

## Tracking mortality changes from health facility data in Sub-Saharan Africa: how do hospital deaths differ from home deaths in Antananarivo (Madagascar)?

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### Short abstract

All causes and cause specific mortality in sub-Saharan Africa remain poorly known due to the incompleteness of death registration systems and a high percentage of home deaths. Even though health facility data are increasingly used to monitor changes in disease patterns, they are not representative of the general population. We take advantage of a death notification system that was set up in Antananarivo (Madagascar), to document over time (1976-2015) the hidden causes of death that are not usually reported in health facility data.

In Antananarivo, age at death has increased and the overall proportion of death occurring in health facilities has declined over time. However, these changes have been uneven across causes of death, and the concordance between cause-specific mortality fractions inferred from deaths that occurred in health facilities and those based on all deaths is gradually increasing. However, some deaths remain consistently under-represented, especially those due to respiratory diseases.

### Background

Public health decision-makers need timely estimates of mortality by cause to monitor health progress and allocate resources (Jha 2012). This need is especially critical in Sub-Saharan Africa, where the burden of preventable mortality is increasingly concentrated. Yet, there is considerable uncertainty around mortality levels and trends in this region, due to the incompleteness of death registration systems. Apart from some countries in Southern Africa and some cities in other regions, often less than half of deaths are registered (Mikkelsen 2015, Setel et al. 2007). As a result, mortality levels are mostly inferred from surveys and censuses, with a risk of biases due to sampling and non-sampling errors. These sources provide limited information on causes of death, apart from some reports on pregnancy-related (Helleringer et al. 2015) or violent deaths (Pison et al. 2018). Thus, evidence on the underlying diseases that contribute most directly to the deaths is sparse in Sub-Saharan Africa. Health and Demographic Surveillance Systems (HDSS) help to fill data gaps through verbal autopsies (Streatfield et al. 2012), but they are quite expensive to maintain in the long run and cause-specific mortality fractions obtained from HDSS refer only to the local areas covered by these systems.

To compensate for the lack of cause-of-death data, international agencies and national governments are devoting considerable efforts to improving the collection of mortality data through health management information systems (HMIS) (AbouZahr et al. 2005, Gething et al.

2006). Health facilities are supposed to report monthly or annually on health conditions observed in patients. Several countries have recently set up digital health information systems, such as DHIS2 (<http://www.dhis2.org/>), to collect and manage health facility data, including deaths and their underlying causes. WHO also developed a Start-up mortality list (ICD-10-SMoL) for initial cause-of death collection in health facilities in low-resource settings. With these tools, countries could potentially have access to real-time mortality data with the underlying causes of death. There are, however, huge challenges associated with the development of mortality statistics from health facility data including: (1) providing appropriate training to physicians and coders; (2) ensuring that ICD standards and the International Medical Certificate for Cause of Death (MCCD) are used in health facilities; (3) compiling, transferring and storing data; (4) consolidating data from the public and private sector; or (5) linking data sources from health facility and the death registration system (English et al. 2018, Rampatige et al. 2014). Even if these challenges were addressed, health facility data would only contribute to mortality estimation if adjustments could be developed to account for non-representativeness of facility death records (Williams et al. 2019, Murray et al. 2007). People who die at home have socio-demographic profiles and health conditions that differ markedly from those who die in health facilities. For example, perinatal deaths occur more frequently in hospitals whereas old people are more likely to die at home. This has been shown in Burkina Faso in a study that also found a strong association between living standards and the likelihood to die at home (Bado et al. 2016). Moreover, the probability to die in hospitals vs at home will vary according to what led to the death i.e. the underlying cause itself. Deaths that occur suddenly from injuries or acute diseases are less likely to take place in hospitals, compared with deaths that occur after a disease period. The availability and quality of health care will also interplay. In the study in rural Burkina (Bado et al. 2016), people who died from infectious and parasitic diseases (including diarrhea), neoplasms, renal and urological diseases, and violent deaths, were more likely to die at home than in health facilities. In the capital city of Addis Ababa, HIV/AIDS deaths in adults were more likely to occur in health facilities compared to deaths attributable to cardiovascular diseases, digestive diseases and other non-communicable diseases (Anteneh et al. 2003). However, this difference was not found in a study conducted in Zambia among adults (Chisumpa et al. 2017). This supports the idea that the interplay between causes of death and place of death depends on the local context and possibly the age groups considered.

