Estimating mortality and causes of death in Turkey: methods, results and policy implications

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**Background:** Cause-specific mortality statistics are primary evidence for health policy formulation, programme evaluation, and epidemiological research. In Turkey, a partially functioning vital registration system in urban areas yields fragmentary evidence on levels and causes of mortality. This article discusses the application of innovative methods to develop national mortality estimates in Turkey, and their implications for national health development policies. **Methods:** Child mortality levels from the Demography and Health Survey (DHS) were applied to model life tables to estimate age-specific death rates. Reported causes of death from urban areas were adjusted using re-distribution algorithms from the Global Burden of Disease (GBD) Study. Rural cause structure was estimated from epidemiological models. Local epidemiological data was used to adjust model-based estimates. **Results:** Life expectancy at birth in 2000 was estimated to be 67.7 years (males) and 71.9 years (females), about 8–10 years lower than in Western Europe. Leading causes of death include major vascular diseases (ischaemic heart disease, stroke) causing 35–38% of deaths, chronic obstructive lung disease and lung cancer in men, but also perinatal causes, lower respiratory infections and diarrhoeal diseases. Injuries cause about 6–8% of deaths, although this may be an underestimate. **Conclusions:** Mortality estimates are uncertain in Turkey, given the poor quality of death registration systems. Application of burden of disease methods suggests that there has been progress along the epidemiological transition. Key health development strategies for Turkey include improved access to communicable disease control technologies, and urgent attention to the development of a reliable, nationally representative health information system.

**Keywords:** causes of death, health policy, mortality, Turkey, vital registration

**Introduction**

Data on mortality by age, sex and cause are primary inputs for assessing population health status, and a cornerstone of the evidence base for health policy, in combination with other epidemiological and socio-economic information. While medically certified cause of death data from complete civil registration systems is the ‘gold standard’ for such statistics, these are generally not available in over two-thirds of all countries.¹² In the WHO European Region, Turkey is the only country that does not have reasonably reliable and timely statistics on causes of death.¹³ A recent paper on national health policy in Turkey identified inadequate health data as a major limitation for informed policy formulation.⁴ Currently, several critical mortality indicators (e.g. infant, child and maternal mortality rates) are estimated using data from demographic surveys.⁵ While trends in these indicators do suggest improvements in maternal and child health over the past three decades,⁶ they are prone to measurement error, due to sampling as well as recall bias. Even if the levels and trends were reliably estimated, further improvements in population health would require accurate information on cause-specific mortality to guide policy and programme priorities.⁸

Despite these statistical problems, currently available data can provide an empirical basis for applying demographic and epidemiological methods to estimate national cause-specific mortality in Turkey. Additional data sources that are available (e.g. urban cause of death reporting systems, hospital statistics, ‘verbal autopsy’ surveys, police records) facilitate the application of such principles of mortality estimation. However, the quality of information from these additional sources requires careful review before they can be applied to estimate basic epidemiological parameters.⁹

In this study, we describe the characteristics of various sources of mortality data in Turkey, and apply the methods from the Global Burden of Disease (GBD) study to these diverse data sets to derive national cause-specific mortality estimates.¹⁰¹¹ The GBD framework first involves the application of demographic techniques to correct registered mortality data for undercount, resulting in estimated age-specific mortality rates across the lifespan. Cause-specific mortality fractions at each age are then estimated based on techniques to correct for misdiagnoses in vital registration data, or using models where data are unavailable, that predict cause of death structure as a function of observed mortality levels. These standard applications of the GBD method have been applied to the Turkish data. To the best of our knowledge, this is the first ever attempt to estimate and report the rank order and magnitude of leading causes of death in Turkey. We emphasize the value of using ‘local’ data in such estimation exercises. We also identify important weaknesses in the data collection systems operating in Turkey, and propose measures to strengthen them.
Methods

The ‘burden of disease’ approach to estimating mortality patterns ensures that, for a particular age–sex population group, the sum of deaths due to different causes does not exceed the overall mortality estimated for it. Hence, age–sex-specific risks of mortality were first estimated, and subsequently applied to national population data to derive the ‘envelope’ of deaths for each age–sex group. Next, information on cause-specific mortality was systematically reviewed and adjusted for biases, errors and probable misdiagnoses to derive a cause-specific mortality distribution for each age–sex group. This distribution was applied to the mortality 'envelope', to derive estimated numbers of deaths by age, sex and cause. We accounted for mortality differentials between urban and rural populations by separately estimating cause-specific mortality in each, and summed them to derive the national estimate.

