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# Estimation life expectancy in Gaza Strip using Brass growth balance method

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## ABSTRACT

Life expectancy is an important demographic indicator that is used for comparison between different population groups. A life table is designed mainly to measure a life expectation. Incompleteness of death registration is causing a problem to estimate the life expectancy.

In this paper, we estimated the life expectancy for Gaza strip using population and mortality data from the Ministry of Health. Estimation of the corrected life expectancy in Gaza strip was conducted by correcting the incompleteness of death registration by Brass growth balance method. By using Brass growth balance method the uncertainty interval was much smaller than that computed without correcting underreporting. The estimate of life expectancy at birth for the total population of Gaza strip in 2006 is about 1.41 year higher than the estimation when correcting underreporting with Brass growth balance method. It is about 2.2 year higher for males and only 0.35 year for females. It is found that this difference is statistically significant for males and both sexes only.

**Keywords**:
Life expectancy - abridged life table - Brass growth balance method – crude mortality rate - incompleteness of death registration.

## تقدير متوسط العمر المتوقع في قطاع غزة باستخدام طريقة ميزان نمو براس

**الدكتور عبدالله محمد الهبيل**
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## المستخلص

**يعتبر مقياس متوسط العمر المتوقع مؤشر ديموغرافي مهم يستخدم للمقارنة بين المجموعات السكانية المختلفة، وقد صممت جداول الحياة بالاساس لتقدير متوسط العمر المتوقع، في حين أن عدم اكتمال تسجيل الوفيات يتسبب في عدم دقة تقدير هذا المقياس.**
**تم تقدير في هذه الورقة البحثية متوسط العمر المتوقع في قطاع غزة للعام ٢٠٠٦ باستخدام بيانات السكان والوفيات من وزارة الصحة في فلسطين، ثم بعد ذلك تم تصحيح عدم**

تأريخ استلام البحث ٢٠١١/٦/٢ تأريخ قبول النشر ٢٠١١/١٠/٤

اكتمال تسجيل الوفيات باستخدام طريقة براس لتوازن النمو، ومن ثم قدرنا متوسط العمر المتوقع المعدل، حيث وجدنا أن فترات الثقة لمتوسط العمر المتوقع أصغر بشكل ملحوظ بعد التعديل عنها قبل التعديل، وكذلك اتضح لنا أن تقدير متوسط العمر المتوقع لسكان قطاع غزة في العام ٢٠٠٦ يزيد ١.٤١ سنة قبل التعديل عنه بعد التعديل، حيث أنه يزيد ٢.٢ سنة في حالة الذكور و ٠.٣٥ سنة في حالة الإناث. واتضح من خلال الاختبار الإحصائي أن هذا الاختلاف بين التقديرين هو اختلافا معنويا في حالة الذكور وكلا الجنسين فقط.

**الكلمات المفتاحية:**

**متوسط العمر المتوقع - طريقة ميزان نمو براس - جداول الحياة.**

## Estimation life expectancy in Gaza Strip using Brass growth balance method

## 1. Introduction

Life expectancy is an important demographic indicator that is used for comparison between different population groups. It is defined as the average of years a cohort of people might expect to live according to the current age-specific mortality rates. By using World Health Organization (WHO) definition (2003), “life expectancy is average number of years that a newborn is expected to live if current mortality rates continue to apply". Life expectancy is one of three indicators adopted by United Nations Development Programme (UNDP) 1990 to determine the status of human development in the particular country.

Countries are often interested in calculating life expectancy, as to the significance of this demographic indicator in the formulation of health policy in the country, the life tables is one of the most important tool of calculating the life expectancy. Many researchers have focused on life expectancy; Pourmalek and others (2009) estimated the life expectancy for 2003 for 23 provinces in Iran, using population and mortality data from the Ministry of Health and Medical Education. The underreporting of deaths above 4 years was corrected using the Brass Growth Balance method; they estimated life expectancy at birth to be 71.56 years for the total population. Their estimates were higher than the model-based estimates of the Statistical Centre of Iran, United Nations agencies and the World Bank. Abdalla and Shaheen (2007) proposed a study paper on completeness of adult death registration in Sudan in 2002. They used Brass Growth Balance method. Partial birth and death rates were calculated from registered deaths in 2002 and total mid-year population projections. Linear regression of partial birth rates and partial death rates was used to calculate the completeness of death registration. The analysis showed that only 4.4% of deaths were registered and registration completeness was more for male deaths (6.5%) than for female deaths (2.8%). Beaie (2008) done a working paper about mortality in Guyana, it was produced by Bureau of Statistics, he calculates the age specific death rates, and construct a life table for Guyana. He concludes that a new born baby boy and girl in Guyana are expected to life up to 63.36 and

