 for men and 122 for women and cumulative mortality is 2,5 for men and 1,3 for women.

We also compared the incidence and mortality within the different age groups from each region (Figure 3a; Figure 3b; Figure 4a; Figure 4b).

Regarding men and women from “La Garrotxa”: the highest cumulative incidence belongs to the 10-19 age distribution group and the lowest cumulative incidence belongs to the 80+ age distribution group.

Regarding men from “Barcelonès”: the highest cumulative incidence belongs to the 20-29 age distribution group and the lowest cumulative incidence belongs to the 0-9 age distribution group.

Regarding women from “Barcelonès”: the highest cumulative incidence belongs to the 20-29 age distribution group and the lowest cumulative incidence belongs to the 80+ age distribution group.

In all three cases, the highest cumulative mortality belongs to the 80+ age distribution group.

When it comes to the Sundbärg Indexes and the calculation of their relation, we have obtained a value of 0,489 for “La Garrotxa” and 0,455 for “Barcelonès”. These results indicate that both are regressive populations, barcelonians being slightly older.

With reference to the wrongly indexed data, a total number of 8.878 confirmed cases out of 893.404 (1% approximately) and 3.478 deaths out of 14.708 (24% approximately) were not considered for our calculations.

DISCUSSION

The incidence of COVID-19 is higher in “La Garrotxa” whereas mortality is higher in “Barcelonès”. Concerning sex groups, cumulative incidence, is slightly superior in the “Barcelonès” men group. When it comes to cumulative mortality, men of both regions present a higher value. Regarding age groups, in “La Garrotxa” the 10-19 group and in “Barcelonès” the 20-29 groups have the highest incidence whilst the 80+ group has the highest mortality in both regions.

According to the results obtained from the statistical analysis, we observe that there is a higher incidence in “La Garrotxa” than in “Barcelonès” (comparative index for men 1,115 and for women 1,298). This result does not follow our initial hypothesis, which stated a higher incidence in “Barcelonès”. We have found studies stating that this might be due to difficulties when implementing prevention measures in rural areas (Ref. 8). Another reason may be because of a lower vaccination rate in rural areas, as an 80% of the total population from “La Garrotxa” is vaccinated, whereas in “Barcelonès” is 85,57% (Ref. 9). In addition, due to the quarantine started on March 2020, there was a big exodus of citizens from urban areas to rural areas (Ref. 10). This could have had a direct impact on the COVID-19 incidence in these areas.

On the other hand, when it comes to mortality ratio, the results show that it’s higher in the “Barcelonès” region (1,226 for men and 1,891 for women in “Barcelonès”; 0,989 for men and 1,498 for women in “La Garrotxa”). This goes along with our hypothesis. This could be due to having a higher polluted environment, degrading the health state of its inhabitants and making them more susceptible to suffering more severe cases of COVID-19. (Ref. 11, 12). Moreover, as an additional reason, the Sundbärg Index in “Barcelonès”

is slightly higher than in “La Garrotxa”, which means that its population is older and has higher chances of developing more severe cases of COVID-19 (Ref. 13).

Regarding COVID-19 incidence between men and women, we have not found any studies that present differences between sex, but we have encountered contradictory information concerning COVID-19 mortality from different studies (Ref. 14, 15).

As per our results for the cumulative incidence between men and women within “La Garrotxa”, there is no apparent difference (139 and 140 respectively). Nonetheless, when looking at the results from “Barcelonès”, we see a slightly higher incidence in men than women (126 and 122 respectively).

When it comes to the cumulative mortality, there is a difference in both “La Garrotxa" (2,1 for men and 1,1 for women) and “Barcelonès” (2,5 for men and 1,3 for women), since our results show higher numbers in men than women. Our results concur with what we have found in some studies (Ref. 16 and 17) as they conclude that there is a higher mortality rate among men because of, as stated by <Tu Haitao, Jane V. Vermunt, Jithma Abeykoon, Et Al.>, s*everal social, behavioral, and comorbid factors are implicated in the generally worse outcomes in men compared with women* (Ref. 18).

When it comes to differences in age groups, a study conducted in the United States shows that at the more advanced stages of the COVID-19 pandemic the incidence was higher in the younger population (Ref. 19).

With reference to the variations in incidence and mortality within age-groups, we have found there are differences neither in regions nor sex. With these results we can conclude that apparently there is a higher incidence in the youngest groups and higher mortality in the eldest.

All these data and results obtained in our study could be useful in terms of designing and implementing public health measures to hinder the advancement of COVID-19 as we have seen differences between age, sex and regions.