Numbers of deaths by age and sex

The year 2000 was chosen as the reference year for mortality estimation, coinciding with the Turkish national census conducted on 22 October 2000. Almost a million enumerators were employed, including personnel to cover non-domiciliary locations such as hospitals, dormitories, military quarters, prisons and even transportation vehicles. Although an independent verification survey was not done, the reliability of census results was assessed through a detailed review of questionnaires in selected localities, where there were discrepancies in geographic and administrative identity of enumeration areas when compared to the national census frame. This assessment estimated that up to 5.2% of the population were double counted. The final national population was determined to be 67.85 million after adjustment, with 65% of the population residing in urban areas.

Registration of births and deaths is a legal requirement in Turkey, under the provisions of the Turkish Civil Registration Law of 1935. The Civil Registration system is operated by the Population Bureau of the Ministry of Internal Affairs, in collaboration with the Ministry of Health and Social Welfare. Under this system, death registration takes place at the time of issuing burial licenses, but these are mandatory only in urban areas. In rural areas, death records are maintained by the mukhtar (village headman) and owing to irregular implementation of the law, coverage is not complete. As a result, life tables were developed independently for urban and rural areas, as follows.

Urban Turkey

The State Institute of Statistics (SIS) compiles annual data on deaths (~ 180,000) by age, sex and cause. The Hill Generalized Growth Balance method assessed the completeness of death registration at ages over 5 years to be 88% for males and 84% for females. The reported SIS age-specific death rates for 2000 were adjusted accordingly, yielding risks of adult mortality between the ages of 15 and 60 (>45q15) of 170 per 1000 for males and 91 per 1000 for females.

The 1998 Demography and Health Survey (DHS) estimates of under-five mortality (i.e. risk of child death, 5q0) for urban Turkey (42 per 1000) are higher than 5q0 values calculated from the SIS data (30 per 1000), confirming that child mortality, at least in urban areas is underreported by ~ 30%, or twice that of adults. The DHS estimate for urban child mortality and the adjusted SIS estimates of adult mortality were used as inputs into the Modified Logit Life Table system, to estimate complete age-specific mortality rates for urban Turkey.

Rural Turkey

The only source of data to obtain a direct estimate of the level of adult mortality in rural Turkey (i.e. age-specific death rates) is the nationwide Special Mortality and Verbal Autopsy survey, carried out in about 60,000 households (a population of ~300,000) by the Ministry of Health in 2000. Mortality rates calculated from this survey are subject to large random error given the small number of deaths (~1200) captured in the study. To assess their plausibility, we applied the observed levels of child mortality (5q0) for the rural population derived from the DHS to predict the level of adult mortality in rural areas using the empirical database underlying the Modified Logit Life Table system. A computer simulation was used to produce 1000 life tables for a given input value of 5q0, resulting in a distribution of possible compatible levels of >45q15. The calculated household survey value of >45q15 for rural males (199/1000) corresponded to the 45q15 Value at the 33rd percentile of this distribution. We took this as confirmation that the level of adult male mortality calculated from the survey was plausible, and chose this level of adult mortality as the estimated level for males in rural Turkey. We then similarly chose the female adult mortality level to correspond to the 33rd percentile value of the adult female mortality distribution (154/1000). Therefore, we used DHS values of >45q0 for rural areas, and the 3rd percentile values for adult mortality as inputs in the Modified Logit Life table system, to estimate complete age-specific mortality rates for rural Turkey (table 1).

These age-sex-specific rates of mortality were then applied to the age-sex structure of the population in urban and rural areas to derive the estimated number of deaths.

