Saudi Arabia Health Profile

Data Sources and Methodology

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The aim of this document is to detail the data and methods used in the interactive link-application: https://population-health.shinyapps.io/saudi-arabia-health-profile/

Sources of data

Two large sources of data were needed in order to assess the health profile of Saudi Arabia from 1999 to 2012 with further projections to the year 2030: cause specific mortality and life table data.

Cause of death information was obtained from the modeled data from the Institute of Health Metrics (https://vizhub.healthdata.org/cod/). The World Health Organization mortality database (WHO), which is the usual source for cause specific mortality information over time for most countries, only had two years of data for Saudi Arabia, namely 2009 and 2012. In order to increase observations and ensure comparability across time we used the IHME database, which although it uses the two years with cause of death data from WHO, it obtains data series from 1999 to 2012 from models that include information from other countries (IHME, 2013). Cause of death information was collected from this source for ages 0, 1-4, and then in five-year age groups until the open age-group 95 and more. Although, this could be thought as problematic, the great share of the changes in life expectancy in Saudi Arabia still happen at ages below 80. Thus, the main results are not affected by decisions made on the last age-interval.

Ten causes of death were selected corresponding the main causes of death in Saudi Arabia: 1) Tuberculosis and HIV/AIDS, 2) Diarrhea, lower respiratory, and other common infectious diseases, 3) Neoplasms, 4) Cardiovascular diseases, 5) Diabetes, 6) Urogenital, blood, and endocrine diseases, 7) Transport injuries, 8) Unintentional injuries, 9) Self-harm and interpersonal violence, and 10) the group of other causes of death including those not accounted by the previous nine causes. The latter group of “Other causes” represented less than 20% of all causes, although by age-groups it fluctuated from 6% to 30% of the total deaths in that age-group. An additional calibration of making the proportions add to 100% was needed. The latter was needed, because the IHME data had some overlapping categories, however, this did not affect the relative proportion of the 10 selected causes mentioned above.

Some of these causes of death are comparable to the mayor International Classification of Diseases revision 10, chapters for causes of death and their corresponding ICD-10 code: (A00-B99) Certain infectious and parasitic diseases, (C00-D48) Neoplasms, (E00-E88) Endocrine, nutritional and metabolic diseases, (F01-F99) Diseases of the circulatory system, (V01-Y89 excluding X60 to Y09) Accidents , (X60-X84) suicide, and (X85-Y09) Homicide.

The proportion of the 10 causes of death used by age is found as the first menu option in the interactive link-application on “Distribution of causes of death”:

https://population-health.shinyapps.io/saudi-arabia-health-profile/

The above interactive link-app has a left dropdown menu which allows user to select among the different years of available data.

Life table data by sex and grouped in five calendar years, to avoid the year to year random fluctuations, were obtained from the UN demographic yearbook. All the life table functions (e.g. age-specific death rates and life expectancy) were retrieved from this data source, including the projections expected for Saudi Arabia for 2025-2030.

The UN life tables had the further advantage that they could be easily combined with the IHME cause of death information. Life tables were selected for the following periods: 2000-2005, 2005-2010 and 2010-2015, as well as the UN projections for 2025-2030. Causes of death were also organized in these five calendar years. We were able to match life table and cause of death data for most of the years, an exception was the last period 2010-2015 which only included data on causes of death for 2010-2012. In the interactive application app whenever we refer to the period 2010-2015 we assume that the causes of death data from 2010-2012 represent the distribution over age of the entire period 2010-2015.

Methodology

Three different methodologies were used in the Saudi Arabian Health Profile: “Life years lost”, Age- and cause decomposition (or “Burden of diseases over time” in the app), and Cause-deleted analysis (or “Change of life expectancy scenarios” in the app). The three methodologies are briefly explained below and more details on them can be found on the suggested reference list at the end of this document.

Life years lost.

Life years lost describes the number of years lost due to death and it is used for analysing differences in mortality between subpopulations or for changes over time. (Andersen, Canudas-Romo and Keiding 2013; Canudas-Romo, Garcia-Guerrero and Echarri-Canovas 2015; Erlangsen et al. 2017). It is calculated as the number of years between death and a set upper limit (=upper value minus life expectancy); in the app we used age 85 as this upper limit. We calculate the *years lost* due to different causes of death by focusing on the cumulative death distribution. We let the life table function of the distribution of deaths from 0 to the given age x, $f(0, x)$, be further subdivided into deaths by the different causes of death i, $f(0, x, i)$. If there are n mutually exclusive causes of death, the number of years lost to each cause of death between ages 0 and a can be calculated as

$$ {}_{a}e_0 + \sum_{i=1}^{n} {}_{a}\daleth_0^i = a, \qquad (1) $$

where ${}_{a}e_0$ is the temporary life expectancy between ages 0 and a, or number of years lived between these ages, and ${}_{a}\daleth_0^i = \int_0^a f(0, x, i)dx$ is defined as the number of years lost between ages 0 and a for cause of death i. More details on this method can be found in Andersen, Canudas-Romo and Keiding (2013).

