Global Death Analysis of Chagas Disease, 1990-2019

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Abstract: Chagas disease (ChD) is a type of parasitic infection caused by the protozoan Trypanosoma cruzi from the American continent discovered in 1909. Up to 7 million people have been infected by ChD, and around 30-40% of patients have or will develop chronic disease e.g., cardiomyopathy, arrhythmias and digestive megaviscera. We collected data of ChD between 1990 and 2019 from Global Burden of Disease 2019, and analyzing the annual changing trend of mortality by sex, region, Socio-demographic index (SDI) and age to identify the potential factors that caused the death. According to the results, the factors that led to more death number are gender differences (physiological difference and presentational behaviors), poor living conditions with higher exposure chance to vectors related to low SDI and heart diseases caused by aging. Chagas disease has caused numerous death cases among these three decades and is not only an endemic disease due to the growing population movements. As a result, it is vital to investigate the main factors contributed to increasing mortality in specific groups of people. Additionally, several recommendations are proposed based on these factors including infrastructure improvement and promotion of hygienic habits to reduce the infection of ChD. Overall, these results shed light for avoiding pandemic and growing mortality rate of ChD.

1. Introduction

In 1909, a protozoan parasite Trypanosoma cruzi was discovered as the causative agent of Chagas disease by a Brazilian physician named Carlos Chagas (1879–1934). This long-standing infection, also known as American trypanosomiasis, yet this disease still remains a major social, economic and public health concern in many Latin American countries and has been regarded as one of the world's most neglected tropical diseases by WHO [1]. According to report from WHO, ChD can be representative of disadvantage and poverty like other neglected tropical diseases. Specifically, it mostly affects populations with low status and visibility, leads to discrimination and disgrace, is comparatively ignored by researchers, and has a significant impact on morbidity and mortality [2]. Around 7 million people worldwide are infected with Trypanosoma cruzi, the parasite that causes ChD, and mostly in Latin America. In Latin America, the main route of transmission to humans is through an insect (vector transmission) called the trypanosome bug, which can carry Trypanosoma krylovii. Other routes of transmission include oral (foodborne) transmission, blood transfusion / blood products, mother to child (congenital) transmission and organ transplantation, and laboratory accidents. ChD was once completely confined to rural areas in the American Region - mainly Latin America. However, in the past few decades, due to population mobility, most of the infected people live in urban environments (urbanization), and the disease has spread to other continents (non-vector transmission of Trypanosoma cruzi).

There are two kinds of morphological life cycle for it: conocellate and amastigote. The infection of echino flagellum through skin wounds invades human blood. The disease can also be transmitted through breast milk, placenta, blood transfusion or ingestion of food contaminated by infectious stink

bug feces. If treatment is started soon after infection, the infection can be cured. For chronic patients, antiparasitic therapy may prevent or inhibit the development of the disease and prevent mother to child transmission. Up to 30% of patients with chronic infection have heart disease and up to 10% have gastrointestinal, neurological or mixed diseases, which may need special treatment.

Besides, plenty of patients are not willing to be informed about the condition because of stigma, the punctual detection and control of ChD are often disturbed. In the 7 countries of South America, the disease leads to the loss of an estimated 752,000 working days due to premature mortalities and $1.2 billion in productivity. The annual global burden of ChD is estimated at $627 million in healthcare expenditures and 806,170 disability-adjusted life-years and 10% of this burden disturbs non-endemic nations. In addition, population movement and specific methods of transmission have caused ChD spreading beyond its natural geographic boundaries and turning into a global issue. Moreover, the profile of the typical patient changes because of growing age and correlated comorbidities [3]. Thus, it is essential for humans to know more about this disease.

2. Methodology

We used data resources from GBD and analyzed the global death rate of Chagas disease from 1990 to 2019.   All GBD causes, risks, etiologies, impairments, injuries by nature, population estimates, fertility estimates, and life tables. Measures: deaths. Years: 1990-2019. All GBD age groups. Sexes: males, females, both sexes. Locations: GBD super regions, regions, countries, select subnational units, and custom regions (WHO regions, World Bank Income Levels, and more). In order to make the GBD data more effective, we created graphs based on the risk factors in RStudio and Prism. We proposed suggestions about the sanitary condition of certain regions based on extra data from some national census and other databases.