Improvements in health care supply in terms of accessibility and quality, coupled with economic development and better access to education should result over time in an increase in the proportion of deaths occurring in health facilities. Yet, the pace of these improvements may vary by health conditions and leads to a change in the association between place of death and causes of death. For example, due to international initiatives, we can expect a more rapid improvement in the management of infectious diseases and maternal diseases, as compared to other diseases. In parallel, with the epidemiologic transition, people tend to die at older ages, predominantly from non-communicable diseases against which the public health systems are still ill-equipped.

In this paper, we take advantage of a rich and unique database of a death notification system that was set up in the beginning of the 20<sup>th</sup> century in Antananarivo, the capital city of Madagascar. We document “who dies where” and “what do they die from” over the period 1976-2015 and evaluate changes over time. We aim to document over time the *hidden* deaths

and more specifically the *hidden* causes that are not usually reported in health facility data in sub-Saharan African populations. This study has policy implications in terms of documenting access to health care in Madagascar, but it also has methodological implications in terms of estimating the burden of diseases from health facility data.

## Study setting, data and methods

In Antananarivo, Madagascar's capital city, the death certificate is compulsory for burials and death registration is virtually complete (Waltisperger et al. 1998, Masquelier et al. 2014). When a death occurs at home (about 60% of deaths of residents since 1976), relatives contact the municipality, and a physician is sent to the house of the deceased to consult medical documents and conduct post-mortem interviews with the family. Hospitals or clinics also transmit reports to the municipality. All records referring to the period 1976-2015 have been digitized and causes of death have been coded according to the ICD 9 classification.

Previous studies have documented the health transition in the city (Masquelier et al. 2014, Waltisperger and Meslé 2005): mortality declined rapidly in the second half of the 20<sup>th</sup> century but resurged again in the 1980s as a result of the re-emergence of malaria and the collapse of Madagascar's economy. Over the past 30 years, impressive gains in life expectancy were registered, with a noticeable shift from communicable to non-communicable diseases. In the period 2012-2015, life expectancy was estimated at 61.7 years for males and 67.8 for females.

Our database comprised the date of birth, date of death, sex, underlying cause of death and place of death of 249 421 residents of Antananarivo-city who died between 1976 and 2015. In the database, place of death was unknown for less than 0.1 per cent of cases. These cases were excluded from the analysis. For this study, we combined specific causes of death in eleven broad categories: (1) infectious diseases (classified in the first chapter of the ICD-9), (2) neoplasms, (3) nutritional deficiencies, (4) cardiovascular diseases (CVDs), (5) diseases of the respiratory system (including influenza and bronchitis), (6) Maternal deaths, (7) Diseases of genitourinary organs, (8) Diseases of the digestive system, (9) Other diseases, (10) External causes (injuries and violent deaths), and (11) unspecified causes. The corresponding ICD codes are reported in the appendix (Annex 1).

## Preliminary results

### *Epidemiologic changes since 1976*

Table 1 presents the cause-specific mortality fractions standardized<sup>1</sup> by age group for 10-year periods since 1976 (details by age group are provided Annex 2). This table illustrates the important changes in the distribution of causes of deaths that occurred since 1976, as a result of the epidemiologic transition. As expected, the share of infectious diseases and nutritional deficiencies has largely decreased in favor of non-communicable diseases, especially cardiovascular diseases and neoplasms.

### *Place of death over time according to age group and sex*

In Antananarivo, over the period 1976-2015, only 40% of deaths took place in health facilities (Table 2). The highest proportion of health facility deaths was among adults (48%) followed by

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<sup>1</sup> The age distribution of deaths during the entire period of analysis is used as the standard.

deaths of children aged less than 5 (45%) and older children and adolescents (40%). With less than 28%, the proportion is the lowest among deaths in the elderly. However, the proportion of deaths that occurred in health facilities has changed over the period with an increase among the youngest age groups and a decrease among adults. In the last period (2006-2015), half of under-five deaths occurred in health facilities (51%) and the proportion of facility deaths clearly declines with age. For all age groups and all periods, proportions were lower for female deaths (37%) than for male deaths (43%). The annex 3 provides details of the proportions by cause of deaths that varied across the periods and the age groups.