68.96 respectively. Habib Ullah and Zafar (2003) did a study about estimation of infant and child mortality. Abridged life table for both sexes, separate for males and females have been constructed to study the mortality pattern at different ages, they found that the level of infant and child mortality are still very high in Pakistan, life expectancy at birth still low compared to many developing countries. Milanović and others (2006) examined the differences in life expectancy and mortality between the populations on Croatian islands and the mainland and among the islands themselves, they used life table and standardized mortality rates to analyze data on population size and mortality collected in Croatia in 2001. The analysis shows that life expectancy at birth of the population on Croatian islands was 76.4 year, which was significantly higher than life expectancy at birth of general Croatian population which was 73.8 year, or mainland Croatian population which was 73.7 year. Traditionally, demographic estimation has been based on data collected by censuses and by a vital registration system. A continuous registration system usually has the task of recording vital events (deaths), Assuming that, both the registration of vital events and the census counts were perfect, demographic parameters specially life expectancy could be estimated directly from the data reported. Some of the possible deficiencies of a vital registration system, where it exists at all, may be outlined. The main deficiency is its failure to record all data of deaths. Incompleteness of death registration is causing a problem of estimating the life expectancy, therefore we will find away to estimate the life expectancy for people in Gaza strip using Ministry of Health (MOH) death registration by using abridged life table after making correction for the incompleteness of deaths by brass growth balance method. Therefore, the research problem is:

By using real data, how can we apply a statistical method for estimating the corrected life expectancy?

The paper is organized as follows: Section 2 recalls definitions, Section 3 data analysis. Section 4 concludes.

## 2. Definitions

Here, we will give an overview of some definitions are related to life expectancy.

### Life expectancy

Life expectancy is defined as the average of years a cohort of people might expect to live according to the current age-specific mortality rates. Life expectancy is using for comparison between countries, and socio-economic levels. It represents the average life span of a newborn and is an indicator of the overall health of a country (UNDP, 1990). Life expectancy reflects the overall mortality level. Life expectancy is declining due the events that occur on the country like famine, war, disease and poor health (Habib, 2007). Life expectancy is the main outcome measure of life table analysis.

## Life table

Life tables models are widely using in demographic studies, mainly in the measurement of mortality. Where is the main entry to life tables are the variable of deaths and the variable of age. Life table is illustrating several statistical issues. It is principally designed particularly to measure the level of mortality of the population involved and life expectation (Siegel and Swanson, 2004). It is a fictitious pattern reflecting the mortality experience of a real population during the interval of age. It is an effective means of summarizing mortality and survival experience of a population and is a sound of basis for making statistical inference about the specific population under the study (UN, 1980). It is based on probabilities of dying, the probability that an individual alive at age x dies before reaching his or her next birthday (age x + 1). Keyfitz and Caswell (2004) state that the probability of surviving from birth to age x is designated as l(x) for a continuous function of x and as $l_x$ for discrete x, it most commonly starting with fixing number 10,000 or 100,000 which is called a radix. There are two kinds of life tables exist, called cohort and current life tables: The cohort life table which describes the actual survival experience of a group or cohort of individuals born at about the same time. It is generated from cumulative data of survival times from the birth of the first member of a population until the death of the last member. And the current life table which is derived from current mortality data of specific population, it is an excellent description of mortality in a year (complete life table) or a short period (abridged life table). An abridged life table is based on a sequence of age intervals of any chosen length, 5 or 10 years of age for most of the age range. Demographers usually prepare the simpler abridged life table rather than the more elaborate complete life table.

## Incompleteness of death registration

In many development countries mortality measures and the analysis of the death statistics depend on the availability of appropriate population data from a census, or population estimates. The registration of deaths may be incomplete because of failure to cover the entire geographic area of the country or all groups in the population and failure to register all of the vital events in the established registration area. Demographers suggested methods to solve this problem. One of these methods is Brass growth balance method.

**Brass growth balance method**

The simplest way of calculating mortality rates is by using the data on deaths and age from vital registration system, but the reported death is usually underestimate of the real death rate. With underreporting of death we fall in a problem with a bias estimate of life of expectancy because the survival function $l_x$ will fall slowly as age increase (UN, 1983).
Brass (1975) proposed the Growth Balance method, this method is based on the stable population equations.

$$\frac{N(x)}{N(x+)} = r + \frac{D^*(x+)}{N(x+)} \qquad (2.1)$$

Where N(x) is the number of persons of exact age x; N(x+) is the total number of persons aged x and over, $D^*(x+)$ is the total number of deaths at age x and over, and r is the growth rate. N(x)/N(x+) can be interpreted as a "birth rate" for the population aged x and over, and $D^*(x+)/N(x+)$ is the "death rate" corresponding to the same population, r(x+) denotes to the growth rate for population aged x and over.

Brass estimates the completeness of death recording and provides an actual adjustment factor for the deaths relating between the N(x)/N(x+) and $D^*(x+)/N(x+)$ (Hill, 2001).