3. Result

3.1 Sex/Gender studies

Since the mortality rate mainly exhibits the global disease burden of Chagas disease, we focused mostly on the data analysis of sex, age, and regional dynamics of ChD mortality burden and its attribution factors base on the data of past thirty years. The global death number of ChD decreased from 1990 to 2019. While the global data is relatively high and surpassed 11,000 deaths in 1990, then gradually decreased over the years then returned for a recovery growth after 2010. Notably, males hold a higher death n umber than females, even though similar to the global trend, both sexes declined before 2010, and recovered to grow to 2019. Female death rate remains low in the last thirty years and never exceeds 5,000 cases, which started from 4736.302596724 cases and remains it to 4126.04901541889 cases in 2019. However, the male death rate of ChD began from 6499.64515172487 cases in 1990, and this number reached 5361.73247668849 in 2019.

Based on Figure 2, the death numbers of females were outnumbered by the death rate of males from 1990 to 2019. The patients with chagas disease experience cardiotic disorder and suffer from digestive, neurological or mixed disorders during chronic phase following acute phase. In later life, infection can lead to sudden death, mainly because of heart arrhythmia or heart failure due to damage of the heart muscle and its nervous system (WHO, 2021). According to the survey of Assunção et al. (2017), male patients in Chagas disease are related to high cardiovascular morbidity and mortality. They proved the gender-differences in myocardial destruction in Chagas disease by CMR (cardiovascular magnetic resonance). As a result, males are associated with higher myocardial fibrosis and worse ventricular remodeling than females, which lead to more severe and frequent heart failure symptoms among male gender. [4]

Behavior risk is one of the conditions to consider. "More than 1 in 4 households in the region are female-headed, representing the world's highest rate of female-headed families." Females in Latin America engage in domestic vocations due to the severe gender inequality; however, home is a relatively safe place compared to the male that has to do manual labor work in a contaminated

environment. In addition, research suggests that testosterone provides males with more extraordinary physical activities and leads to a higher death rate due to accidents and homicide. Also, according to UN Women, 95.4 % of these women practiced corporal hygiene at least once daily and 2.8 %, once or twice a week. 71.% cleaned their genital area backward (from the vulva to anus). The type of soap most commonly used is bar soap, followed by liquid body wash. Women have a relatively more punctilious sanitary level [5]. These all indicated that women has a relatively more punctilious sanitary level, which is what made them possess less death cases.

3.2 SDI and Geographic Region Studies

ChD is related to the geographical location, SDI, on the other hand. Figure 3 and 4 generally describe the varying SDI and the relative rate of the death population from 1990 to 2019 in both sexes, all ages. The global death cases of ChD decreased from 1990 to 2010 (12,000 death cases to 8,500 death cases). The cases number increased from 2010 to 2019(8,500 to 9,500). In the highest SDI region, the number of cases decreased to zero from 1990 to 2010. The low SDI region held a stable zero case from 1990 to 2010. The High middle and middle SDI region had a decline in cases from 1990 to 2010 (4,000 to 3,000 in high middle SDI; 5,000 to 3,000 in middle SDI). The death cases rose up in 2019 in these regions (3,000 to 3,200 in high-middle SDI; 3,000 to 3,500 in middle SDI). The low-middle SDI countries increased from 1990 to 2019(3,000 to 5,000). Generally, the low-middle SDI region has the most degree of increasing death cases. Middle and high-middle regional SDI have the secondary increasing death cases. The high SDI region has the most death cases' decreasing.

Low SDI regions may not have effective detecting and testing technology, e.g., some parts of Africa, thus ignoring this tropical disease. Moreover, urbanization and industrialization in High and middle SDI countries also obliterated the living environment of Chagas disease. Therefore, middle SDI regions have the most death cases from the current data.

The low-middle SDI region covers the regions such as Mexico, Latin America and the Caribbean, Southern America, and tropical Latin America. Different parts of Latin America have their unique weather. The Low middle SDI region discussed is the tropical area (23' South to 26' North altitude). In this region, rainforests are common landscapes-- the home of animals and insects. It provides a cradle of T. cruzi parasites. The high SDI regions are the modern cities; the low SDI regions are dry and hot in Central Africa. The moist weather gives T. cruzi parasites a place to live.

Additionally, the architecture of Central Latin American, made of straws and muds, gives comfortable places for insects and tiny reptiles. The traditional buildings of Central America have their ways to prevent the insects-- build the architectures above the ground with several logs. By the impact of colonists in Europe, the building style changes to the buildings that attach to the ground, increasing the risk of infection (Brillembourg, para.2) [6].

