# Assessing the quality of national life tables in Algeria using specific surveys

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**Abstract:** *Civil status represents the main source of the data needed to estimate national life tables. One way to estimate the completeness of civil records is by a comparison to parallel sources of data, e.g., surveys data. Based on the survey data, the coverage rates of the civil registration system are estimated and used to correct the recorded numbers. In Algeria, the coverage rates estimated in 2002 are still used to achieve such a correction. The present paper deals with mortality analysis within the Algerian population, where a national representative household survey; the Multiple Indicator Cluster Survey MICS; is used as a comparison reference to assess the quality of national life tables delivered by the Office of National Statistics (ONS).*

**Key words:** *mortality, data quality, MICS, life table, Algeria.*

## 1. Introduction

Making efficient health and population policies need to be based on reliable indicators. In this sense, national life tables are one main tool to explore the risk of death, mainly by age and sex of a population. Thus, it is necessary to assess the quality of these life tables before being used. Mortality data is usually collected using three methods; population censuses, civil registration and household surveys (United Nations, 2004); these sources are complementary. Therefore, the accuracy and the completeness of data require coordination and exploration of the three methods.

Reducing mortality has been the aim of the authorities over the years, these analyzes are considered as a helpful tool to evaluate the situation of the country comparing with other countries in term of development and living conditions. Data quality importance in the analysis has led us to devote an effort to consider this issue.

The demographic information system in Algeria relies mainly on civil registration. When its coverage is incomplete, the use of other data sources is needed. Being aware of the impact of data quality on the demographic indicators estimation, we decided to explore surveys data for more accurate and reliable results. Considering the limitations of using civil records, the quality of indicators published by the Office of National Statistics (ONS) is questioned. Thus, the Multiple Indicator Cluster Survey (MICS) provides a rich data source that could assess the reliability of the later. Whereas, the main question we aim to answer is whether exploring the MICS data in the mortality analysis context will give the same results as ONS publications or it will provide additional information.

Mortality analyses are usually performed using life tables. Provide details about the procedure used for calculating life tables defines one of the purposes of the present paper. Life tables are constructed using the survival and mortality data, the first step is to calculate the mortality rate, which is considered as demographic and health indicator. It enables identifying the most age ranges affected by this natural phenomenon, then search for an explanation and finally put the most effective targeted policies of prevention. Generally, life tables are built using vital registrations provided by civil status but given the possible limitations in the system, using other data sources for providing complementary information is required.

The first step of constructing a life table is the estimation of mortality rates; defined as the probability of dying between the age x and x+n; therefore two major components are required; Mortality distribution by age and the exposure to death risk known also as the number of person-years spent in each age interval. Mortality levels differ by age, sex. Therefore, the next step will be to clarify these differences within the Algerian population. Constructing separately life tables for each of these variables will fulfill this objective. The final step that prescribes the aim of the paper is to compare the constructed life table to ONS publications, followed by life expectancies results provided by both data sources.

## 2. Data source

Our dataset is taken from The Multiple Indicator Cluster Survey MICS which, is a nationally representative household survey, using a sample of almost 28000 households. The MICS is being sponsored by the United Nations International Children’s Emergency Fund **(UNICEF)**, conducted by the Algerian Ministry of Health, Population and Hospital Reform **(MSPRH)**. The purpose of the survey is to analyze the situation of women and child in Algeria regarding human development indicators.. It contains three questionnaires, one is dedicated for the household, one for women aged 15 to 49 years old and another one for children aged 0 to 5.

Conventionally, the survey takes place every six years, the waves 1, 2, 3, and 4 have been respectively conducted in 1995, 2000, 2006, and 2012. . In this paper, we will be interested by exploring the data provided by the MICS **III** and MICS IV. The "General Mortality" sub-questionnaire was only introduced for Algeria starting from the third wave. For the third wave, data collection lasted for two months and a half starting from mars $25^{th}$ in 2006 and from October $21^{st}$, 2012 until January $31^{st}$, 2013 for the fourth wave.

The data set derived from the MICS allows having information by detailed ages and by gender. The questions asked in the survey were about the number of individuals in the household, alive at the date of the interview as well as, their characteristics, i.e., sex, birth date. Also, the survey gathered, for each household, the number of deaths occurred during the five previous years and their characteristics.

The multiple indicator cluster survey is an accessible data source, performed on a considerable sample, includes the variables needed for our study. The previous features of the survey make it a potential source of mortality data and a good frame of reference that serves the aim of the paper.

## 3. Methods and Results

Life table is considered as a tool for decision-making, used by a wide range of specialists in various science branches mostly by actuaries, demographers, statisticians for different purposes like life and health insurance, social security, population statistics, prevention policies, living conditions evaluation. Indeed, it allows knowing the probability of surviving to the next birthday of any individual given his age, constitutes the first step for the calculation of life expectancy and health life expectancy Thus, it is very fundamental to give the highest importance for this element. The present paper attempts to use it as a tool for describing and analyzing mortality of the Algerian population using the multiple indicator cluster survey data.