If deaths are reported with completeness C(x) of registration at age x and over, assumed constant by age at least over age 5, so $D^*(x+) = D(x+)/C(x)$, here D(x+) is the reported deaths at ages x and over. If we replace constant c with C(x), let K = 1/c, then, K here refers to correction coefficient for deaths registered, so the equation (2.1) will be

$$\frac{N(x)}{N(x+)} = r + K\frac{D(x+)}{N(x+)} \qquad (2.2)$$

Where N(x) is the population at an age x during the course of year under consideration, when the total of population is the classified by n years of ages, so N(x) can be estimated as

$$N(x) = \frac{{}_nN_{x-n} + {}_nN_x}{2*n}$$

N(x+) is the total number of persons aged x and over, and D(x+) is the total number of deaths after an exact age, so if the data is classified by n years of age groups, then

$$N(x+) = \sum_{j=x}^{A-5} {}_nN_j + N(A+)$$

$$D(x+) = \sum_{j=x}^{A-5} {}_nD_j + D(A+)$$

Where N (A+) is the number of persons in the last open ended age group, and D (A+) is the deaths in the open ended age interval A and over. From equation (2.2) the relationship between the entry rate or birth rate and reported death rate is linearity. To display the relation graphically by plotting D(x+)/N(x+) and N(x)/N(x+), there are many methods to fit a line defined by points [N(x)/N(x+), D(x+)/N(x+)] such as least square method (LS) (UN, 1983).

## 3. Data analysis

We will start with the data requirements to generate the life table, and its functions and then estimates the completeness of death registration using the Brass growth balance method.

The main data sources in the generation of the life tables are the deaths and the population data.

To construct an abridged life table, the data used was estimated population data in 2006 based on 1997 census conducted by Palestinian Central Bureau of Statistics (PCBS), and registered deaths available in the Ministry of Health (MOH) through the vital registration system by age and sex. The source of these data is from the electronic version of the Statistical Health Reports (Annul Report 2006) [http://www.pcbs.gov.ps]. The data are derived from sets of tables: population by age and sex, and deaths by sex and age. The live population data are available by 5-year age group with the exception of age 80 and above. The death data were divided into five-year age categories running from 0-4, 5-9, and so on, up to the age category of 80 and more. Stats direct statistical Software was used to perform and generate life tables functions.

**Table 1**
**Distribution of population and Deaths by gender and age group in Gaza strip (2006)**

| | Male | | Female | | Total | | Age Specific Death Rates | | |
|---|---|---|---|---|---|---|---|---|---|
| | Population | Death | Population | Death | Population | Death | Male | Female | Total |
| 0-4 | 140,325 | 633 | 134,616 | 457 | 274941 | 1090 | 4.51 | 3.40 | 3.96 |
| 5-9 | 118,578 | 50 | 113,866 | 35 | 232444 | 85 | 0.42 | 0.31 | 0.37 |
| 10-14 | 100,173 | 56 | 97,422 | 38 | 197595 | 94 | 0.56 | 0.39 | 0.48 |
| 15-19 | 82,510 | 196 | 80,047 | 41 | 162557 | 237 | 2.38 | 0.51 | 1.46 |
| 20-24 | 64,243 | 215 | 61,212 | 26 | 125455 | 241 | 3.35 | 0.43 | 1.92 |
| 25-29 | 51,040 | 128 | 49,623 | 23 | 100663 | 151 | 2.51 | 0.46 | 1.50 |
| 30-34 | 40,706 | 88 | 40,074 | 30 | 80780 | 118 | 2.16 | 0.75 | 1.46 |
| 35-39 | 32,720 | 62 | 31,546 | 28 | 64266 | 90 | 1.90 | 0.89 | 1.40 |
| 40-44 | 29,816 | 68 | 26,863 | 36 | 56679 | 104 | 2.28 | 1.34 | 1.84 |
| 45-49 | 21,851 | 80 | 20,030 | 43 | 41881 | 123 | 3.66 | 2.15 | 2.94 |
| 50-54 | 15,501 | 82 | 15,061 | 59 | 30562 | 141 | 5.29 | 3.92 | 4.61 |
| 55-59 | 11,536 | 124 | 12,302 | 111 | 23838 | 235 | 10.75 | 9.02 | 9.86 |
| 60-64 | 7,068 | 122 | 8,876 | 134 | 15944 | 256 | 17.26 | 15.10 | 16.06 |
| 65-69 | 5,237 | 147 | 7,619 | 206 | 12856 | 353 | 28.07 | 27.04 | 27.46 |
| 70-74 | 4,792 | 220 | 6,209 | 193 | 11001 | 413 | 45.91 | 31.08 | 37.54 |
| 75-79 | 2,845 | 224 | 4,171 | 244 | 7016 | 468 | 78.74 | 58.50 | 66.71 |
| 80+ | 2,287 | 150 | 3,049 | 436 | 5336 | 586 | 65.59 | 143.00 | 109.82 |
| Unknown | | 14 | | 7 | | 21 | | | |
| Total | 731,228 | 2659 | 712,586 | 2147 | 1,443,814 | 4806 | 3.64 | 3.01 | 3.33 |

Number of deaths is based on information from all death certificates which was reported in Gaza Governorates. Table (1) shows the distribution of the deaths by gender and age group (each group contains of five-year age groups except 80+, start from 0-4 group and end with up to 80), 4806 persons died in Gaza strip (2659 males, 2147 females), out of them 21 people died and misreporting their age (14 male, 7 female).

The population of the 5 provinces of Gaza strip in 2006 was 1,443,814 persons, the crude mortality rate was 3.33 per 1000, Mortality rates for children under 5 years 4.51 and 3.40 per 1000 for male and female respectively, the death rate of a particular age group is referred as an age specific death rate. It is derived by dividing the total deaths in each age group by the corresponding total population in the same age group.