Causes of death

Urban areas

In urban Turkey, local health centres and municipal health units in each district are responsible for civil registration, and

Table 1: Mortality estimates for Turkey and comparator groups, by region and sex, 2000

<table>
<thead>
<tr>
<th>Population group</th>
<th>Males</th>
<th>Females</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>ε0a</td>
<td>ε0b</td>
</tr>
<tr>
<td>Turkey: Rural</td>
<td>66.2</td>
<td>53.0</td>
</tr>
<tr>
<td>Turkey: Urban</td>
<td>68.6</td>
<td>40.0</td>
</tr>
<tr>
<td>Turkey</td>
<td>67.7</td>
<td>44.9</td>
</tr>
<tr>
<td>High-income countries</td>
<td>75.5</td>
<td>7.0</td>
</tr>
<tr>
<td>Europe and Central Asia</td>
<td>63.0</td>
<td>32.0</td>
</tr>
</tbody>
</table>

Source: Authors’ estimates for Turkey. Estimates for Comparator Groups from

- a: Life expectancy at birth (in years).
- b: Probability (per 1000) of dying between birth and the age of 5 years.
- c: Probability (per 1000) of dying between the ages of 15-60 years.
periodically submit death certificates to the Provincial Health Directorate (PHD). In addition, all hospitals located in cities within each province submit copies of death certificates to the PHD. Copies of all death certificates from each province are forwarded to the State Institute of Statistics (SIS) (the national level agency responsible for collection and collation of Turkish mortality statistics), for selection and coding of underlying causes of death, which are subsequently tabulated according to the Basic Tabulation List of the Eighth Revision of the International Classification of Diseases (ICD-8). A scrutiny of the Turkish death certificate revealed that it does not comply with current recommendations from the World Health Organization on recording the causes of death.

We applied several principles from the Global Burden of Disease (GBD) study to convert the basic Turkish cause of death data into a format suitable for international comparison. Firstly, we used a standard mapping algorithm to retabulate the ICD-8 coded data set into the GBD cause list. The GBD cause list is a hierarchical list which first divides all diseases and morbid conditions into ‘communicable, maternal, perinatal and nutritional’ on the one hand, and ‘non-communicable’ on the other. Injuries form the third broad group. Within each group, major disease categories such as neoplasms, cardiovascular diseases, etc., are identified, and within these groups, specific causes (e.g. sites of neoplasms) are listed. The GBD List thus places more emphasis on epidemiological characteristics than the ICD list, which is based more on anatomical or pathophysiological considerations.

Next, since data were only available in 10-year age intervals (5–14, 15–24, etc.) we interpolated the data using standard methods to estimate cause of death distributions by 5-year age groups to match the 5-year age groups for total deaths. Several anomalies in the reported causes of death were corrected according to GBD principles, or by using alternate data sources that provided more reliable evidence, as follows:

**Ill-defined causes (9.8%)**: Deaths at the ages <5, and ≥5 years, coded to this category were proportionately reassigned to causes within communicable and non-communicable diseases, respectively, assuming that deaths from injuries would not have been assigned to ill-defined codes.

**Other cardiac diseases (31.9%)**: Deaths assigned to these codes, which include codes for heart failure and cardiac arrest, were reassigned to specific codes within the cardiovascular disease group, namely ischaemic heart disease, cerebrovascular disease, hypertensive heart disease and inflammatory heart disease (pericarditis, myocarditis, endocarditis and cardiomyopathies), based on the redistribution algorithm developed for the GBD study. This algorithm is based on the assumption that most ill-defined heart disease deaths are in fact due to ischaemic heart disease. Together, the two categories of ill-defined causes and non-specific cardiovascular conditions account for more than 40% of the registered deaths.

**Cancers (13.6%)**: National cancer site-specific mortality rates were developed using local cancer incidence to survival ratios to predict mortality by site. Data from the İzmir Cancer Registry were used to estimate site-specific cancer incidence and mortality rates for Turkey.