A Mortality rate is defined as the probability of dying between the age x and x+n; depends on estimating two major components, i.e. deaths counts by age and the population at risk by age. Mortality counts by age that shows the event intensity within the different ages or age groups. The population at risk is expressed by the number of years lived along the studied period (Kimball, 1960). Complexity of the definition of the later has induced researchers to consider it as a study field concerning estimation methods given the available data. In our case, detailed information enable estimating the exact number of years experienced by each individual within the survey period.

In the following, we will explore and correct data supplied by the MICS, provide a complete abridged and unabridged life tables, construct a separate life tables for males and females, in addition to fitting the mortality curves obtained. Finally, calculate the corresponding life expectancies at birth to appraise the ones provided by the ONS.

### 3.1. Data preparation

For the MICS **III,** during the studied period , the number of the survival subjects were **171,052, 50.5%** are males and 49.5% are femaleswhile in **MICS IV** the involved number was **152,373 ; 51%** are males and 49% are females. Concerning the death data, the important death numbers were recorded for males.. Still, it is insufficient to allow judging whether death counts are increasing or decreasing because it is affected by the different number of households included in each wave. The table bellow recapitulates the raw numbers of subjects included in the study before any treatment.

***Table 1 :*** *Raw number of subjects included in the study*

| | **MICS III** | **MICS IV** |
|---|---|---|
| | ***Survival data*** | |
| ***Total number*** | *171 052* | *152 373* |
| ***Males*** | *86 458* | *77 792* |
| ***Females*** | *84 594* | *74 581* |
| | ***Death counts*** | |
| ***Total number*** | *2639* | *2143* |
| ***Males*** | *1559* | *1134* |
| ***Females*** | *1080* | *786* |

Reliable results rely on data quality. The process of data collecting in any sample survey faces various problems, our data set contains some irregularities due to misstatement or misreported information in the different variables needed in these analyzes which are the age, sex, and occurrence of the targeted event “death”. The data set treatments were removing all the cases which, include at least one missing value, use a combination of several tests to find the outliers, it could be **misdeclaration** in the years, months, it may also appears as “**no answer”**, “**don’t know”**. Finally, perform the necessary changes, removing or correcting if it is possible. Regarding the date of birth or death, the inconsistencies in months was corrected by transforming the value to 7 whilst day by 15 and if it is for both of them it will be replaced by 01/07. For those alive, when correcting their birth date is impossible, the questionnaire included a direct question about the age of the individual. During the use of such information, we noticed that some declarations are unreliable. Therefore, this information was ignored, still we did not confront a big loss of observations.

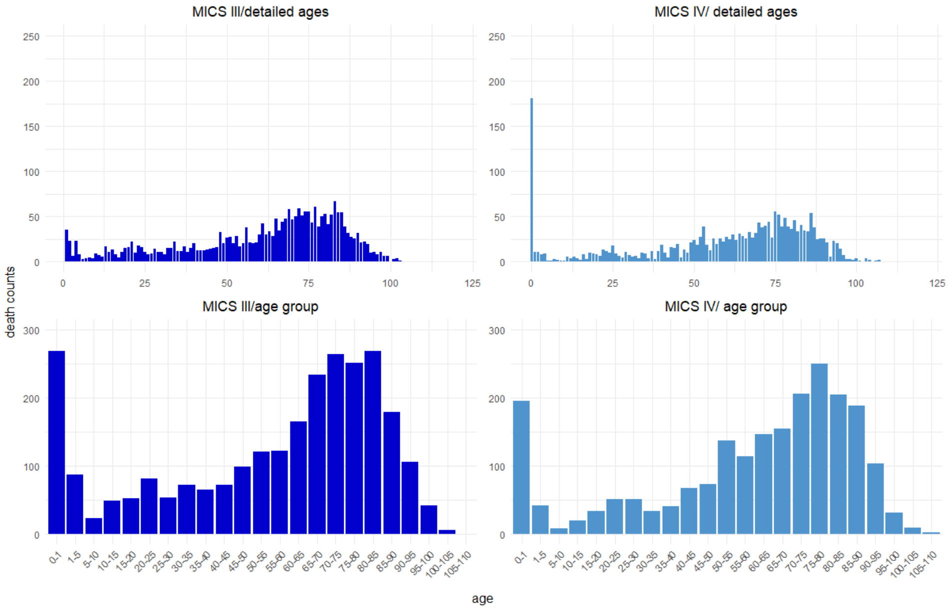
### 3.2. Life tables construction

In order to build life tables of the Algerian population using the MICS data, we employed the following steps.

### *Age distribution of deaths*

Mortality distribution shows the event intensity within the different ages. The graphics below represent the death counts by detailed ages and the conventional age groups (five-years each except the first two groups 0-1, 1-4). The total number of deaths involved in this study after treatment is 2581 for **MICS III** and 1824 for **MICS IV**.