#### *Cause-specific mortality fractions among total deaths versus deaths that occurred in health facilities*

We compare age-standardized cause-specific mortality fractions using only deaths occurring in health facility to cause-specific mortality fractions using all deaths in Table 3. Deaths from unknown causes were proportionally redistributed in the other groups of causes as it is commonly done in cause-specific mortality statistics. There are large differences for some groups: in total, deaths due to a respiratory diseases contribute to 12.6% of the male deaths and 12% of the females deaths whereas proportions are twice lower when considering deaths in health facilities (with respectively 6.8% and 5.9%). By contrast, external causes and other diseases are over represented among deaths occurring in health facilities. Deaths due to external cases represent 22.6% among male deaths in health facilities against only 17.5% among all deaths. Over time, the difference has remained quite large for these three groups of causes (Annex 4). For the other groups, differences seem to have decreased. For example, for female deaths, maternal causes represented in 1976-1985 2.7% of the total deaths but 4.0% among those that occurred in health facilities. In the last period (2006-2015), these percentages were respectively 1.2% of total deaths compared to 1.6% of deaths among those occurring in health facilities.

#### *The likelihood of dying in a health facility*

The likelihood of dying in a health facility was estimated by age, sex, group of cause, and period of time, using a binary logistic regression. This analysis confirms descriptive results presented above (Table 3). Related to the cause, maternal conditions, genitourinary diseases and external causes tend to occur more often in health facilities, compared to deaths due to infectious diseases. However, except for the external causes, the relative risks tend to decrease over time. For neoplasms, nutritional deficiencies, and diseases of the digestive system, odds ratios have changed over time from higher to lower risks of dying in hospitals, compared to infectious diseases. The likelihood of dying in a health facility appears to be very low when people suffer from respiratory diseases. For cardiovascular diseases, the association has varied over time with no distinct pattern. Finally, deaths from unspecified causes occur mostly at home.

## **Discussion**

Several results are contrary to our expectations. From an historical perspective, the association between the proportion of deaths occurring in health facilities and the age at death has varied over time. The proportion of deaths occurring in health facilities has increased for young deaths (less than 15) but it has declined in adults aged 15-59. As ages at death are gradually increasing (driven by the epidemiological transition), and percentages of deaths taking place in health

facilities are lower among adults, these changes result in slight declines in the overall proportion of death occurring in health facilities.

When considering causes of death, surprisingly deaths due to external causes (injuries and violent deaths) tend to occur more frequently in health facilities than at home. This is due to the fact that some corpses are transferred from home to the mortuary to conduct autopsy. These deaths including most external deaths were recorded as if they have occurred in health facility. We also noticed some non-linear trends in the likelihood of dying in health facility by group causes of deaths. The succession of periods of health progress periods and health crises that characterized Madagascar probably explains this situation. However, deaths due to respiratory diseases particularly tend to occur at home overtime, leading to a probable underestimation of this group of causes in health statistics when based on health facility data.

### **Limitations**

Our study has some limitations. First, this analysis did not take into account risks of dying. However, because the deaths registration is virtually complete, we could analyze the cause-specific mortality fractions that would be obtained if estimates were entirely based on health facility data, as is mostly the case in statistics produced by the Malagasy Ministry of Health. Second, in the database, the quasi totality of the deaths occurred either at home or in hospitals. This suggests that deaths that occurred in public areas were probably coded according to the place where the body was carried right after the death. This suggests that there could be some misclassification errors in the place of deaths due to external causes as highlighted above. Finally, deaths from unknown causes are not negligible as they represent 12% of deaths in total and mostly occur at home. Redistributing these deaths in other acceptable categories could affect our results.

### **Conclusion**

In Antananarivo, cause-specific mortality fractions derived from deaths occurring in health facilities are biased due to non-representativeness. The concordance between cause-specific mortality fractions inferred from all deaths and only health facility deaths has increased over time. However, some causes remain consistently over- or under- represented and some changes were not linear, probably due to health or economic crises.