The tropical and humid weather give the parasite an exterior environment to live in. The residents' behaviors allow T. cruzi parasites chances to attack and infect humans [7].

3.3 Age Studies

While the global Aged-standard death rate (ASDR) is steadily decreasing, age differences became a severe factor for the disease burden. The trend of death cases didn't change a lot in the past thirty years; even though 1990 has the most intense mortality rate, there is no obvious sign of the decline of ChD in 2019. Senior people have higher ASDR than young and middle-aged people. The mortality rate increases with age and is proportional to generation, especially for elderlies of 65 to 69 years old, which surpassed 1.3 thousand deaths in 2000. However, people around that age range met the lowest ebb in 2010 (UI) and steadily recovered to 2019. Besides, people aged 70 to 74, 75 to 79, 80-84, 90-94 all rapidly grew through the past three decades, and the death rate of 70-74 surpassed 1.3 thousand in 2019.

In contrast, the overall trend of other age ranges began to decline. For ages 85-89, it exceeded 1.4 thousand death cases in 1994, and this number plummeted to hundreds of cases in 2009, but after 2009 it continued growing for the later decade. Infant and teenage mortality rates remain low, and the data become more valuable after 30 years old. Moreover, for people under 60, the mortality caused by ChD

continues to decline. Therefore, the mortality rate of elderlies will increase for ChD as shown in Figure 5.

According to the mortality data in 2019, males in Latin America have an average of seventy-two years of longevity, and females have about seventy-eight years of longevity. Thus, dying before seventy years old is an abnormal condition. ChD can cause death due to severe infection of heart muscles or meningitis. Because of this unique way of death, people with a weaker immune system should be more likely to be affected. However, younger children don't display high deaths on the database [8]. Apart from the problem of statistics, most Latin American countries are impoverished and do not have a sound medical system, so that the data could be imprecise. Low child mortality depends largely on adult protection. The elderly over 70 will no longer engage in manual work [9]. Although Chagas disease is an infectious disease, it is also closely related to the patient's contact environment. Chagas disease patients are usually poor people living in extreme poverty and poor sanitary conditions. They are engaged in a lot of manual labor and may be exposed to sewage or animal feces. The gaps in the walls and roofs of houses in rural and urban areas are the ideal living environment for Chagas. Therefore, they are very susceptible to infection. Additionally, since access to quality care in Latin America can prove challenging. In Latin America and the Caribbean, there are 1.9 hospital beds (per 1000 people) in 2017. Such hygiene levels lead to the death of these age groups. Therefore, society must focus more on sanitary equipment in impoverished regions.

4. Discussion

4.1 Figures and Graphs

Table 1. The Death Cases of Chagas Disease

Characteristics	1990 Number of deaths (95% UI)	2000 Number of deaths (95% UI)	2010 Number of deaths (95% UI)	2019 Number of deaths (95% UI)
Global	11235.95(4555.27-13702.36)	8913.87(4330.84-10357.98)	8653.30(5194.23-13104.99)	9487.78(5499.97-16518.65)
Sex				
Males	6499.65(2156.41-8088.57)	5182.07(2135.62-7013.07)	4915.75(2446.91-8262.16)	5361.73(2463.12-10193.99)
Females	4736.30(1685.20-5779.45)	3731.80(1378.23-5499.33)	3737.55(1721.27-6712.96)	4126.09(1805.02-8511.76)
Socio-demographic index				
Low	89.23 (20.68-388.34)	85.76(26.88-356.41)	104.60(37.91-397.72)	121.19(42.69-415.03)
Low-middle	2846.03(1206.27-3640.62)	2915.77(1506.61-3969.92)	3023.49(1897.11-4707.99)	3580.42(2258.29-6089.43)
Middle	4084.63(857.83-5636.09)	3028.38(967.85-3900.89)	2788.50(1065.30-3415.37)	3004.86(1105.98-4134.71)