***Figure 1 :*** *Age distribution of deaths by detailed ages and age groups of the third and the fourth wave of the MICS*



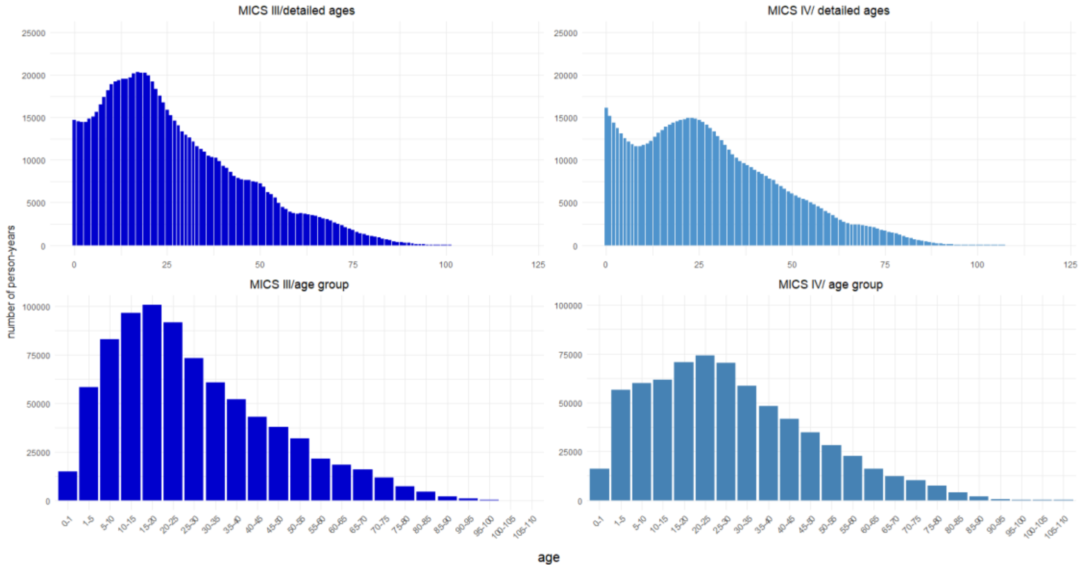

For detailed ages, same shape of the death distribution for both waves but with less mortality levels for MICS IV, the highest numbers of deaths are noticed in the age interval [60,85[ for both waves in addition to the infant mortality which is a special case where the biggest number of deaths has been recorded in the age 0.

For the conventional five year age groups, overall both plots look similar to each other. We can notice that the highest number of deaths has been recorded in the age interval [75,80[ where it almost claims 300 and 250 for MICS III and MICS IV respectively and it is almost equals the number of infant mortality for MICS III. the same observation for MICS IV but with different age range [80,85[, a general increase trend starting from 5 years old with a bump between 20 and 35 years old.

### *Exposure to death risk*

The second important component for estimating the death rate is the number of person-years, which represents the population at risk. In our case, the existed information enabled estimating the period experienced for each individual. The estimation results using the MICS III and MICS IV survey are illustrated in Figure 2.

*Figure 2 : Exposure to death risk by detailed ages and age groups of the third and fourth wave of the MICS*

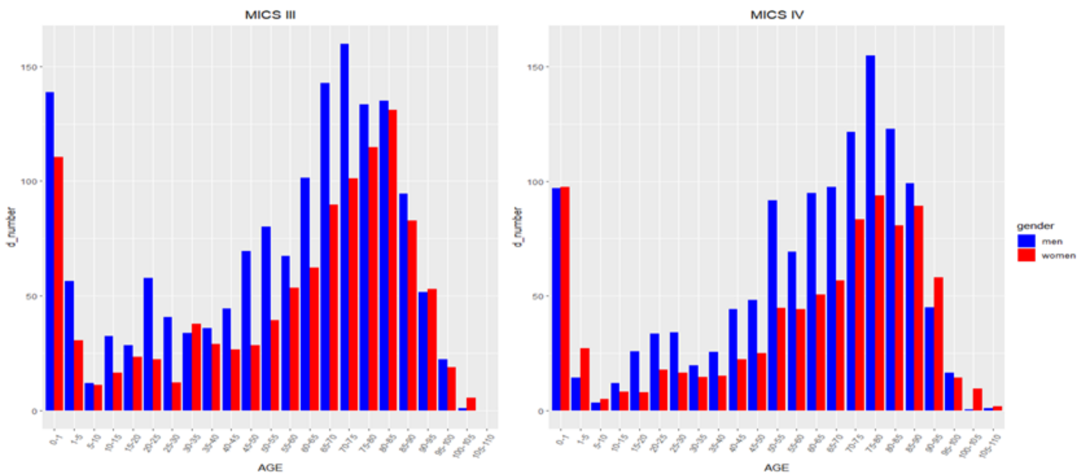



Concerning the population exposed to the death risk, or the age 0, practically the level is the same but for the rest of ages the exposure in MICS IV is lower than MICS 3, this could be explained by the differences in the number of subjects included in each survey.