Since the proportion of age-specific deaths that occurred in hospitals can be estimated based on our data covering Antananarivo, in-hospital deaths record in other cities and rural areas could be adjusted accordingly and provide a detailed picture of the distribution of causes of death in the entire country. This strategy has been tested in Mexico (Murray et al. 2007) but other validation studies should evaluate its performance in countries with weaker health systems.

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Table 1: Cause-specific mortality fractions standardized by age group by 10-year period in Antananarivo since 1976

Group causes of death	1976-1985	1986-1995	1996-2005	2006-2015	Total
Infectious diseases	19.7%	20.7%	15.7%	9.6%	17.1%
Neoplasms	4.7%	4.1%	4.9%	6.2%	5.0%
Nutritional deficiencies	4.9%	7.5%	4.4%	3.0%	5.1%
Cardiovascular diseases	22.0%	20.0%	23.0%	25.3%	22.8%
Diseases of the respiratory system	10.8%	11.7%	10.4%	10.8%	10.8%
Maternal deaths	1.1%	1.2%	0.8%	0.5%	0.8%
Diseases of genitourinary organs	2.9%	2.1%	2.1%	2.4%	2.3%
Diseases of the digestive system	4.9%	4.4%	4.4%	4.6%	4.5%
Other diseases	11.4%	10.4%	15.0%	21.4%	14.0%
External causes	4.9%	5.6%	6.0%	5.9%	5.4%
Unspecified causes	12.8%	12.4%	13.2%	10.4%	12.1%
Total	100.0%	100.0%	100.0%	100.0%	100.0%

Note: The distribution of group ages at death during the entire period of analysis is used as standard.

Table 2: Proportions of deaths occurred in health facilities by age group and period in Antananarivo since 1976, among males and females

Sex	Age group	1976-1985	1986-1995	1996-2005	2006-2015	Total
Males	<5 y.o	47.8%	42.7%	46.5%	51.9%	46.5%
	5-14 y.o	42.2%	34.7%	45.1%	49.9%	41.6%
	15-59 y.o	57.6%	46.1%	47.5%	46.6%	48.4%
	>= 60 y.o	32.9%	28.6%	31.8%	31.1%	31.1%
	Total	46.7%	40.0%	42.5%	42.4%	42.8%
Females	<5 y.o	44.0%	38.4%	44.5%	50.6%	43.1%
	5-14 y.o	38.8%	32.5%	41.2%	45.1%	38.1%
	15-59 y.o	52.8%	45.8%	46.8%	43.9%	46.6%
	>= 60 y.o	22.6%	20.6%	26.5%	25.6%	24.2%
	Total	40.1%	35.1%	38.6%	37.1%	37.6%
Total	<5 y.o	46.0%	40.6%	45.6%	51.4%	44.9%
	5-14 y.o	40.6%	33.7%	43.3%	47.8%	40.0%
	15-59 y.o	55.5%	46.0%	47.2%	45.5%	47.7%
	>= 60 y.o	27.8%	24.6%	29.1%	28.3%	27.6%
	Total	43.7%	37.7%	40.7%	40.0%	40.4%
Observations		56147	65551	60729	67118	249545



Table 3: Cause-specific mortality fractions standardized by age group, for total deaths and deaths occurred in health facilities, by sex in Antananarivo for the total period 1976-2015

Note: Deaths from unknown causes are proportionally redistributed among other groups of causes.

Group of causes	Males		Females	
	Total	Health fac.	Total	Health fac.
Infectious diseases	19.9%	17.3%	19.0%	15.9%
Neoplasms	4.5%	5.6%	7.3%	8.0%
Nutritional deficiencies	5.7%	4.6%	5.9%	5.2%
Cardiovascular diseases	22.7%	20.7%	29.9%	27.6%
Diseases of the respiratory system	12.6%	6.8%	12.0%	5.9%
Maternal deaths	-	-	2.1%	3.1%
Diseases of genitourinary organs	3.0%	4.0%	2.2%	3.1%
Diseases of the digestive system	6.4%	6.4%	3.7%	4.2%
Other diseases	17.5%	22.6%	14.0%	20.6%
External causes	7.8%	12.0%	4.2%	6.5%
Total	100.0%	100.0%	100.0%	100.0%

Table 4: Adjusted odds ratios of the binary logistic regression for the probability that a death occurred in a health facility for each 10-year period in Antananarivo since 1976