Our study has several strengths and limitations. As an upside, it requires few resources to compute all the data as well as it does not need monitorization of patients for large periods of time. Additionally, it can also be carried out by the data already collected worldwide by other trustworthy institutions publicly available, thus allowing to obtain results in a quick manner. As our topic of study concerns COVID-19, all the articles and information are free of use and easily accessible. Despite this, the nature of our study has intrinsic limitations, mainly due to our high dependence upon the available data, which was biased at the beginning of the pandemic due to being underreported because of a lack of resources and a well-established detection system. Moreover, in the region of "La Garrotxa", there were not enough deaths to proceed with the direct method, so we had to use the indirect method. Another limitation that we encountered when calculating the Sundbärg Index we had to adapt the formula to best replicate the original methodology. Although when selecting the data from "*Portal dades obertes de Catalunya"* we had to exclude some wrongly indexed information; since it was only 1% of the total confirmed cases available in the data bank, there was not a huge impact on the results. However, excluded data from confirmed COVID-19 deaths rose to a total of 24%, which might produce a negative impact on the results. Another limitation we encountered is that the data used for this study manifests the broad situation of regions, not the individualized characteristics of its inhabitants, such as: socioeconomic situation, other comorbidities, suburbs of residence, exposure to pollution, level of education and so on.

Furthermore, COVID-19 is a recent disease, and as such, many things stated about it still require further investigation.

CONCLUSION

The incidence of COVID-19 in “La Garrotxa” is higher than in “Barcelonès” whereas mortality is higher in “Barcelonès” than in “La Garrotxa”.

Public health measures implemented by the government should be individualized as we have observed that COVID-19 does not have the same impact on every region.

We propose that more in-depth studies should be carried out to improve epidemiological behaviour knowledge of COVID-19 in the geographical area studied as well as in Catalonia.

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Tasks distribution

All the members of the group took part in the conception and writing process of every section of the paper.

Annex document

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Figure 1.

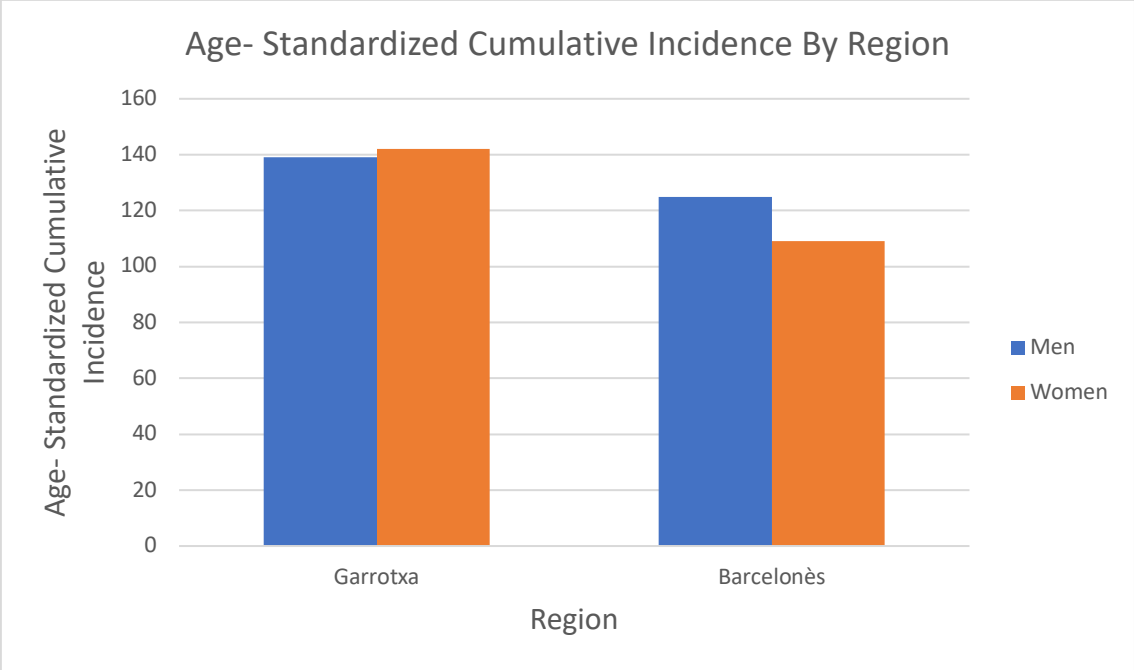

Figure 2.