In the Saudi Arabia Health Profile app, for example, it is possible to see the life years lost profile for females in 2005-10 in Snapshot 1. Here again it is possible to see the excessive burden of Cardiovascular mortality, followed by Neoplasms and transport injuries. The latter is hardly visible, however, its occurrence is predominantly at young ages and thus accumulates a great amount of lost years for the population. For males this is such a burden that it is equivalent to the number of life years lost due to cardiovascular mortality.

[Snapshot 1 about here]

Age- and Cause-Decomposition of Differences in Life Expectancies at Birth

The age- and cause-decomposition of the difference in life expectancies derive from the formulations of Arriaga (1984). Other methods exist (e.g. Vaupel and Canudas-Romo 2003, and the particularly relevant public health use by Aburto et al. 2016), however, the simple exposition of Arriaga's method by Preston et al. (2001) has popularized the former.

Differences in life expectancy at birth between two times, denoted e_0^2 and e_0^1, can be written as the sum of the age-specific contributions as

$$e_0^2 - e_0^1 = \sum_x \Delta_x, \tag{2}$$

where Δ_x is the age-specific contribution to this difference. The age-specific contributions in equation (2) are derived from the life table functions: survivors at age x,

l_x , person-years lived in the interval x to $x+1$, L_x , and person-years lived after age x, T_x , for the two given times:

$$\Delta_x = \left(\frac{l_x^1}{l_0^1}\right)\left(\frac{L_x^2}{l_x^2} - \frac{L_x^1}{l_x^1}\right) + \left(\frac{T_{x+1}^2}{l_0^1}\right)\left(\frac{l_x^1}{l_x^2} - \frac{l_{x+1}^1}{l_{x+1}^2}\right). \quad (3)$$

The difference in life expectancy at birth between two populations can be further decomposed by causes of death, that is, we can estimate the contribution of the total difference in life expectancy attributable to specific causes of death by age.

In order to estimate cause specific mortality contributions we partition the age-specific contribution, Δ_x, into the part that corresponds to each of the causes of death i of interest, or $\Delta_{x,i}$.

Assuming that there are n independent causes of death we calculate the cause i contribution based on a set of all cause age-specific mortality rates and the proportions of deaths at each age attributable to cause of death i:

m_x^1 = all-cause mortality rate at age x and time 1

$R_{x,i}^1$ = proportion of deaths from cause i, at age x and time 1,

A similar set of information is needed for time *2*. All the above information is combined to calculate the age- and cause-contribution to the difference in life expectancy as

$$\Delta_{x,i} = \frac{R_{x,i}^2 m_x^2 - R_{x,i}^1 m_x^1}{m_x^2 - m_x^1}. \tag{4}$$

Multiplying the previously derived mortality contribution for each age, Δ_x, with the addition over all causes of the age- and cause-contribution in equation (4) returns the desired difference in life expectancy at birth due to changes in age-specific and cause-specific mortality:

$$e_0^2 - e_0^1 = \sum_x \Delta_x \left(\sum_i \Delta_{x,i}\right). \tag{5}$$

The results of the age- and cause-decomposition of the change in life expectancy are presented for two group of years in the interactive app left dropdown menu: life expectancy changing from 2000-05 to 2005-10, and the second option is from 2005-10 to 2010-15.

Snapshot 2 shows the output from the app for the comparison from 2000-05 to 2005-10. The Table at the bottom of this snapshot shows that females had a life expectancy in 2000-05 of 74.44 and by 2005-10 this had increased by 0.22 years to 74.66. The Figure on top of the Table shows the separation of this 0.22 years into ages and causes of death that contributed to the increase in life expectancy, as well as those that opposed the increase. For females Neoplasms, Diabetes and other endocrine diseases are among the main providers of the increase in life expectancy, however, cardiovascular mortality increased in this period offsetting the life expectancy progress. Details on the specific contribution of each cause of death can be found on the submenu Table "Total contributions by cause of death (Table)" and in the visualization submenu "Total contributions by cause of death (Figure)".