	1976-1985	1986-1995	1996-2005	2006-2015
Sex (ref. male)				
Female	0.803***	0.842***	0.937***	0.918***
Age group (ref. <5 y.o.)				
Age group 5-14 y.o.	0.835***	0.757***	0.850***	0.789***
Age group 15-59 y.o.	1.374***	1.008	0.937**	0.756***
Age group 60+ y.o.	0.523***	0.475***	0.543***	0.477***
Group of causes (ref. infectious diseases)				
Neoplasms	2.474***	3.071***	1.518***	0.901**
Nutritional deficiencies	1.281***	0.930**	1.013	0.659***
Cardiovascular diseases	0.866***	1.159***	1.182***	0.925**
Diseases of the respiratory system	0.539***	0.471***	0.448***	0.408***
Maternal causes	5.817***	8.050***	3.163***	1.964***
Genitourinary diseases	3.067***	3.835***	2.194***	1.409***
Diseases of the digestive system	1.873***	1.903***	1.464***	0.766***
Other diseases	3.361***	3.289***	2.553***	1.688***
External causes	3.059***	3.045***	4.086***	5.325***
Unspecified causes	0.388***	0.378***	0.435***	0.277***
Constant	0.809***	0.666***	0.745***	1.076**
Frequencies	56,147	65,551	60,729	67,117

Note : \*\*\* p<0.01, \*\* p<0.05, \* p<0.1.

Annex 1: ICD 9 codes corresponding to the defined group causes of death

<b>Group causes of death</b>	<b>Codes ICD 9</b>
Infectious diseases	10-1398
Neoplasms	1400-2399
Nutritional deficiencies	2600-2699
Cardiovascular diseases	3900-4599
Diseases of the respiratory system	4600-5199
Maternal deaths	6300-6769
Diseases of genitourinary organs	5800-6299
Diseases of the digestive system	5200-5799
Other diseases	2400-2599;2700-3899;6800-7799
Unspecified causes	7800-7999;0

Annex 2: Distribution of causes of deaths by age group and period in Antananarivo since 1976 (males and females)

Group of causes	1976-1985					1986-1995				
	<5	5-14	15-59	>=60	Total	<5	5-14	15-59	>=60	Total
Infectious diseases	37.2%	33.1%	15.7%	6.4%	23.7%	31.0%	33.3%	21.3%	8.7%	21.9%
Neoplasms	0.2%	3.0%	7.2%	6.1%	3.6%	0.4%	2.5%	5.9%	5.5%	3.7%
Nutritional deficiencies	12.2%	7.0%	2.0%	1.1%	6.6%	15.6%	14.8%	4.1%	2.9%	8.4%
Cardiovascular diseases	0.6%	5.3%	24.2%	41.7%	17.2%	0.6%	4.5%	20.7%	39.4%	17.9%
Diseases of the respiratory system	15.9%	13.8%	6.5%	10.6%	12.1%	18.5%	12.0%	7.8%	9.9%	12.3%
Maternal deaths	0.0%	0.0%	3.0%	0.0%	0.8%	0.0%	0.0%	3.2%	0.0%	1.1%
Diseases of genitourinary organs	0.2%	1.5%	4.3%	3.9%	2.2%	0.2%	1.3%	2.5%	3.4%	1.9%
Diseases of the digestive system	1.2%	3.4%	8.2%	4.7%	4.0%	1.2%	2.8%	7.2%	4.2%	4.1%
Other diseases	22.0%	8.1%	8.5%	5.2%	13.7%	22.0%	5.6%	7.4%	3.4%	11.4%
External causes	1.6%	10.6%	9.0%	2.2%	4.1%	2.2%	10.1%	10.1%	2.9%	5.4%
Unspecified causes	8.9%	4.0%	11.4%	17.9%	12.0%	8.3%	13.1%	9.6%	19.5%	12.0%
Total	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
	1996-2005					2006-2015				
Infectious diseases	23.1%	27.5%	15.6%	7.4%	15.0%	12.8%	18.8%	10.9%	3.9%	8.8%
Neoplasms	0.6%	4.3%	7.2%	6.3%	5.2%	0.9%	7.2%	8.8%	7.8%	7.3%
Nutritional deficiencies	13.1%	6.9%	0.8%	0.3%	3.8%	8.7%	5.5%	0.5%	0.4%	1.7%
Cardiovascular diseases	1.2%	7.2%	25.4%	42.5%	24.7%	1.8%	7.3%	29.9%	44.0%	30.6%
Diseases of the respiratory system	19.0%	9.9%	6.0%	7.7%	9.8%	18.0%	11.7%	7.6%	7.6%	9.2%
Maternal deaths	0.0%	0.0%	2.1%	0.0%	0.8%	0.1%	0.2%	1.3%	0.0%	0.6%
Diseases of genitourinary organs	0.2%	1.5%	2.8%	3.2%	2.3%	0.3%	1.4%	3.2%	3.4%	2.8%
Diseases of the digestive system	1.4%	2.9%	7.2%	4.2%	4.7%	1.9%	3.5%	7.6%	3.8%	5.3%
Other diseases	29.6%	11.1%	12.5%	4.6%	13.9%	43.7%	19.1%	16.0%	7.3%	16.8%
External causes	3.8%	15.6%	9.7%	2.6%	6.1%	5.0%	16.4%	8.8%	1.9%	5.9%
Unspecified causes	7.9%	13.0%	10.8%	21.1%	13.6%	6.7%	8.8%	5.4%	19.8%	11.0%
Total	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