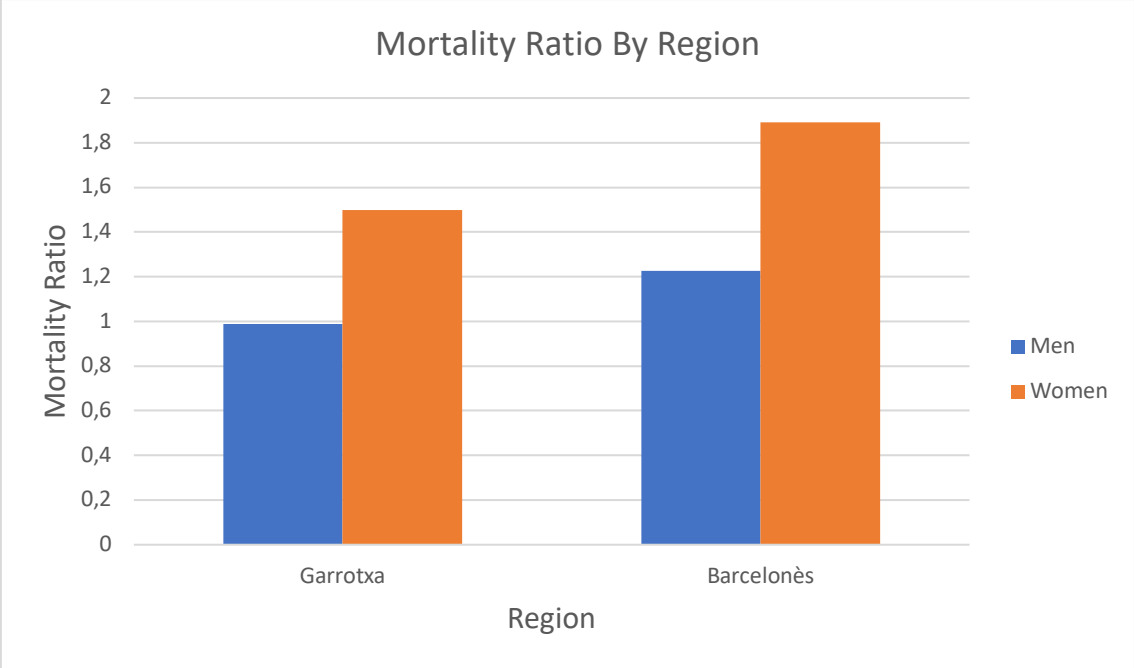

Figure 3a.

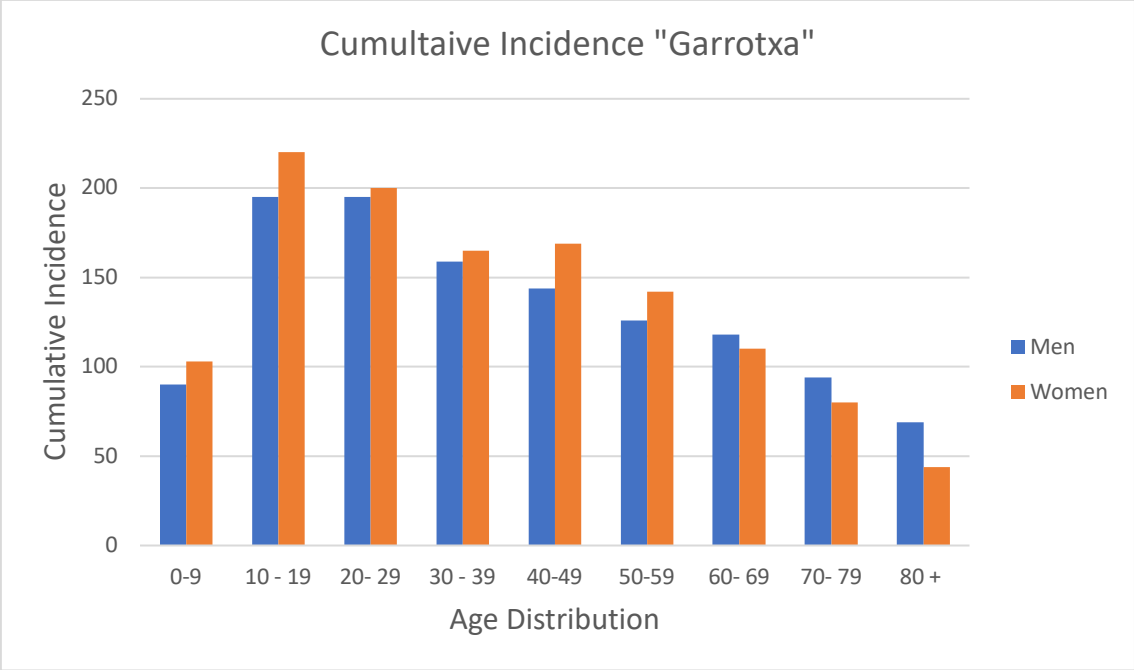

Figure 3b.