**Meningitis**: Over 2% of all the deaths were coded to meningitis in the SIS data set, almost all at ages under 5 years. This is highly implausible, since no epidemics have been notified, nor had any meningitis mortality been observed in hospitals. Epidemiological estimates based on observed case-fatality rates from community studies in Turkey were used to estimate the likely numbers of meningitis deaths, and the remainder were reassigned to pneumonia, and ‘other infectious diseases’, which includes a code for unknown infections.

**Maternal causes**: A national survey on maternal mortality reported that the Maternal Mortality Ratio (MMR) in 1996 was 49/100,000 live births. An estimate of all maternal deaths in 2000 was derived by applying this MMR to the estimated births in that year. Hospital-based data, the only available evidence on causes of maternal death, was used to proportionately distribute deaths by cause as follows: haemorrhage, 30%; hypertensive disorders, 20%; abortion, 10%; sepsis, 10%; obstructed labour, 5%; other and unknown causes of maternal death, 25%.

**Injuries**: Information from the Traffic Police records and the Ministry of Justice was used to correct the SIS data for deaths due to traffic accidents, self-inflicted injuries, and deaths due to homicide.

Following the above adjustments, the resultant cause-specific mortality proportions, were then applied to the overall age–sex–specific mortality estimates, to estimate deaths by cause, age and sex in urban areas of Turkey for the year 2000.

**Rural areas**

In rural areas, which comprise 35% of the Turkish population, vital registration is dysfunctional, and no statistics are routinely compiled from these data. Further, there is no information on the cause composition of rural mortality, either from hospital statistics or other health institutions.

Given this situation, statistical models were used as a starting point to develop cause-specific mortality estimates. These models capture the historical relationship between broad causes of death and overall levels of mortality and income. Levels of national wealth are closely related to the cause structure of mortality, through health service provision and coverage. Therefore, the model [Causes of Death Model (CODMOD)] uses total mortality by age and sex, and GDP per capita, to estimate proportionate cause-specific mortality from the following three broad cause groups in the GBD List, which collectively cover all causes of death in the ICD.

**Group I**: Communicable diseases, maternal causes, perinatal causes and nutritional deficiencies.

**Group II**: Non-communicable diseases, including cardiovascular diseases, respiratory diseases, digestive diseases, endocrine, nutritional and metabolic diseases, sense organ disorders, genitourinary diseases, malignant neoplasms, musculoskeletal diseases, neurological disorders and neuropsychiatric disorders.

**Group III**: Injuries, whether intentional or unintentional.

The underlying estimation philosophy of the GBD approach, therefore, is to first derive plausible estimates of the relative importance of these broad causes before attempting to estimate specific causes of death. We used the estimated age–sex specific risks of mortality from the Turkish rural life table as model inputs, as well as the per capita income for the rural populations, estimated by local economists to be roughly half the national per capita income. The model-based predictions of GBD cause group–specific composition by age and sex, are shown in figure 1. For comparison purposes, the figure also includes (in bold lines) the broad cause group proportions by age and sex for urban areas of Turkey, based on our adjustments to the SIS data (as mentioned earlier).

These model-based predictions of the relative importance of broad causes of death for rural Turkey appear plausible, in view of the higher predicted proportions from Group 1 conditions during early childhood and young adulthood (particularly in women) in populations with lower socioeconomic status (i.e. rural areas), compared with wealthier urban areas.

We combined these predicted proportions of deaths by age and sex from the three broad cause groups with the demographic estimates of deaths by age and sex, to first derive the broad cause group–specific estimated numbers of deaths within each age group. In the absence of rural data on
specific causes, we then assumed that the urban proportionate cause structure applied in rural areas as well, within each broad cause group, to derive rural cause-specific estimates.