### *Gender consideration*

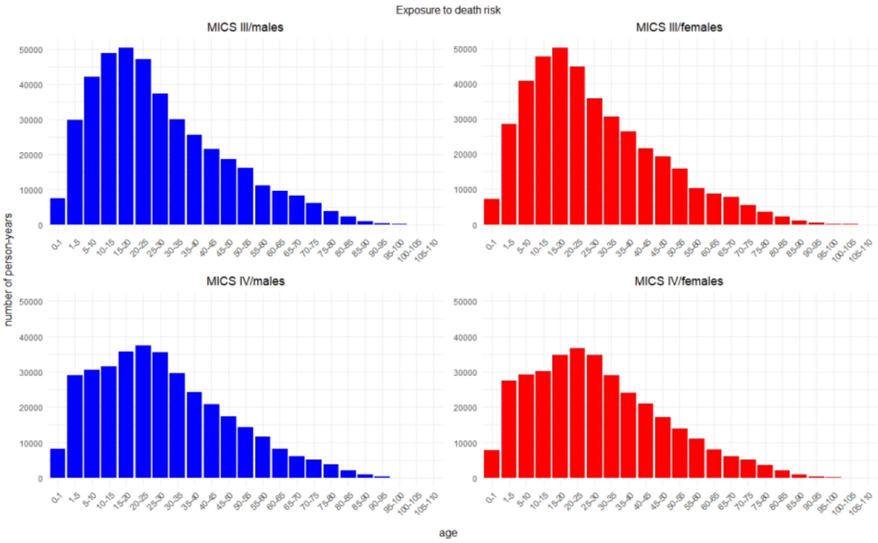
Giving the difference in mortality pattern for males and females, the following section will clarify these disparities for the Algerian population by constructing a separate life tables.

*Figure 3 : Age distribution of deaths considering gender for MICS III and MICS IV*




Both genders follow the same pattern in term of death distribution with low mortality levels in MICS IV. The number of deaths for males is greater than females regardless the last age groups starting from the age 80 years old where the number of deaths is almost alike. The most considerable numbers are noticed in the age intervals 0and [70,75[. For females, the increases and decreases are more uniformly comparing with females.

*Figure 4 : Exposure to death risk for males and females for MICS III and MICS IV*




Basically, the remarks are alike with the population exposed to death risk without distinction; it will be interesting to mention that the differences between males and females are almost nonexistent.

***Mortality curves***

The death rate represents the probability of dying between the age x and x+n. It is calculated by dividing the number of deaths ${}_nd_x$ by the exposure to death risk for each age interval ${}_nL_x$. The estimation has been carried out using the following formula:

$${}_nm_x = \frac{{}_nd_x}{{}_nL_x}$$

***Conversion from death rate to mortality rate***

We will calculate mortality rates using the approximation of Kimball (1960):

$${}_nq_x = \frac{2 * n * {}_nm_x}{2 + n * {}_nm_x}$$

For infant mortality the assumption that the distribution of mortality is uniform in not valid, the deaths at these age intervals are more likely concentrated to the beginning of the age intervals. Thus we took the mean age of death in consideration for the first two age groups. The corresponding formulas proposed by (Wilmoth et al., 2007) derived from the mortality rate:

$$q_0 = \frac{m_0}{1 + (1 - a_0) * m_0}$$

And

$$ {}_4q_1 = \frac{4 * {}_4m_1}{1 + (1 - {}_4a_1) * {}_4m_1} $$

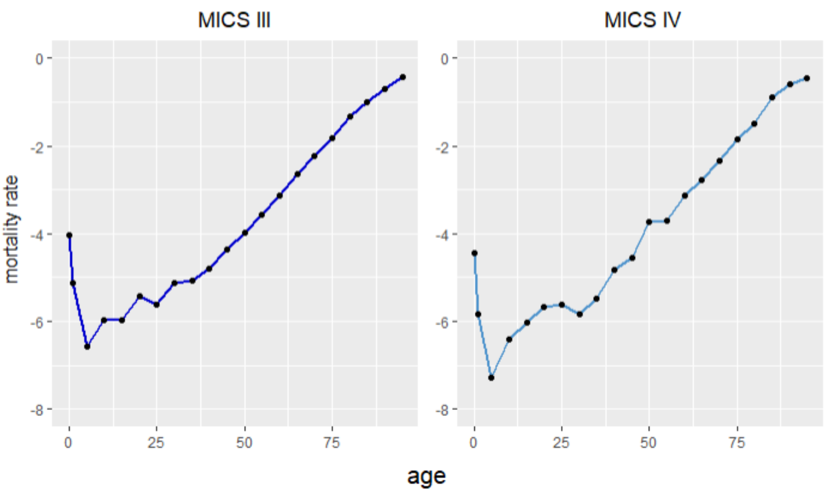
Table 2 reports the values of average number of years lived by infant and child death in the corresponding age intervals, noted $a_0$ and ${}_4a_1$ respectively. The obtained values confirm the result of Bourgeois (1946) and of Coale and Demeny (1966) that infant and juvenile mortality is concentrated in the beginning of the age interval.

Table 2: Estimates of $a_0$ and ${}_4a_1$ for both MICS waves

| | MICS III | | MICS IV | |
|---|---|---|---|---|
| | $a_0$ | ${}_4a_1$ | $a_0$ | ${}_4a_1$ |
| Total | 0.17 | 2.03 | 0.13 | 1.99 |
| Boys | 0.18 | 2.14 | 0.11 | 1.78 |
| Girls | 0.15 | 2.21 | 0.13 | 2.10 |

Generally the mortality rates are calculated over extended periods of time, five years in our case which represents the period of the survey .The crude mortality rates are presented in Figure 5.