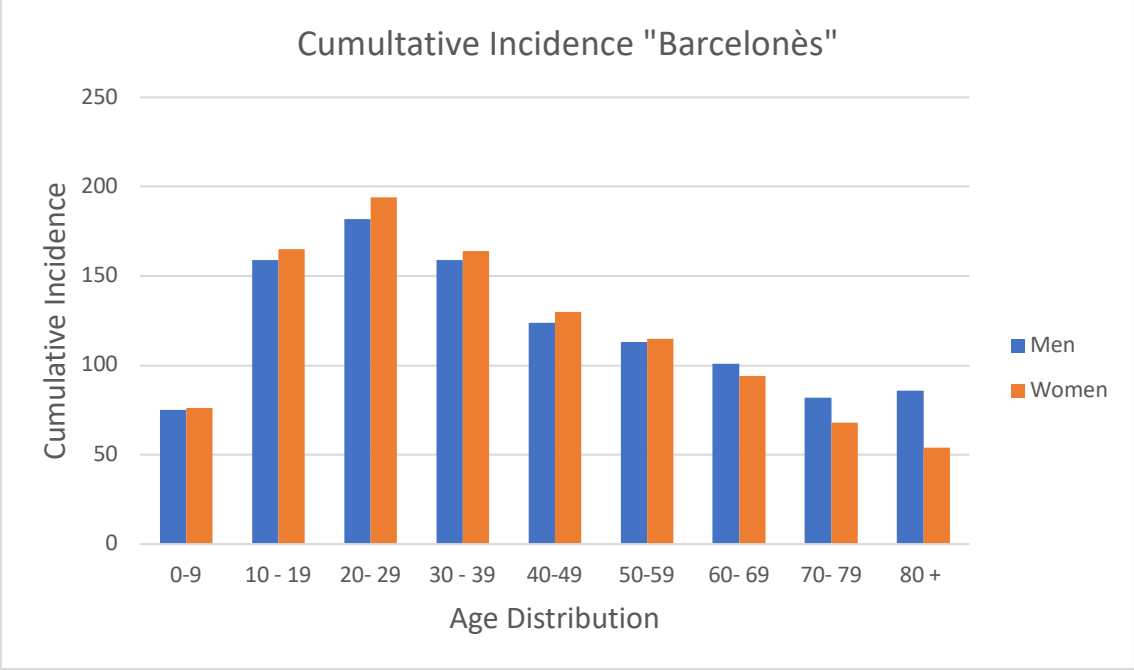

Figure 4a.

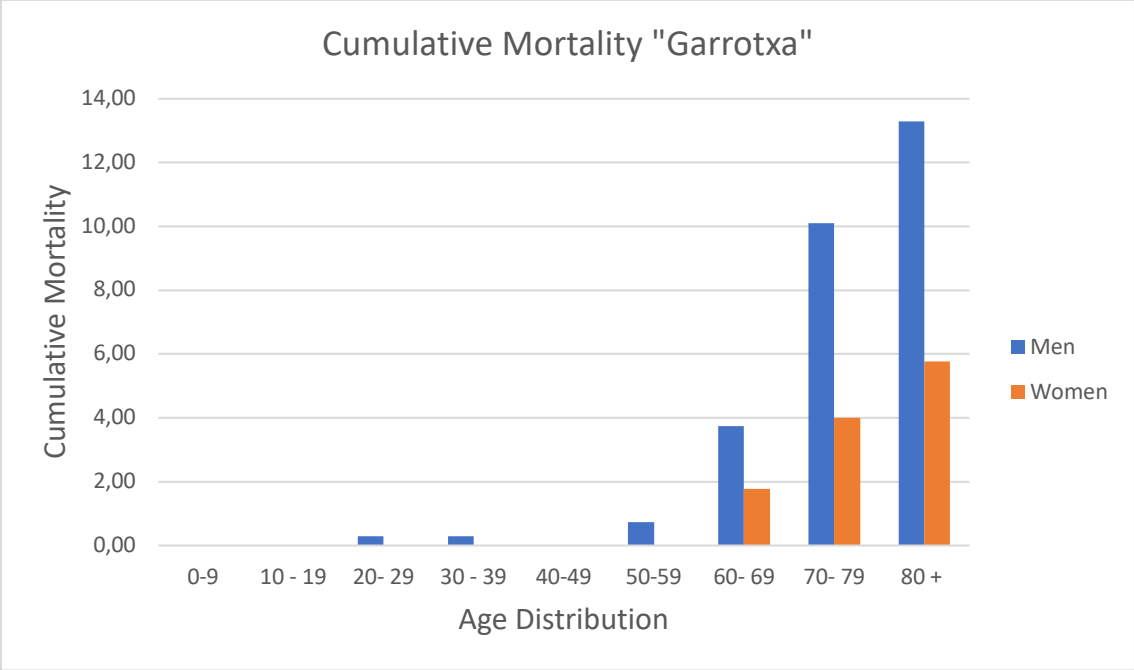

Figure 4b.