National estimates
The resultant urban and rural estimates from these modelling and adjustment exercises were summed to obtain preliminary Turkish national cause of death estimates. We then used surveillance, survey and other information available to several WHO disease control programs (e.g. tuberculosis, measles, HIV/AIDS)\(^{10}\) to further adjust the national cause of death estimates. In addition to the number of deaths, we also calculated leading causes of premature mortality from different causes, measured by Years of Life Lost [YLLs; they are calculated as the simple sum of deaths at each age from a given cause, weighted by the average life expectancy (i.e life ‘potential’) at that age. We used the GBD standard life expectancy represented by the Coale and Demeny Model life table West level 26. Lost years were age weighted and discounted according to GBD methods\(^{10}\) using the procedures followed in the GBD study.\(^{10,12}\)

Results
Overall measures of mortality
Table 1 summarizes the key mortality measures for urban and rural Turkey, and for the country as a whole, in 2000. By way of comparison, comparable indices for high-income countries, and for the World Bank’s Europe and Central Asia region (including countries of Eastern, but excluding countries of Western Europe) are also shown in the table. Child death rates in rural areas are about one-third higher than in urban areas. Overall, child mortality levels in Turkey are about 6 times higher than in countries of Western Europe.

Adult mortality levels, as assessed by the probability of dying at ages 15–59 \(1_{5,15}\), are marginally (18%) higher for rural than urban men, but substantially higher (70%) among rural women compared with those living in the urban areas. National levels of adult mortality (180/1000 for men; 114/1000 for women) are 50–75% higher than levels prevailing in developed countries, but lower than average levels in neighboring countries of Europe and Central Asia, primarily due to the excessively high risk of adult death observed in Russia and several other countries of the former Soviet Union.\(^{26,27}\) As a result, life expectancy at birth in Turkey (67.7 for males; 71.9 for females) falls about midway between the two groups of counties for males, but is similar to the average level in Europe and Central Asia, since lower female adult mortality in Turkey is countered by higher rates of death among young girls.

Leading causes of death
The leading causes of death in Turkey (table 2) characterize a population that has not yet completed the epidemiological transition, with non-communicable diseases, perinatal conditions and lower respiratory infections among the top five conditions. Although the magnitude of mortality due to diarrhoeal diseases and tuberculosis is comparatively small, their presence among the leading causes further suggests an unfinished agenda in the conquest of infectious diseases.

Ischaemic heart disease and stroke are estimated to be the leading causes of death for both males and females, together causing 35–38% of all deaths. Chronic obstructive pulmonary disease (COPD), lung cancer and diabetes are in the top 10 causes for men, and with the exception of lung cancer, each cause ~3% of deaths for women as well. The rank order and magnitude of cardiovascular conditions, COPD and lung cancer suggests that smoking is already having a significant impact on the health of Turkish men. Road traffic accidents are a much greater cause of death among males than females. Interestingly, inflammatory heart conditions (endocarditis, myocarditis, pericarditis and cardiomyopathies), caused largely by infection, are still prominent as causes of death in Turkey.

A key concern for public health policies is the avoidance of premature death, effectively summarized by the YLLs. This analysis more appropriately emphasizes the public health importance of tuberculosis, external causes of death such as road traffic accidents and self-inflicted injuries in both sexes, and of violence among men, than is apparent from table 2. Conversely, the rank order and magnitude of COPD and hypertensive heart disease is decreased when YLLs are used as a summary measure of mortality, given the strong age dependence of mortality due to these causes (table 3).

Discussion and Conclusions
Comparative mortality analyses of the leading causes of death, and of premature death, are a critical component of the evidence base to guide health development strategies. Public
health programmes and policies will be better served by information on the rank order and magnitude of diseases and injuries in the population. To be truly useful, these analyses should apply transparent and defensible methods to adjust for missing data and for misdiagnoses in reported data. The Global Burden of Disease framework provides a set of techniques and approaches to estimate population-level cause-specific mortality patterns from incomplete and mis-specified data.\textsuperscript{10–12} In this study, we have applied these methods to estimate the pattern of causes of death in Turkey in 2000 from over 100 specific causes of death, thus filling a key information gap in knowledge about causes of death among WHO’s European Region Member States.