High-middle	3483.50(1501.96-4142.41)	2844.01(1517.58-4322.59)	2678.84(1753.76-5179.00)	2781.23(1669.87-6217.57)
High	730.97(677.75-787.07)	39.85(28.95-52.78)	50.98(38.17-65.56)	N/A
Region				
Mexico	17.53(11.30-32.31)	26.90 (13.49-35.17)	40.55(17.41-49.42)	48.46(19.69-67.43)
Latin America and Caribbean	9372.05(3115.24-11850.34)	8014.42 (3578.72-9458.36)	7704.57(4176.23-11015.20)	8625.4(4674.61-14475.20)
United Sates of America	7.03(3.03-13.06)	9.16 (4.28-16.57)	16.64(9.40-25.03)	N/A
Western Europe	725.71(673.73-781.33)	36.23 (26.14-48.27)	136.16(114.42-159.14)	N/A
Central Europe	61.48(47.23-78.72)	2.06 (0.22-5.59)	2.52(0.47-6.31)	N/A
Central Latin America	1009.64(408.26-1249.48)	997.23 (518.83-1293.13)	1088.42(643.69-1733.68)	1409.9(832.42-2570.27)
Southern Latin America	1066.97(504.57-2095.99)	836.48 (555.92-2234.14)	781.73(455.97-2481.85	862.38(462.58-2821.18)
Tropical Latin America	7948.33(2458.87-10124.54)	6589.37 (2910.05-7799.60)	6091.6(3180.91-8806.35)	6573.93(3376.56-11313.58)
Central Europe, Eastern Europe, and Central Asia	61.48(47.23-78.72)	12.30 (6.45-19.70)	2.52(0.47-6.31)	N/A
High-income	N/A	887.16 (610.19-2279.36)	946.21(616.79-2630.61)	862.38(462.58-2821.18)
Central Asia	N/A	10.24 (4.91-17.26)	N/A	N/A
UI: uncertainty interval				

The disease burden is related to the wealthy or not of that country and local economy. According to the UN's sustainable development goals, no poverty and good health are two essential elements. It is comparably hard to change Latin America's economic situation at once; however, the government's liability is to provide guidance to their residents (Research of the local residents to the parasite disease). The carelessness and neglect of the parasite diseases, such as ChD, could put them in a dangerous circumstance and impact their lifetime potentially. What the government can do is stop building and using the materials (especially straws, muds) on their local families' houses. To directly cut off the

breeding place of the parasites can economically decrease the infection and death rate of Chagas and other diseases.

In order to control ChD, we need to address the problems that appear during the infection period and patients. In Latin American, the weather there is usually humid and a typical tropic climate with distinct hot and distinct rain. It provides a cradle for the insects and other microorganisms, some of them can easily take along the viruses or parasites.

ChD is found in a Triatomine bug that is a bug that often bites human's faces and livestocks, the Trypanosoma cruzi, a parasite that lives inside Triatomine bug, can enter the human and livestocks' body directly. On the other hand, the food or water that is polluted by infectious feces can also be pathogenic. For the local government, the local buildings that are made of wood, muds or straws should be banned, then rebuilt to prevent the living space of these parasites. The local citizens ought to have the large-scale forum to let them know the danger of Chagas and other localized diseases. The government may also provide the expelling parasites policy or service to eradicate the parasites. The ChD is not considered a person-to-person contagious disease; whereas, the people who have already been infected by Trypanosoma cruzi need a special detection and observation to stop deterioration from acute phase to chronic phase. The high-risk groups for instance, the scientists who work in the tropical jungle and the farmers in Latin American, can be the potential population that may be infected by ChD. It is necessary for them to wear the proper suit during working. Additionally, the government can regulate the compulsory detection for the high-risk populations. The News report of a new infection: once a certain village breaks out the ChD, the local government should report it to the central government or Central of Disease Control (CDC).
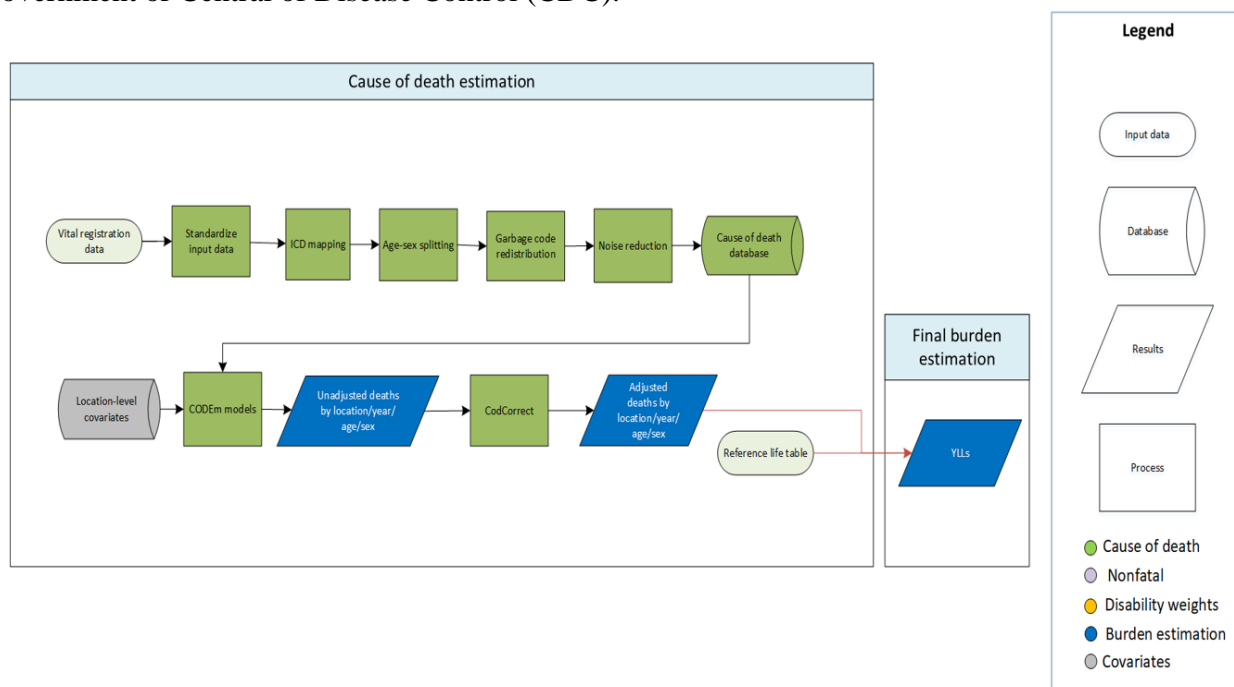