Abridged life tables for both sexes, separate for males and females have been constructed to study the mortality pattern at different ages according to registered death and adjusted death. The key step of life table construction is the derivation of $_nq_x$, the probability of dying, which shows the proportion of a cohort alive at the beginning of an indicated age interval, who will die before reaching the end of that age interval.

**Table 2**
**Abridged Life Table Based on Registered Deaths and Population Distribution for Gaza Strip, males: 2006**

| Interval | Death Rate | Probability of dying | Standard error of ($_nq_x$) | Alive at start | Dying in interval | Fraction | Years in interval | Years beyond | Life expectancy | Variance of life expectancy | 95 % Confidence Interval | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | $_nm_x$ | $_nq_x$ | SEq | $l_x$ | $_nd_x$ | $_nf_x$ | $_nL_x$ | $T_x$ | $e_x$ | Var($e_x$) | LCI ($e_x$) | UCI ($e_x$) |
| (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) | (12) | (13) |
| 0 to 4 | 0.0045 | 0.0223 | 0.00088 | 100000 | 2230.326 | 0.5 | 494424.2 | 7371150 | 73.71 | 0.1187 | 73.04 | 74.39 |
| 5 to 9 | 0.0004 | 0.0021 | 0.00030 | 97769.67 | 205.9124 | 0.5 | 488332.6 | 6876766 | 70.34 | 0.1199 | 69.66 | 71.01 |
| 10 to 14 | 0.0006 | 0.0028 | 0.00037 | 97563.76 | 272.3262 | 0.5 | 487138 | 6388433 | 65.48 | 0.1200 | 64.80 | 66.16 |
| 15 to 19 | 0.0024 | 0.0118 | 0.00084 | 97291.44 | 1148.742 | 0.5 | 483585.3 | 5901295 | 60.66 | 0.1201 | 59.98 | 61.34 |
| 20 to 24 | 0.0033 | 0.0166 | 0.00112 | 96142.69 | 1595.44 | 0.5 | 476724.9 | 5417709 | 56.35 | 0.1203 | 55.67 | 57.05 |
| 25 to 29 | 0.0025 | 0.0125 | 0.00110 | 94547.25 | 1178.159 | 0.5 | 469790.9 | 4940984 | 52.26 | 0.1202 | 51.58 | 52.94 |
| 30 to 34 | 0.0022 | 0.0108 | 0.00114 | 93369.09 | 1003.822 | 0.5 | 464335.9 | 4471194 | 47.89 | 0.1206 | 47.21 | 48.57 |
| 35 to 39 | 0.0019 | 0.0094 | 0.00119 | 92365.27 | 870.9729 | 0.5 | 459648.9 | 4006853 | 43.38 | 0.1205 | 42.70 | 44.06 |
| 40 to 44 | 0.0023 | 0.0115 | 0.00137 | 91494.3 | 1057.42 | 0.5 | 454828 | 3547209 | 38.77 | 0.1205 | 38.09 | 39.45 |
| 45 to 49 | 0.0037 | 0.0181 | 0.00201 | 90436.88 | 1640.887 | 0.5 | 448082.2 | 3092381 | 34.19 | 0.1205 | 33.51 | 34.87 |
| 50 to 54 | 0.0053 | 0.0261 | 0.00234 | 88816.01 | 2318.513 | 0.5 | 438282.3 | 2644143 | 29.77 | 0.1206 | 29.09 | 30.45 |
| 55 to 59 | 0.0107 | 0.0523 | 0.00157 | 86197.5 | 4527.136 | 0.5 | 421169.7 | 2205863 | 25.50 | 0.1205 | 24.82 | 26.18 |
| 60 to 64 | 0.0175 | 0.0827 | 0.00318 | 81670.38 | 6751.761 | 0.5 | 392897.4 | 1784693 | 21.77 | 0.1204 | 21.09 | 22.45 |
| 65 to 69 | 0.0281 | 0.1311 | 0.01010 | 75188.6 | 9860.381 | 0.5 | 351291.6 | 1391798 | 18.51 | 0.1161 | 17.84 | 19.18 |
| 70 to 74 | 0.0459 | 0.2059 | 0.01237 | 65328.02 | 13452.05 | 0.5 | 293010 | 1040506 | 15.93 | 0.1081 | 15.28 | 16.57 |
| 75 to 79 | 0.0787 | 0.3289 | 0.01590 | 51875.95 | 17063.16 | 0.5 | 216721.2 | 747496 | 14.41 | 0.1021 | 13.78 | 15.04 |
| 80 up | 0.0656 | 1.0000 | * | 34812.51 | 34812.51 | * | 530774.8 | 530774.8 | 15.25 | * | * | * |