*Figure 5 : Mortality curves of the third and fourth wave of the MICS*

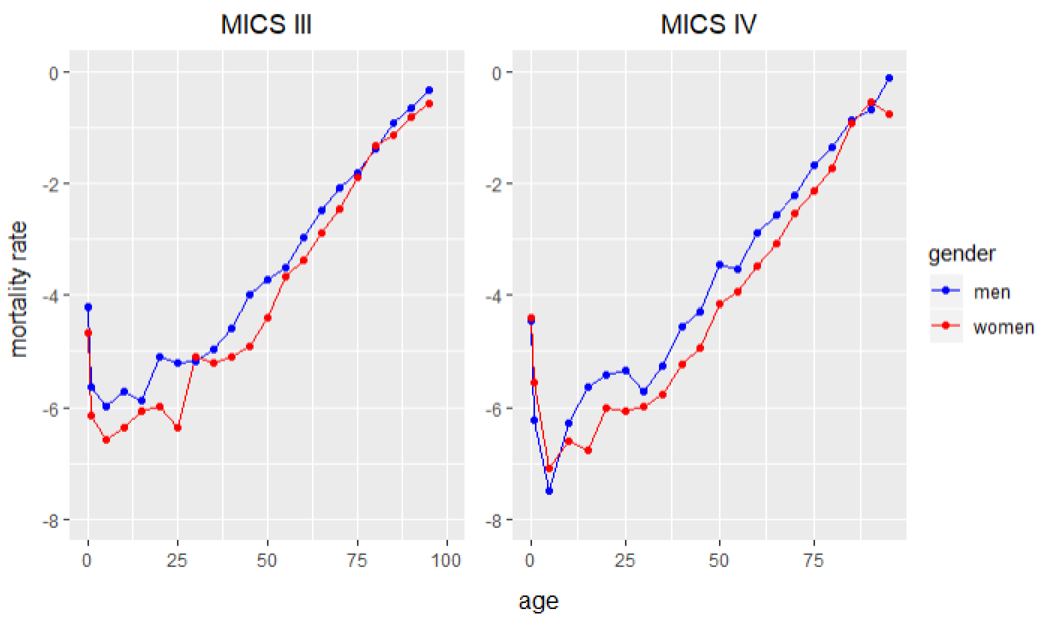



As illustrated above, both mortality curves are conformed to the standard form of mortality curves .We can describe it by the combination of three trends: **the first one** a decrease from 0 to 5 years old, t**he second one** is recorded at young ages that could be explained by accidents, suicide and maternal mortality, t**he last one** an increase starting from the age 30 until the ultimate age of survival due to aging. We also need to point out that there are some parts more fluctuated than others, noticed in the fourth wave more than the third one.

***Mortality curve for males and females:***

Figure 6 represents the mortality curves for males and females for both the MICS waves. It shows the gap between mortality rates by gender. The infant mortality is steeper comparing with mortality in the other ages. In MICS III, infant mortality for males is important comparing with females but it is the opposite case for MICS IV. It serves to underline additionally that there is a slight bump where the location is in the age interval [5,35], it is explained by accidents and suicide for males in addition to maternal mortality for women, for men the accident hump appears stronger comparing with the one of women. A straight line is traduced by an exponential increase starting from the age 35 years old.

*Figure 6 : Mortality curves of the third and fourth wave of the MICS considering gender*




The fluctuations in the different curves could be inferred to some statistical irregularities, or data quality issues. Consequently, the recall of adjustment is crucial to smooth these curves.

***Correction of infant mortality rates using Model life tables:***

In this part, we will try to identify the most adequate model life table to the data provided by the MICS. There are different types of Model Life Tables from which, e.g. the UN Model Life Tables, the Coal Denemy Model Life Tables (1966). In this study, we will use the united nations and Coal Denemy Model Life Tables where they defined a specific life tables for each region (North, South, East, West), the aim from designing such models is to group all the countries having similar age mortality pattern, this method has been frequently used to adjust mortality levels for several countries. We recall that the construction of these tables did not include any African data, so one of the challenges was to find the most adequate model to the African countries given their particular characteristic. Previous studies show that the results differ from country to another (EKANEM and

SOM, 1984), where they found that the North model is the best model for Algerian data satisfying the property of high infant mortality.

Regarding potential errors in younger and advanced ages, we chose working with the age interval [10, 75] to avoid any probable biased implication on the results. Aiming to have the best fitting model, the techniques we implemented depends on the principle of the ordinary least squares (OLS). Admittedly, the best fit is when the sum of squared errors approaches zero due to the small differences between the observed values and the ones using model life tables. The conceptual framework used to determine the most suitable model life table is the following:

- The first step was to derive the sum of squared errors from the differences between each model life table and the observed mortality rates, and then we select the most appropriate one that verifies the least sum of squared errors.
- The next step is to use the model life tables that come before and after the chosen one and try to model the observed mortality rates using a simple linear regression of these tables using the ordinary least squared method, where , the equation that describes the model is :

$$y = \alpha\, x_1 + \beta\, x_2 + \varepsilon$$

Where

$y$ : observed mortality rates

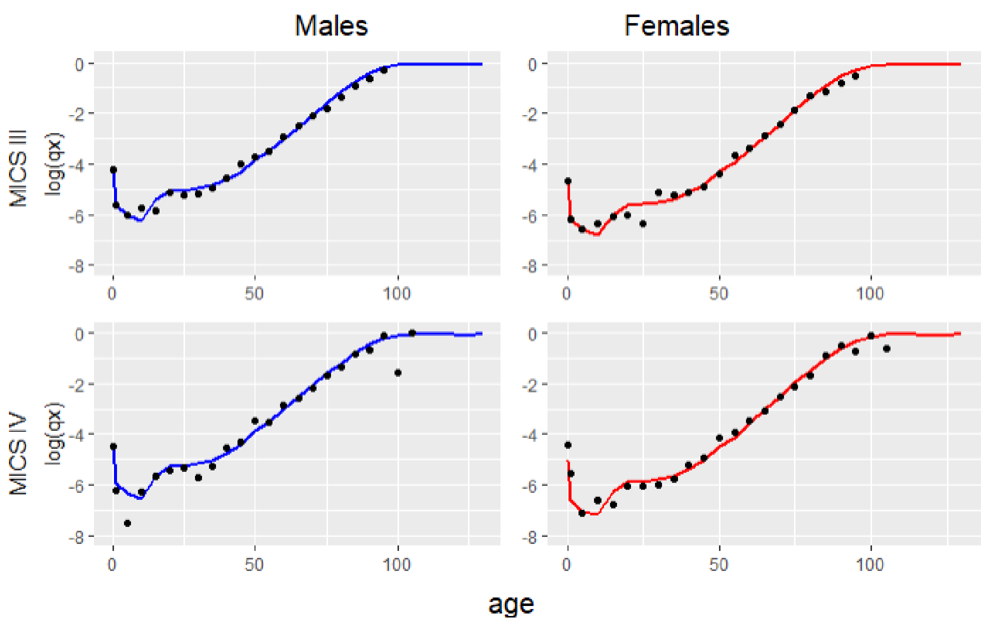
$x_1, x_2$ : Values of mortality rates of model life tables

$\alpha$ , $\beta$ : Coefficients to be estimated

$\varepsilon$ : Error term

- The last step will be to replace the first three values; related to infant mortality; in the MICS life tables with the ones resulting from the implemented model.

*Figure 7 : Fitting results using the Model Life Tables*



The findings show that the selected model life tables for the entire cases belong to the same region that is “North” but with different levels each. After estimating the regression parameters for each mortality curve, the results are shown in Figure 7.

Using this method, the values of the sum of squared errors have decreased, enabling capturing more information from the observed mortality rates.

***Mortality curves adjustment***

Mortality curves are characterized by a regular shape; however; in most of cases ragged, the use of abridged life table instead of the unabridged is therefore preferred. The observed irregularities could be inferred to statistical irregularities due to sampling fluctuations. Thus, the recall for graduation is judged crucial to smooth these curves. The best model needs to be chosen based on the fidelity to the crude data. Across time, different attempts tried to find a mathematical expression to model mortality at all ages or what is so-called “the law of mortality”. Literature exposes a variety of models that served this purpose. All the parametric models which were proposed to graduate mortality rates depended on age (Gompertz, 1825; Makeham, 1860; Heligman and Pollard, 1980). In our case, the mortality curves shape is characterized by its complex shape that shows clearly the mixture of three functions. Therefore, given the features of the Heligman and Pollard model (Heligman and Pollard, 1980; Hartmann, 1987) we assume that it is the most adequate one.

In order to enhance the quality of mortality graduation at older ages, HP suggests two other formulas, and the results were more satisfying comparing with the first one. The limit was that using the formula with nine parameters (+K) could provide some values bigger than the unit at a certain age (Heligman and Pollard,1980).

In our case, the mortality curves shape is characterized by its complex shape that shows clearly the mixture of three functions. Therefore, given the features of the Heligman and Pollard model (Heligman and Pollard, 1980; Hartmann, 1987) we assume that it is the most adequate one.

This section is devoted to fitting the crude mortality rates, we used the abridged life table instead of the unabridged because the estimation results of the later are very ragged and unstable (Andreev and Vaupel, 2005), these irregularities are the consequence of random variation due to random sampling and age misstatement.

$$\frac{q_x}{p_x} = A^{(x+B)^C} + D\,.\,e^{-E\,(ln x - ln\,F)^2} + G.\,H^x$$

$q_x$ : is the probability of dying between ages x and x+1 (as they define it in HP paper: the prob of dying within one year for a person aged x exactly)

The authors suggest that the mortality curve is composed from three phases. **The first one** is a rapidly declining exponential, it describes **t**he infant and childhood mortality where three parameters are introduced, the first one is **A** which is the level of mortality during early life period and **B** indicates how much ${}_1q_0$ is above ${}_1q_1$ or what is called age displacement of infant mortality, finally **C** indicates the rate at which the mortality decreases with age during childhood years of life. **The second phase** is represented by the middle term of the equation. Generally, it concerns adult mortality or what is called the accident hump, the mortality curve allows having information about its location (F), spread (E) and severity (D). **The third phase** is illustrated by the third part of the equation, known as Gompertz term which contains only two parameters (G and H), it is characterized by an exponential increase that describes the mortality in advanced ages.