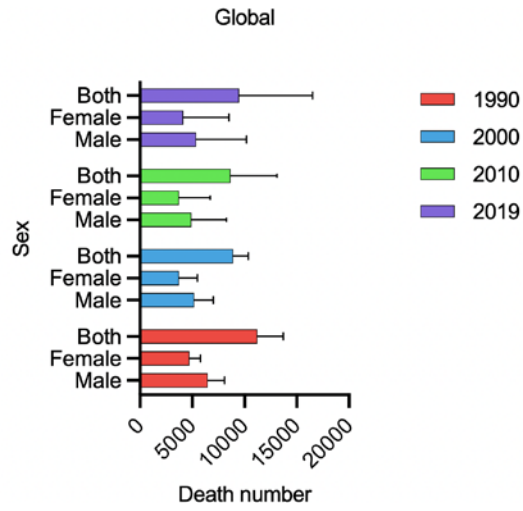Figure 1. Cause Of Death Estimation

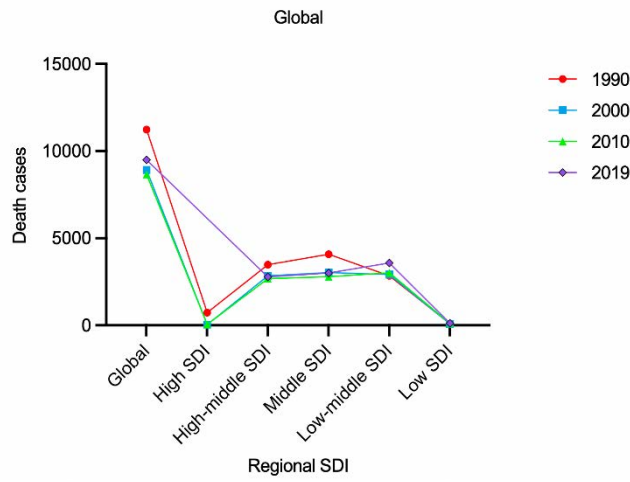Figure 2. Gender And Death Number
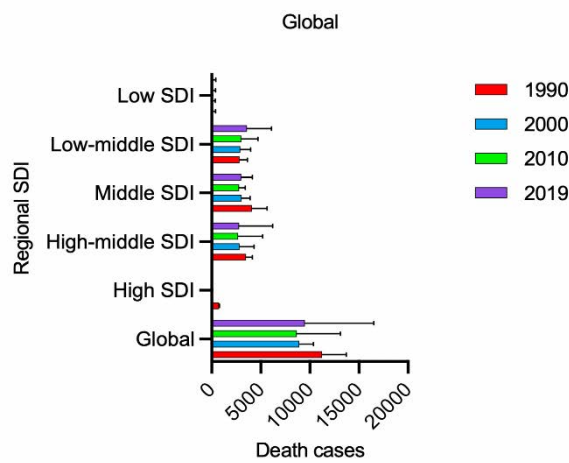