There is undoubtedly substantial uncertainty in the estimated cause of death pattern given the problems with the underlying mortality data for Turkey. Overall, mortality data are only available for urban Turkey (65% of the national population in 2000) and even these data underreport true levels of mortality. Cause of death data are also only available for urban Turkey, and unadjusted, are largely inadequate for most public health purposes. Prudent interpretation of the results of applying various correction algorithms and modeling techniques suggests that Turkey is well advanced in its epidemiological transition, but that significant avoidable mortality from communicable diseases (diarrhoeal diseases, lower respiratory infections and tuberculosis), perinatal conditions (low birth weight, prematurity, birth asphyxia and birth trauma) and nutritional causes still occur.

Programmes to accelerate progress in reducing disease burden from these largely preventable conditions must remain a priority for public policy in Turkey.

Our methods suggest that the epidemiology of cardiovascular diseases in Turkey more closely resembles the pattern of Western Europe, with higher ischaemic heart disease mortality.
than for stroke (rate ratio 1.5) than that for countries of East Asia, where stroke predominates.\textsuperscript{10,11} While this is in accord with other studies,\textsuperscript{2,3} our estimated rates of IHD mortality are lower than that reported elsewhere,\textsuperscript{28} arising in part from an under-diagnosis of IHD in official mortality statistics in Turkey.\textsuperscript{29} We emphasize, however, that comparative mortality assessments based on our findings should be made with caution given the quality of the underlying data. We believe, however, that the broad causes of death patterns are reasonable, given the level of socio-economic development, urbanization and health services delivery in Turkey.

While our results about the comparative importance of various diseases and injuries are novel and relevant for public policy, an equally important finding to emerge from our study was the very poor state of health statistics in Turkey. This detailed ‘data audit’ assessed the quality and usability of existing mortality information, and identified critical weaknesses and omissions in the data collection system. An obvious conclusion to draw is the urgent need to establish reliable cause of death reporting systems for rural populations in order to guide and help evaluate health development strategies. The complete absence of routine mortality data for this population implies that our modelled estimates are a ‘best guess’ of causes of death in rural areas. This has obvious implications for the reliability of the national cause of death estimates reported here. Similarly, the poor quality of data for some major causes of death in urban areas introduces substantial uncertainty into estimation patterns. The unacceptably high proportions of deaths coded to ill-defined conditions and to mis-specified vascular diseases, particularly cardiac arrest, strongly suggests the need for urgent measures to improve the cause of death certification and coding practices among urban populations where data are collected. The comparatively low mortality rates from injuries are also of concern and may be indicative of miscoding of injury deaths to ill-defined causes.\textsuperscript{30,31}

A major advantage of the GBD approach for estimating mortality patterns is that the methods force epidemiological consistency across causes and preserve a sensible relationship between the level and cause structure of mortality. The use of models to define broad cause group proportionate mortality also ensures that biases in registered mortality data (e.g. relative neglect of injuries in official mortality data) are minimized. The approach, however, is only as reliable as the underlying data to which the methods are applied and no amount of methodological rigour can compensate for poor quality data in mortality estimation. Hence, although applicable in Turkey, these considerations should be borne in mind while applying the GBD approach in other countries with incomplete or fragmentary mortality data.

Given the critical importance of good cause of death statistics for health development policies, and given the substantial funding undoubtedly being allocated to maintaining these systems, a complete review and revision of current data collection practices should be seen as a priority by the government in Turkey. A key outcome of such a review must be vastly improved training programmes for physicians in cause of death certification procedures, and rigorous attention to mortality registration procedures, particularly in rural areas.

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Conflicts of interest: None declared.

Key points

- Incomplete vital registration necessitates the use of statistical models and epidemiological data from different sources to estimate levels of mortality and cause of death patterns in Turkey. The Burden of Disease methodology provides a framework for such estimations.
- The resultant estimates suggest significant burden due to chronic disease mortality in urban areas, coupled with an unfinished agenda on communicable disease control, particularly in rural Turkey.
- There is an urgent need to strengthen death registration and other health information systems in Turkey, that will yield valid and reliable statistics for health policy and evaluation.

References


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