Fitting the crude data is crucial giving that our observed data doesn't correspond with the hypothesis that two consecutive probabilities of death should be very close (Debon, Montes, and Sala 2005). In the later, we will try to adjust the crude mortality rates by the most suitable parameters estimation using the Heligman and Pollard model.

***The criterion used to assess the quality of adjustment:***

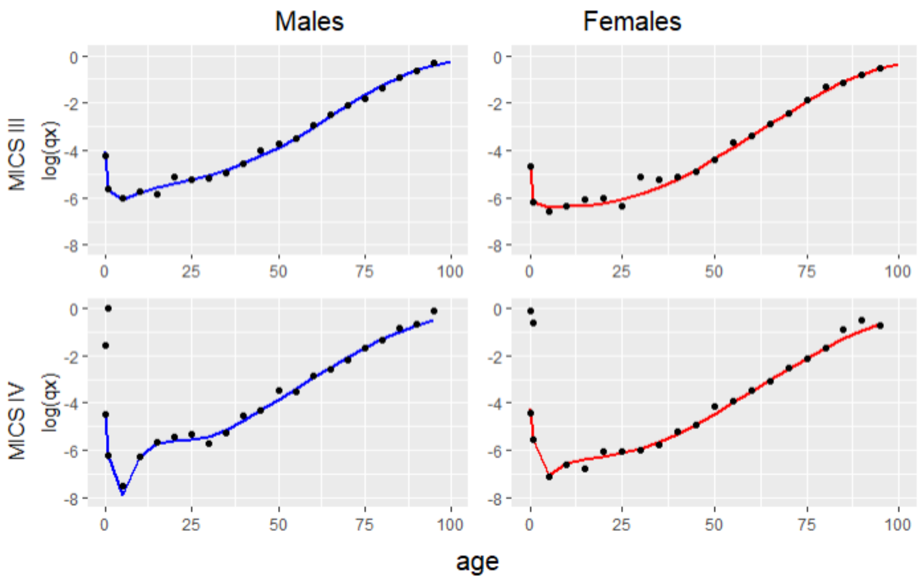
There are several criteria used for this purpose such as least squares using Gauss Newton iteration employed by Heligman and Pollard (1980). For testing the goodness of fit for the crude Algerian mortality data and weighting the differences between the crude estimates and the adjusted ones, we used the mean percentage average deviation criterion (MPAD).

$$\boldsymbol{MPAD} = \frac{\mathbf{1}}{\boldsymbol{N}} \sum_{\boldsymbol{x=0}}^{\boldsymbol{N}} \left| \frac{{}_nq_x - {}_n\widehat{q_x}}{{}_nq_x} \right|$$

***Fitting results***

The technique used in adjustment is to fix some parameters while varying the others, the method was proposed by Congdon (1993). The results of adjustment for MICS III and MICS IV are presented in Figure 8.

*Figure 8 : adjustment results using Heligman Pollard model*



We need to point out that there are some small differences in the distance between the fitting curve and our crude data. Each plot shows clearly that these differences are relatively important at younger ages from 10 years old until 35 in addition to the old ages [80-100[ only for MICS IV . The plots related to Algerian women shows a high spread of mortality rates in the hump location

The data set provides us the mortality rates until the age group [105,110[. For the adjustment, we will use the mortality rates by five years age group for the interval [0,85[, because the estimates are not representative due to the small size of the population at that age . Those aged above 90 years old were excluded due to the unreliable estimation results, the values of the logarithms decline or show an unexplained numbers beyond this age, where we can notice that it is located outside the range of the corresponding model. Thus, it will be replaced by the values calculated using the fitting model.

### 3.3. The ultimate age of survival

Knowing the ultimate age of survival of a specific population is critical for the closure of life tables using any extrapolative method.

*Table 3 : Observed maximum ages of survival within the MICS*

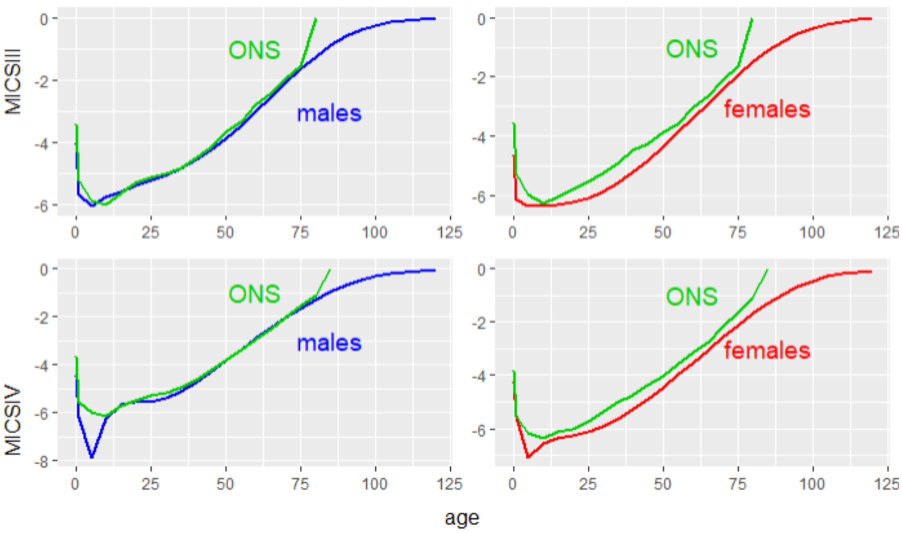
| **MICS III** | | **MICS IV** | |
|---|---|---|---|
| **Sex** | **Age** | **Sex** | **Age** |
| 2 | 104 | 2 | 109,66 |
| 2 | 103 | 2 | 108,947 |
| 1 | 102.56 | 2 | 107,967 |
| 2 | 102.54 | 1 | 107,358 |
| 2 | 102.51 | 1 | 106,36 |