Figure 3. Sdi And Death Number
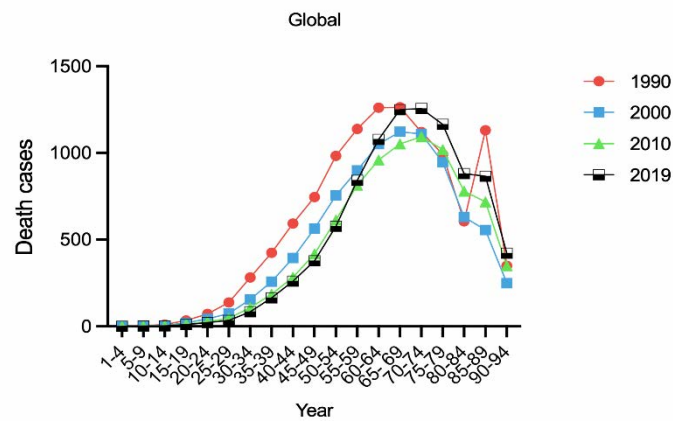

Figure 4. Sdi And Death Number
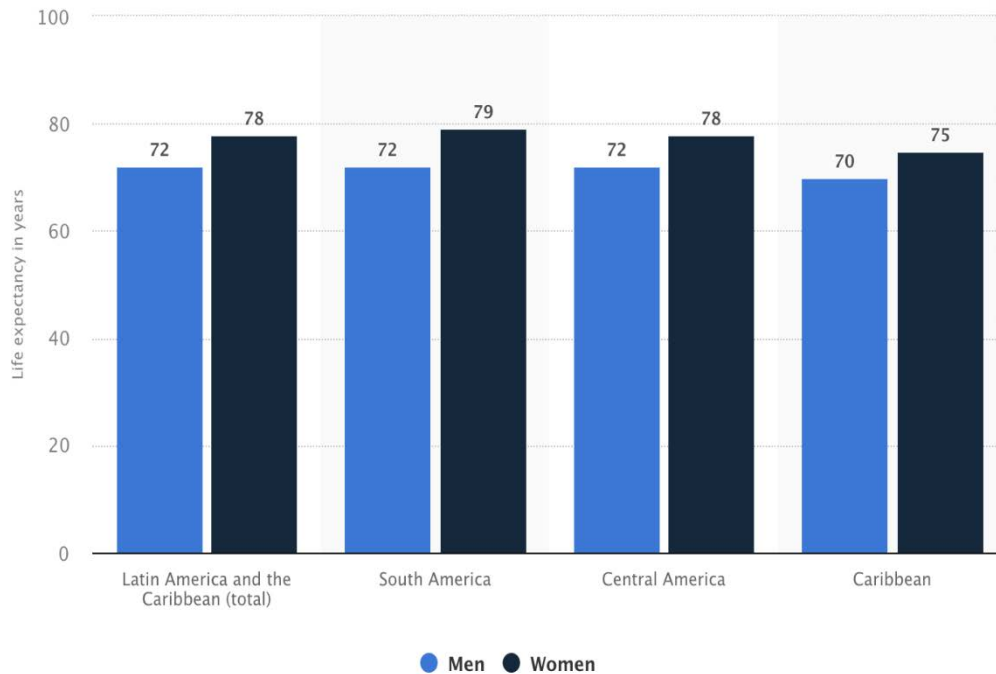
Figure 5. Age And Death Number

Figure 6. Gender And Geographic Location [10]

5. Conclusion

In summary, Central and Latin American are the infectious disease ChD most spreading area based on our analysis. ChD is caused by a particular parasite that can transmit in foodborne and feces. The unconcerned hygiene and traditional buildings are two main causes of Trypanosoma cruzi. Public health control is essential to stop and eradicate infection cases and tolls. Local governments could replace the old constructions to eliminate the living environment of parasites. Government can allocate the bed net or insecticide to directly prevent the bite from the parasites. Building public washrooms and centrally dealing with the feces could decline the infection cases by feces contamination. Based on analyzing our data from different age ranges, sex, and SDI; the Low middle SDI regions; males; and 65-69 people have a higher death rate. Consequently, controlling the vector in three aspects can stop the ChD in a progressively way. These results offer a guideline for Central and Latin American about their local ChD prevention.

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