Annex 3: Proportions of deaths that occurred in health facilities by group of causes of death, age group, and period in Antananarivo since 1976

Group of causes	<5	5-14	15-59	>=60	Total	<5	5-14	15-59	>=60	Total
	1976-1985					1986-1995				
Infectious diseases	37.9%	39.9%	64.7%	35.2%	42.4%	30.4%	33.7%	47.2%	30.2%	36.1%
Neoplasms	81.7%	58.9%	63.4%	56.2%	60.8%	67.4%	69.4%	61.4%	50.8%	57.6%
Nutritional deficiencies	49.0%	42.0%	48.8%	37.8%	48.2%	43.0%	27.5%	17.4%	12.5%	34.5%
Cardiovascular diseases	45.3%	41.4%	46.1%	24.3%	32.8%	53.0%	34.7%	40.9%	25.3%	31.7%
Diseases of the respiratory system	29.3%	20.7%	38.3%	13.6%	26.7%	23.2%	16.3%	23.0%	10.6%	20.1%
Maternal deaths	-	-	83.5%	-	83.7%	-	-	82.0%	-	81.9%
Diseases of genitourinary organs	51.9%	37.8%	78.0%	55.7%	65.9%	56.0%	63.6%	74.7%	50.8%	62.0%
Diseases of the digestive system	61.5%	50.6%	64.0%	45.0%	57.5%	67.6%	47.3%	51.8%	37.4%	49.3%
Other diseases	80.0%	53.8%	47.9%	42.9%	70.7%	74.6%	51.6%	47.8%	41.8%	65.5%
External causes	50.6%	68.9%	76.9%	71.9%	70.7%	40.4%	59.8%	70.4%	53.7%	62.7%
Unspecified causes	17.6%	25.4%	36.0%	10.7%	19.9%	17.0%	15.6%	24.6%	7.4%	14.8%
Total	46.0%	40.6%	55.5%	27.8%	43.7%	40.6%	33.7%	46.0%	24.6%	37.7%
	1996-2005					2006-2015				
Infectious diseases	36.4%	38.1%	44.8%	29.7%	38.9%	37.5%	42.9%	46.8%	41.2%	43.8%
Neoplasms	69.1%	69.1%	47.4%	38.8%	45.1%	61.2%	59.7%	37.4%	34.1%	37.1%
Nutritional deficiencies	43.6%	29.2%	30.4%	36.5%	41.5%	40.1%	37.9%	34.0%	24.8%	37.8%
Cardiovascular diseases	47.0%	38.5%	44.9%	31.2%	37.1%	51.7%	46.5%	43.3%	29.9%	36.3%
Diseases of the respiratory system	18.8%	17.8%	29.3%	20.0%	21.6%	17.4%	25.1%	26.8%	25.0%	23.6%
Maternal deaths	-	-	67.3%	-	67.3%	-	-	59.0%	-	59.6%
Diseases of genitourinary organs	43.8%	57.1%	67.4%	39.4%	53.6%	40.6%	45.8%	52.8%	41.8%	47.6%
Diseases of the digestive system	68.8%	56.4%	45.2%	41.9%	46.2%	44.8%	40.0%	35.3%	33.6%	35.4%
Other diseases	74.1%	60.4%	48.9%	55.5%	62.7%	76.7%	49.7%	46.9%	45.5%	57.7%
External causes	44.5%	67.8%	79.8%	68.5%	72.0%	54.2%	80.3%	86.6%	71.3%	80.4%
Unspecified causes	27.7%	26.8%	27.6%	10.2%	18.6%	17.5%	23.5%	32.3%	7.4%	14.3%
Total	45.6%	43.3%	47.2%	29.1%	40.7%	51.4%	47.8%	45.5%	28.3%	40.0%