## Table 3
## Abridged Life Table Based on Registered Deaths and Population Distribution for Gaza Strip, females: 2006

| Interval | Death Rate | Probability of dying | Standard error of (nqx) | Alive at start | Dying in interval | Fraction | Years in interval | Years beyond | Life expectancy | Variance of life expectancy | 95 % Confidence Interval | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | nmx | nqx | SEq | lx | dx | nfx | nLx | Tx | ex | Var(ex) | LCI (ex) | UCI (ex) |
| (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) | (12) | (13) |
| 0 to 4 | 0.0034 | 0.016831 | 6.09E-07 | 100000 | 1683.136 | 0.5 | 495792.2 | 7530540 | 75.3054 | 0.056501 | 74.83951 | 75.77128 |
| 5 to 9 | 0.0003 | 0.001536 | 6.75E-08 | 98316.86 | 150.9866 | 0.5 | 491206.9 | 7034748 | 71.55179 | 0.054995 | 71.09216 | 72.01142 |
| 10 to 14 | 0.0004 | 0.001948 | 9.57E-08 | 98165.88 | 191.2645 | 0.5 | 490351.2 | 6543541 | 66.658 | 0.054841 | 66.19901 | 67.11698 |
| 15 to 19 | 0.0005 | 0.002558 | 1.59E-07 | 97974.61 | 250.5917 | 0.5 | 489246.6 | 6053189 | 61.78374 | 0.054647 | 61.32509 | 62.2414 |
| 20 to 24 | 0.0004 | 0.002122 | 1.73E-07 | 97724.02 | 207.3229 | 0.5 | 488101.8 | 5563943 | 56.93526 | 0.054358 | 56.4783 | 57.39222 |
| 25 to 29 | 0.0005 | 0.002315 | 2.32E-07 | 97516.7 | 225.7308 | 0.5 | 487019.2 | 5075841 | 52.05099 | 0.054073 | 51.59523 | 52.50675 |
| 30 to 34 | 0.0007 | 0.003736 | 4.61E-07 | 97290.97 | 363.4831 | 0.5 | 485546.1 | 4588822 | 47.16596 | 0.053748 | 46.71157 | 47.62035 |
| 35 to 39 | 0.0009 | 0.004428 | 6.97E-07 | 96927.48 | 429.2082 | 0.5 | 483564.4 | 4103276 | 42.33346 | 0.053213 | 41.88134 | 42.78558 |
| 40 to 44 | 0.0013 | 0.006678 | 1.23E-06 | 96498.27 | 644.4436 | 0.5 | 480880.3 | 3619711 | 37.51063 | 0.052561 | 37.06129 | 37.95998 |
| 45 to 49 | 0.0021 | 0.010677 | 2.02E-06 | 95853.83 | 1023.394 | 0.5 | 476710.7 | 3138831 | 32.74602 | 0.051721 | 32.30028 | 33.19176 |
| 50 to 54 | 0.0039 | 0.019397 | 6.25E-06 | 94830.44 | 1839.43 | 0.5 | 469553.6 | 2662120 | 28.07243 | 0.050559 | 27.63268 | 28.51217 |
| 55 to 59 | 0.0090 | 0.044119 | 1.68E-05 | 92991.01 | 4102.707 | 0.5 | 454698.3 | 2192567 | 23.57827 | 0.047928 | 23.14919 | 24.00735 |
| 60 to 64 | 0.0151 | 0.072739 | 3.66E-05 | 88888.3 | 6465.656 | 0.5 | 428277.4 | 1737869 | 19.55115 | 0.043553 | 19.14271 | 19.96009 |
| 65 to 69 | 0.0270 | 0.126629 | 6.8E-05 | 82422.64 | 10437.09 | 0.5 | 386020.5 | 1309591 | 15.88873 | 0.036252 | 15.51566 | 16.26181 |
| 70 to 74 | 0.0311 | 0.144213 | 9.22E-05 | 71985.55 | 10381.24 | 0.5 | 333974.6 | 923570.8 | 12.82995 | 0.026555 | 12.51056 | 13.14934 |
| 75 to 79 | 0.0585 | 0.255177 | 0.000190 | 61604.31 | 15719.90 | 0.5 | 268721.6 | 589596.1 | 9.570696 | 0.017913 | 9.308377 | 9.833015 |
| 80 up | 0.1430 | 1 | * | 45884.42 | 45884.42 | * | 320874.5 | 320874.5 | 6.993119 | * | * | * |

## Table 4
## Abridged Life Table Based on Registered Deaths and Population Distribution for Gaza Strip, both sexes: 2006