[Snapshot 2 about here]

<u>*Cause-deleted analysis.*</u>

Associated single decrement life table techniques, are used to measure the hypothetical situation where only causes of death other than the deleted causes are present (Preston et al. 2001). The technique goes back to discussions of life lost to specific causes of death in the famous debate on smallpox between (Bernoulli 1766) and (d'Alembert 1761). The dominant assumption is that removal of a cause of death may be modeled by equating the corresponding death intensity to zero in the relevant multiple decrement model. In other words, assuming independence between the causes of death. The removal of a cause of death can thus be measured by comparing the life expectancy with and without that cause operating. Similarly, and a more realistic approach is to use the same mathematical procedure of elimination to simply reduce the causes of death (Perston et al. 2001).

Let the proportion of deaths due to cause i at age x be denoted as R_x^i and the associate single decrement probability of surviving from age x to $x+1$ be $p(x,i)$. The latter is a life table where the only operating cause of death is cause i, and can be calculated from the overall mortality life table probability of surviving, $p(x)$, and the proportion R_x^i, as $p(x,i) = p(x)^{R_x^i}$. From the latter relation it can be deducted that the overall mortality probability of surviving with n independent causes of death is equal to the product of all the associate single decrement probabilities for each cause $p(x,i)$:

$$p(x) = p(x,1)p(x,2)\cdots p(x,n). \quad (6)$$

Equation (6) also holds for the cases when there is specific reductions in one cause of death. Let the proportion decline in cause i be denoted r^i. The new probability of surviving from age x to x+1 for cause of death i, denoted as $\hat{p}(x,i)$, will be calculated as before, including also the proportion of decline as $\hat{p}(x,i) = p(x)^{r^i R_x^i}$. This procedure is applied for each of the causes of death and a new overall probability of surviving $\hat{p}(x)$ culated as in equation (6).

Snapshot 3 presents the interactive app menu of *Cause-deleted analysis*. The left menu allows the user to select the desired reduction, e.g. in Snapshot 3 cardiovascular and neoplasm mortality both are selected to decline by 25%. The Figure on the right presents six life expectancies corresponding to Saudi Arabia in: 2010-15 (females 75.47 and males 72.82); in 2025-30 (females 78.25 and males 74.99), and the two ”new life expectancies”. The latter life expectancies are 76.79 for females and 74.07 for males which in the case of the 25% reduction in neoplams and cardiovascular mortality respect to the levels of mortality in 2010-15.

All calculations were performed using the R-software programing language and its’ shiny-app package, the accompanying folder RCode includes all the programs used.

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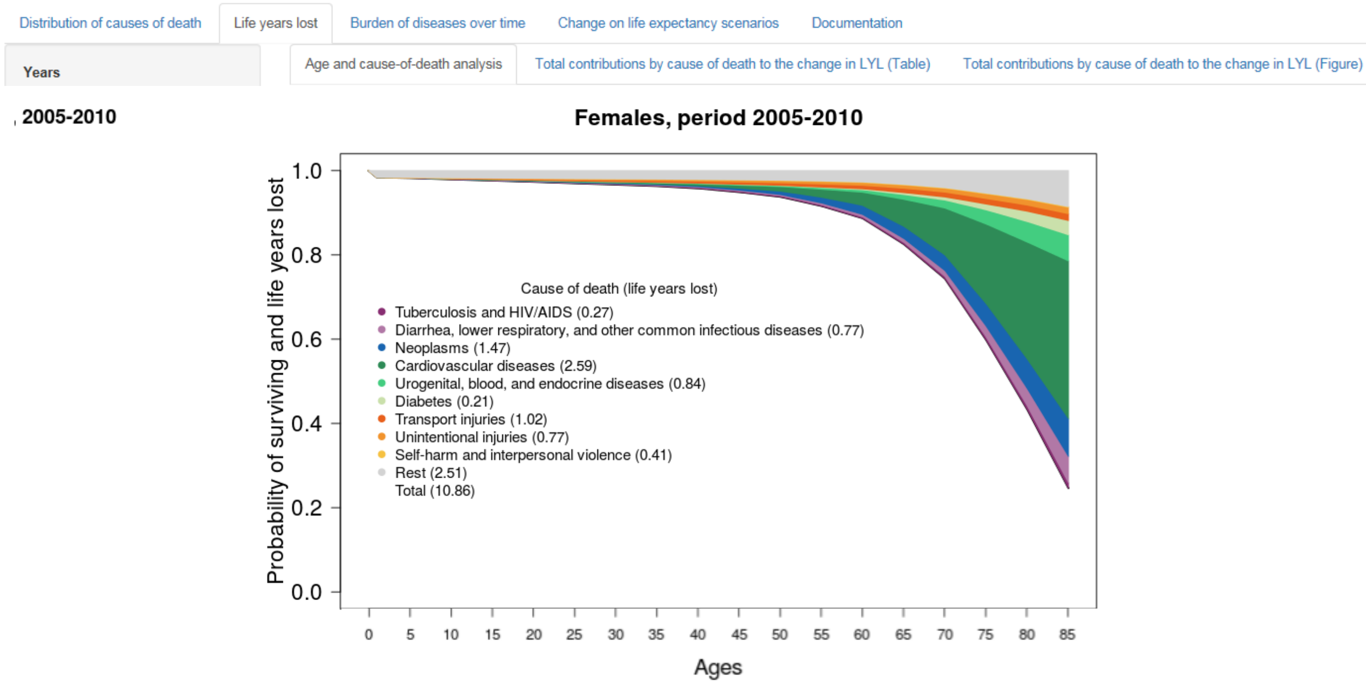
Snapshot 1