Annex 4: Cause-specific mortality fractions standardized by age group, for total deaths and deaths occurred in health facilities by 10-year period and for each sex in Antananarivo since 1976

Group of causes	1976-1985		1986-1995		1996-2005		2006-2015	
	Total	Health fac.	Total	Health fac.	Total	Health fac.	Total	Health fac.
<b>Males</b>								
Infectious diseases	23.6%	21.9%	24.0%	21.2%	18.6%	15.4%	11.4%	9.8%
Neoplasms	4.5%	6.2%	3.8%	6.2%	4.2%	4.9%	5.4%	5.4%
Nutritional deficiencies	5.9%	5.6%	8.8%	6.2%	4.8%	4.0%	3.1%	2.2%
Cardiovascular diseases	21.6%	17.1%	19.5%	18.0%	23.3%	21.9%	25.3%	23.8%
Diseases of the respiratory system	12.5%	7.5%	13.7%	6.7%	12.2%	6.1%	12.3%	6.2%
Maternal deaths	-	-	-	-	-	-	-	-
Diseases of genitourinary organs	3.7%	5.5%	2.7%	4.3%	2.8%	3.5%	2.9%	3.4%
Diseases of the digestive system	7.1%	8.1%	6.2%	7.1%	6.4%	6.4%	6.3%	4.9%
Other diseases	13.9%	18.1%	13.0%	18.1%	19.1%	24.6%	25.2%	31.1%
External causes	7.1%	9.9%	8.3%	12.2%	8.6%	13.1%	8.1%	13.0%
<b>Total</b>	<b>100.0%</b>	<b>100.0%</b>	<b>100.0%</b>	<b>100.0%</b>	<b>100.0%</b>	<b>100.0%</b>	<b>100.0%</b>	<b>100.0%</b>
<b>Females</b>								
Infectious diseases	21.4%	18.7%	23.1%	19.1%	17.5%	14.2%	9.9%	9.2%
Neoplasms	6.4%	9.3%	5.7%	8.2%	7.4%	7.6%	8.9%	7.8%
Nutritional deficiencies	5.2%	5.3%	8.2%	7.1%	5.5%	4.8%	3.7%	2.8%
Cardiovascular diseases	29.7%	24.7%	26.9%	24.3%	30.4%	29.3%	31.8%	30.2%
Diseases of the respiratory system	12.1%	5.8%	13.0%	5.9%	11.8%	5.3%	11.6%	5.4%
Maternal deaths	2.7%	4.0%	3.0%	4.9%	2.0%	2.6%	1.2%	1.5%
Diseases of genitourinary organs	2.7%	4.0%	2.0%	3.3%	1.9%	2.6%	2.4%	2.8%
Diseases of the digestive system	3.8%	5.1%	3.6%	4.5%	3.6%	4.3%	3.7%	3.5%
Other diseases	12.0%	17.3%	10.4%	16.7%	14.9%	22.0%	22.3%	29.4%
External causes	3.8%	5.8%	4.2%	6.0%	5.0%	7.4%	4.5%	7.2%
<b>Total</b>	<b>100.0%</b>	<b>100.0%</b>	<b>100.0%</b>	<b>100.0%</b>	<b>100.0%</b>	<b>100.0%</b>	<b>100.0%</b>	<b>100.0%</b>

Note: The distribution of group ages at death during the entire period of analysis is used as standard for each sex. Deaths from unknown causes are proportionally redistributed among other groups of causes.