| Interval | Death Rate | Probability of dying | Standard error of (nqx) | Alive at start | Dying in interval | Fraction | Years in interval | Years beyond | Life expectancy | Variance of life expectancy | 95 % Confidence Interval | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | nmx | nqx | SEq | lx | dx | nfx | nLx | Tx | ex | Var(ex) | LCI (ex) | UCI (ex) |
| (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) | (12) | (13) |
| 0 to 4 | 3.96 | 0.0196 | 0.00039 | 100000.00 | 1962.79 | 0.5 | 495093.03 | 7391252.22 | 73.91 | 0.0370 | 73.54 | 74.29 |
| 5 to 9 | 0.37 | 0.0018 | 0.00020 | 98037.21 | 179.09 | 0.5 | 489738.33 | 6896159.19 | 70.34 | 0.0366 | 69.97 | 70.72 |
| 10 to 14 | 0.48 | 0.0024 | 0.00024 | 97858.12 | 232.49 | 0.5 | 488709.39 | 6406420.86 | 65.47 | 0.0365 | 65.09 | 65.84 |
| 15 to 19 | 1.46 | 0.0073 | 0.00047 | 97625.63 | 709.08 | 0.5 | 486355.46 | 5917711.47 | 60.62 | 0.0365 | 60.24 | 60.99 |
| 20 to 24 | 1.92 | 0.0096 | 0.00061 | 96916.55 | 926.44 | 0.5 | 482266.66 | 5431356.01 | 56.04 | 0.0363 | 55.67 | 56.41 |
| 25 to 29 | 1.50 | 0.0075 | 0.00061 | 95990.11 | 717.26 | 0.5 | 478157.41 | 4949089.34 | 51.56 | 0.0358 | 51.19 | 51.93 |
| 30 to 34 | 1.46 | 0.0073 | 0.00067 | 95272.85 | 693.32 | 0.5 | 474630.96 | 4470931.93 | 46.93 | 0.0355 | 46.56 | 47.30 |
| 35 to 39 | 1.40 | 0.0070 | 0.00073 | 94579.53 | 659.95 | 0.5 | 471247.78 | 3996300.97 | 42.25 | 0.0351 | 41.89 | 42.62 |
| 40 to 44 | 1.84 | 0.0091 | 0.00089 | 93919.58 | 857.73 | 0.5 | 467453.59 | 3525053.19 | 37.53 | 0.0347 | 37.17 | 37.90 |
| 45 to 49 | 2.94 | 0.0146 | 0.00130 | 93061.85 | 1356.60 | 0.5 | 461917.76 | 3057599.60 | 32.86 | 0.0343 | 32.49 | 33.22 |
| 50 to 54 | 4.61 | 0.0228 | 0.00190 | 91705.25 | 2091.32 | 0.5 | 453297.95 | 2595681.84 | 28.30 | 0.0337 | 27.94 | 28.66 |
| 55 to 59 | 9.86 | 0.0481 | 0.00306 | 89613.93 | 4310.92 | 0.5 | 437292.34 | 2142383.90 | 23.91 | 0.0327 | 23.55 | 24.26 |
| 60 to 64 | 16.06 | 0.0772 | 0.00463 | 85303.01 | 6583.93 | 0.5 | 410055.22 | 1705091.56 | 19.99 | 0.0308 | 19.64 | 20.33 |
| 65 to 69 | 27.46 | 0.1285 | 0.00638 | 78719.08 | 10113.13 | 0.5 | 368312.59 | 1295036.35 | 16.45 | 0.0271 | 16.13 | 16.77 |
| 70 to 74 | 37.54 | 0.1716 | 0.00760 | 68605.96 | 11773.07 | 0.5 | 313597.09 | 926723.74 | 13.51 | 0.0229 | 13.22 | 13.80 |
| 75 to 79 | 66.71 | 0.2859 | 0.01117 | 56832.88 | 16245.90 | 0.5 | 243549.65 | 613126.66 | 10.79 | 0.0168 | 10.53 | 11.04 |
| 80 up | 109.82 | 1 | * | 40586.98 | 40586.98 | * | 369577.00 | 369577.00 | 9.11 | * | * | * |

**Calculating $_nq_x$**

The symbol $_nq_x$ represents the conditional probability that a member of the life table cohort who is alive at age x dies before age x+n. In symbols,

P (death before age x + n | alive at age x) = $_nq_x = {_nd_x} / l_x$

$_nd_x$ is the number out of the artificial cohort die within the indicated age interval (x to x + n)

$l_x$ is the number out of the artificial cohort alive at age x

The relationship between $_nq_x$ and $_nm_x$ can be determined by the following equation
(WHO, 1980)

$$_nq_x = \frac{_nm_x}{\frac{1}{n} + 0.5 \ * \ _nm_x} \qquad (3.1)$$

$$_nm_x = \frac{_nd_x}{_nL_x} = \frac{_nD_x}{_nP_x} = {_nM_x}$$

Where n is the length of the interval, $_nm_x$ is the age-specific death rate in the life table population, $_nM_x$ is the death rate in the interval, $_nL_x$ The total number of years lived during the indicated age interval, $_nD_x$ is the observed number of deaths in age interval (x to x+ n), $_nP_x$ is the For example, according to registered death $_nq_4$ is the proportion of male dying between exact age 0 and 4, by using equation (3.1), an estimate of child mortality for males is

$$_nq_4 = \frac{0.0045}{\frac{1}{5} + 0.5 * 0.0045} = 0.0223$$

This means that, out of every 10,000 males born, 223 will die before reaching their 4th birthday. And so on the $_nq_{29}$ the probability of male dying between exact age 25 and 29 is

$$_nq_{29} = \frac{0.0025}{\frac{1}{5} + 0.5 \ * \ 0.0025} = 0.01246$$

Similarly, an estimate of child mortality for female is

$$_nq_4 = \frac{0.0034}{\frac{1}{5} + 0.5 \ * \ 0.0034} = 0.0168$$

This means that, out of every 10,000 females born, 168 will die before reaching the 4th birthday, (see columns 3 in tables (3.2) to (3.4)).

The graphical features of these probabilities are illustrated in figure (3.1), and are seem to depict a concave pattern.