Distribution of causes of death
Life years lost
Burden of diseases over time
Change on life expectancy scenarios
Documentation
Years
Age and cause-of-death analysis
Total contributions by cause of death to the change in LYL (Table)
Total contributions by cause of death to the change in LYL (Figure)
, 2005-2010
Females, period 2005-2010
Probability of surviving and life years lost
1.0
0.8
0.6
0.4
0.2
0.0
Cause of death (life years lost)
Tuberculosis and HIV/AIDS (0.27)
Diarrhea, lower respiratory, and other common infectious diseases (0.77)
Neoplasms (1.47)
Cardiovascular diseases (2.59)
Urogenital, blood, and endocrine diseases (0.84)
Diabetes (0.21)
Transport injuries (1.02)
Unintentional injuries (0.77)
Self-harm and interpersonal violence (0.41)
Rest (2.51)
Total (10.86)
0
5
10
15
20
25
30
35
40
45
50
55
60
65
70
75
80
85
Ages

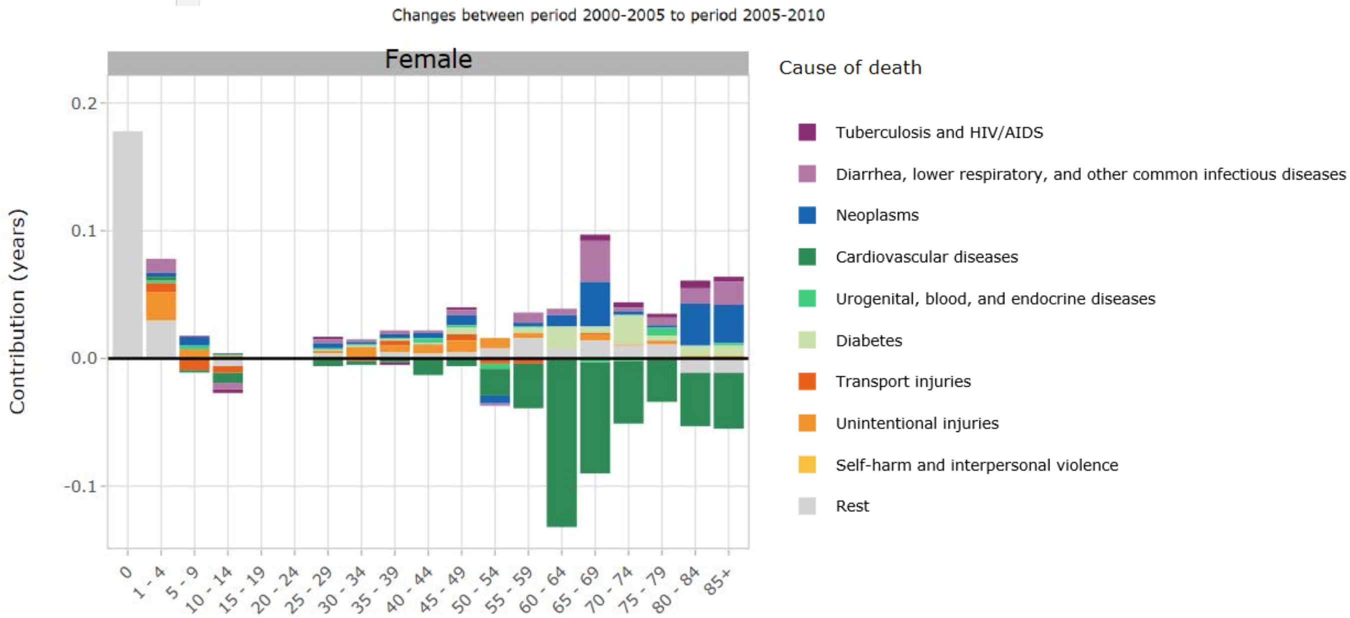
Snapshot 2

Distribution of causes of death | Life years lost | Burden of diseases over time | Cause-deleted analysis | Documentation