Algerian people are living longer than they used too, the numbers extracted from the MICS III and MICS IV confirm this idea. Moreover, we found that the ultimate age of survival increased by more than 5 years for both genders over only five years (2006-2012). Thus, prior conclusion could be expected in term of life expectancy at birth that it is improving with time.

### 3.4. Life expectancy results

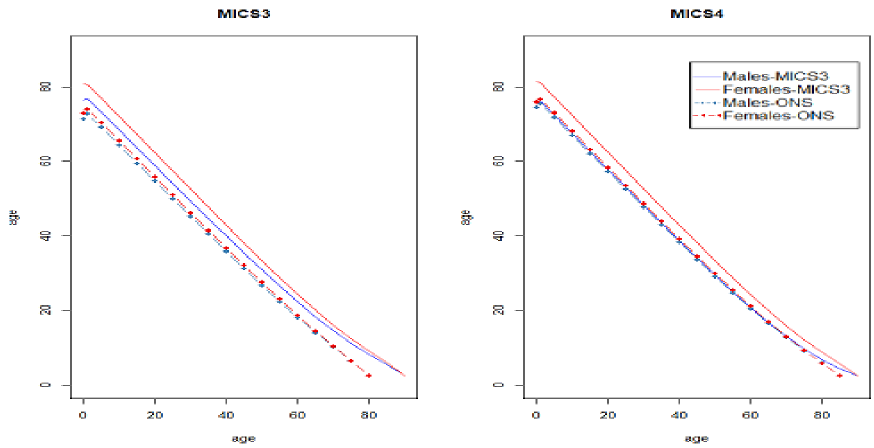
The final stage is to calculate the corresponding life expectancy at birth and compare it with the one provided by the Office of the National Statistics ONS. In this section, we are going to use the tables provided by the MICS to appraise the national mortality tables delivered by ONS. Results are illustrated and discussed in the following.

*Figure 9 : Comparison between the mortality curves published by the ONS and the ones estimated using the MICS*




The panels of Figure 9 reveal the differences between the results using the MICS data and the national life tables published by the National Office of Statistics. The comparison with the results obtained from MICS show clearly by visual inspection that the mortality curves of males are almost juxtaposed with slight differences in infant mortality, but it is not the case for women where the ONS overestimate the mortality rates among all ages. The common point is that starting from approximately the age 75 the curves diverge from each other.

Figure 10 : Comparison of life expectancy results between the ONS and the MICS




Our results suggest that there is a difference between the numbers published by ONS and those obtained from the MICS, this finding will be followed by an underestimation of life expectancy at birth for females but the same for males with small differences, the evidence is presented in Figure 10 where we can notice that there is a gain of five years for females referring to the MICS results comparing with that of the ONS.

## 4. Conclusion

Considering the limitations of using vital registration system, MICS survey provides new data source that could be used as a tool to fill this gap. The objective of this paper is to assess the national life tables based on another data source where we chose the MICS data given the features of such surveys. Moreover, we gave some examples about the different errors existing in surveys data and how to deal with. In addition to providing the whole process of life table estimation.

Based on the results we had, we draw several conclusions, some confirmed results already found, others reveal new facts and suggest different explanations. The most relevant were that the probability of death increases with age except the special case of infant mortality. Additionally, the mortality in the second study period (2007-2012) was substantially lower than the first one (2001-2006). Thus, we conclude that there was a reduction in overall mortality across the study period starting from 2006 until 2012. In the other hand, the drop in mortality levels will constitute a new challenge for insurance companies, pension funds, health institutions and social security in general.

Regarding the purpose of the paper, the results suggest a remarkable difference of almost five years in the results of life expectancy between the ONS publications and MICS estimates. The possible explanations behind the differences we found could be either the relevance of civil registration system or the methods used to construct the national life tables.

These findings will have a great importance for constructing more reliable national life tables, national population mortality projections, life expectancy at birth and health life expectancies. However, we should note that the validity of our findings depends largely on the data we had.

Giving the importance of the legal and statistical function of the civil registration system, we recommend the government to devote more efforts to enhance the coverage of the civil registration system. Concerning surveys data, pay more attention to the process of data collection and search for better ways to improve it and minimizing the common errors that investigators always fell in.

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