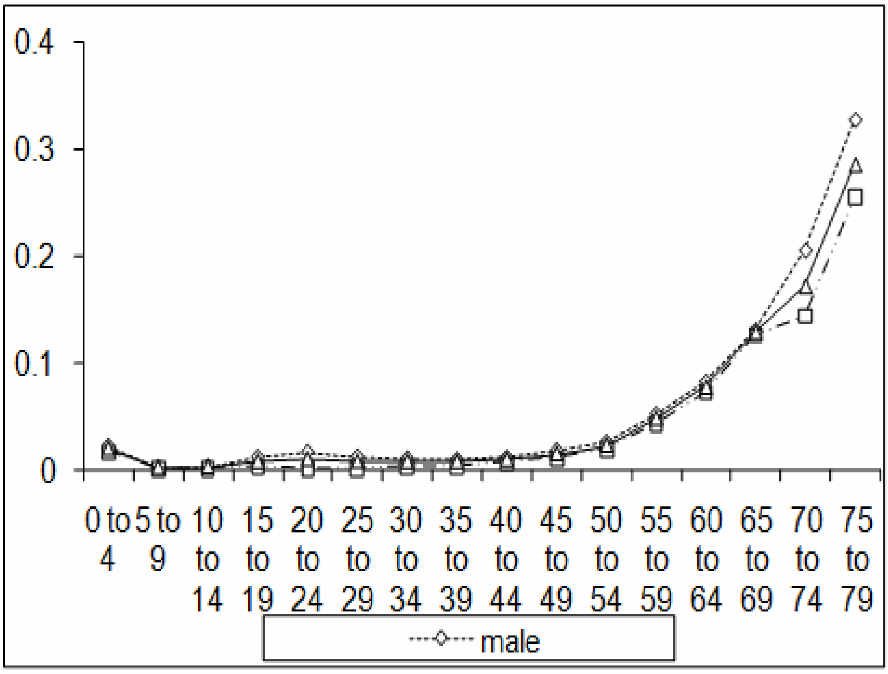


**Figure 1**
**Plot of probabilities of death, Gaza Strip, 2006**

probabilities of dying can be applied to census or survey population age distributions to derive an estimated mortality. For instance, in table (1), the male population in age group, 20-24 years is 64,243 persons, but the corresponding probability of dying shown in table (2) is 0.01659. Applying this rate to the population means that, out of those who are alive and passing through 20-24 years, about 1066 will die before reaching their 25$^{th}$ birthday, while 63,177 will survive to celebrate the 25$^{th}$ birthday.

### Calculating the variance of $_nq_x$

To calculate a variance of the probability of dying we will use the equation which obtained according to Chiang's method (1968)·

$$Var({}_n q_x) = \frac{{}_n q_x^2 * (1 - {}_n q_x)}{{}_n D_x} = Var({}_n p_x) \qquad (3.2)$$

By using equation (3.2), the variance of the probability of male dying between exact age 0 and 4 is

$$Var({}_n q_4) = \frac{{}_5 q_4^2 * (1 - {}_5 q_4)}{{}_5 D_4} = \frac{0.0223^2 * (1 - 0.0223)}{633} = 7.683E - 007$$

And so on the variance of the probability of male dying between exact age 15 and 19 is

$$Var({}_n q_{19}) = \frac{{}_5 q_{19}^2 * (1 - {}_5 q_{19})}{{}_5 D_{19}} = \frac{0.0118^2 * (1 - 0.0118)}{196} = 7.0202E\text{-}007$$

Similarly, the variance of the probability of female dying between exact age 0 and 4 is

$$Var({}_n q_4) = \frac{{}_5 q_4^2 * (1 - {}_5 q_4)}{{}_5 D_4} = \frac{0.0168^2 * (1 - 0.0168)}{457} = 6.0937E - 007$$

And at the same age interval for both sexes the variance of the probability of dying is

$$Var({}_n q_4) = \frac{{}_5 q_4^2 * (1 - {}_5 q_4)}{{}_5 D_4} = \frac{0.0196^2 * (1 - 0.0196)}{1090} = 3.4553E - 007$$

**Estimation of life expectancy $e_x$**

The expectation of life at age x, ($e_x$-value) summarizes life table survival in terms of mean additional years of remaining lifetime from age x. This mean value is calculated just like any mean value. It is

$$e_x = \frac{\text{total person-years lived beyond age x}}{\text{number of persons of age x}} = \frac{T_x}{l_x} \qquad (3.3)$$

Where $T_x$ is a total time lived beyond age x by all individuals who are age at x. The value $T_x$ is the sum of the total person-years-at-risk lived in each age interval starting at age x.

In symbols,

$$T_x = L_x + L_{x+1} + L_{x+2} + \ldots.. L_w \qquad (3.4)$$

w denote to the lower boundary of the upper age group.

$$L_x = 5 * \left(l_x + {}_n d_x\right) + 0.5*5*{}_n d_x \qquad (3.5)$$

The accumulated time lived, $T_x$, is primarily a computational step in the life table construction.

To calculate a life expectancy we need at first find to $T_x$ and $L_x$, by using equation (3.4) and equation (3.5) we will get values of $T_x$ and $L_x$ in the abridged life tables (see columns 8,9 in tables (3.2) to (3.4)).