Decomposition of life expectancy over time | Total contributions by cause of death (Table) | Total contributions by cause of death (Figure)

Initial Period

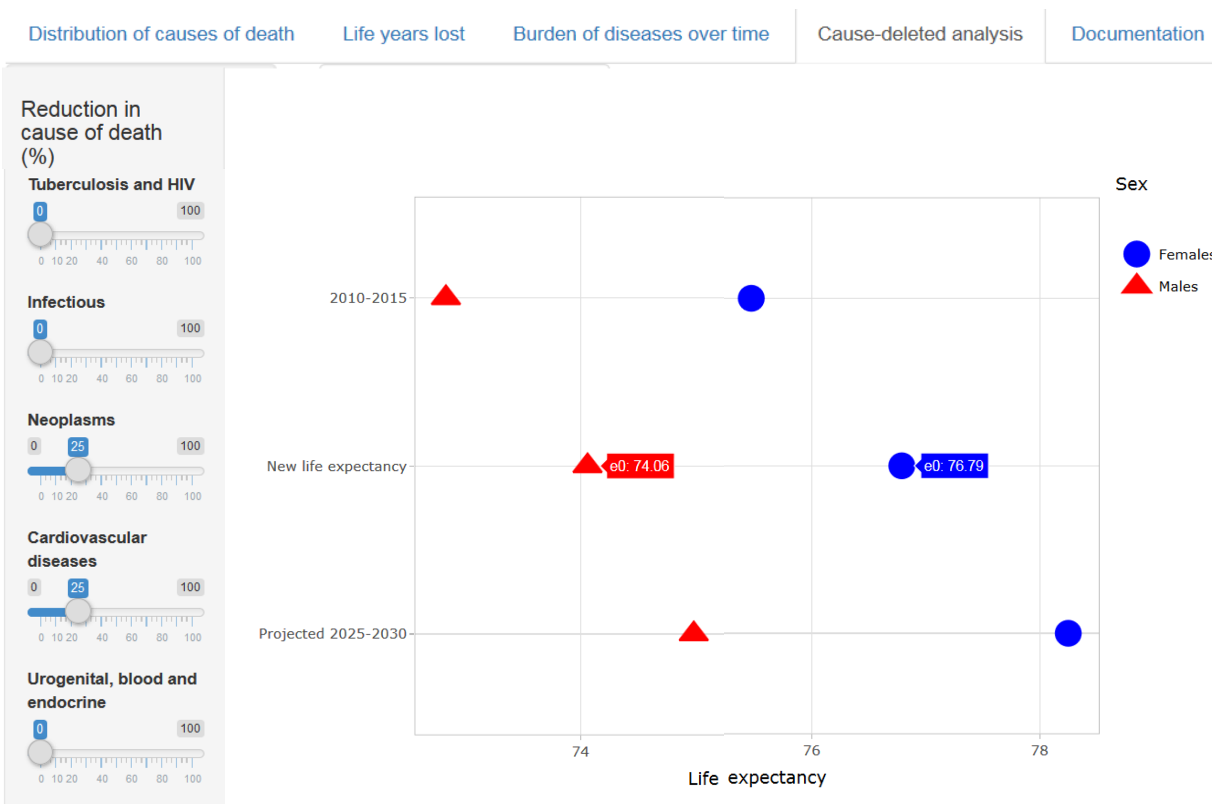
2000-2005



Life expectancy by sex and period

Period	Sex	Life expectancy	Difference
2000-2005	Female	74.44	
2005-2010		74.66	0.22

Snapshot 3



Distribution of causes of death
Life years lost
Burden of diseases over time
Cause-deleted analysis
Documentation
Reduction in cause of death (%)
Tuberculosis and HIV
Infectious
Neoplasms
Cardiovascular diseases
Urogenital, blood and endocrine
2010-2015
New life expectancy
Projected 2025-2030
e0: 74.06
e0: 76.79
74
76
78
Life expectancy
Sex
Females
Males