So the estimation of life expectancy for males at birth is

$$e_0 = \frac{T_0}{l_0} = \frac{7371190}{100000} = 73.71$$

The estimation of life expectancy for females at birth is

$$e_0 = \frac{T_0}{l_0} = \frac{7530540}{100000} = 75.31$$

And the estimation of life expectancy for both sexes is

$$e_0 = \frac{T_0}{l_0} = \frac{7391252}{100000} = 73.91$$

The value of life expectancy is rounded to one or two decimals according to the size of the population and the accuracy of the original data.

## Calculating the variance of $e_x$

According to Chiang's (1984) the variance of life expectancy is

$$\operatorname{Var}(e_x) = \frac{\sum_{a=x}^{w-n} l_a^{\,2}\left[e_{a+n} + 2.5\right]^2}{l_x^2} \operatorname{Var}({}_n p_a) \qquad (3.6)$$

where w denotes the final age interval.

By using equation (3.6) the variance of the life expectancy at 65 for males is

$$\operatorname{Var}(e_{65}) = \frac{\sum_{a=65}^{75} l_a^{\,2}\left[e_{a+5} + 2.5\right]^2}{(75188.604)^2} \operatorname{Var}({}_5 p_a) = 1*(2.5+15.93)^2*(0.000102)+$$

$$(\frac{65328.02}{75188.604})^2*(2.5+14.41)^2*(0.000153)+(\frac{51875.978}{75188.604})^2*(2.5+15.25)^2*(0.000324)=1.11615$$

And similarly, we can calculate the variance of $e_x$ at any interval of age. (See columns 11 in tables (2) to (4)).

## Estimation of uncertainty limits

One important use of the standard error of a life expectancy is to determine boundaries of the uncertainty intervals (UI), UI provides explicit characterizations of the precision around estimates derived from limited information sources. By using Chiang's variance estimate the 95% UI can be calculated by using the equation:

$$e_x \pm Z_{\frac{\alpha}{2}} * SE_e \qquad (3.7)$$

Where as Z is normal deviate, and α is the probability of normal deviate being greater than |Z|. It is customary to select α = 0.05, hence Z = 1.96.

So 95% UI for life expectancy at birth for both sexes to first class is

$$73.91 \pm 1.96 \ * \sqrt{\mathrm{Var}(e_x)} = 73.91 \pm (1.96 \ * \sqrt{0.0370}) = (73.54,\ 74.29)$$

Table (3.5) shows an estimate of child mortality for Gaza strip is 20 deaths for every 1000 children under 5 years. The estimate of child mortality for male and female were 22.3 per 1000 and 16.8 per 1000 respectively. Life expectancy was 73.9 years, while it was 73.7 for males and 75.3 for females.

**Table 5**
**Estimate of child mortality per 1000 and life expectancy at birth for Gaza strip, 2006**

| | Total | Male | Female |
|---|---|---|---|
| Child mortality (0-4) years | 19.6 | 22.3 | 16.8 |
| Life expectancy | 73.9 | 73.7 | 75.3 |
| 95 % C.I | 73.54 - 74.29 | 73.04 – 74.39 | 74.84 - 75.77 |

## Correction for the under-reporting of deaths

The simplest way of calculating mortality rates is by using the information on deaths by age produced by a vital registration system, However registration of deaths in many developing countries is often incomplete, and even when reporting is adequate, information regarding age is immediately inaccurate and the death rate implied by the reported deaths is usually an underestimate of the true death rate. If deaths are underreported, the survival function, lx, will fall too slowly as age increases and estimates of life expectancy will be biased upward. Some methods of adjustment are required to transform the reported death rate into a better estimate of true mortality conditions. One of these methods is Brass growth balance method.

### Calculating partial birth rate

The calculation of the partial birth rate, N(x)/N(x+), where N(x) is the population at an age x during the course of year under consideration, when the total of population is the classified by 5 years of ages, and N(x+) is the total number of persons aged x and over so

$$N(x) = \frac{{}_5N_{x-5} + {}_5N_x}{10} \qquad (3.8)$$

And

$$N(x+) = \sum_{j=x}^{75} {}_5N_j + N(80+) \qquad (3.9)$$

Where as 5Nx is a population at exact age.

By using equations (3.8) and (3.9), N(20) and N(20+) for males can be calculated as the following:

$$N(20) = \frac{{}_5N_{15} + {}_5N_{20}}{10} = \frac{82510 + 64243}{10} = 14675$$

$$N(20+) = \sum_{j=20}^{75} {}_5N_j + N(80+)$$

$$= 64243 + 51040 + 40706 + \dots\dots\dots + 2287 = 289642$$

N(40) for female will be

$$N(40) = \frac{{}_5N_{35} + {}_5N_{40}}{10} = \frac{31546 + 26863}{10} = 5841$$

$$N(40+) = \sum_{j=40}^{75} {}_5N_j + N(80+)$$

$$= 26863 + 20030 + 15061 + \dots\dots\dots + 3049 = 104180$$

And similarly by using the same equation, we can obtain all values for males, females, and both sexes of age x up to 80.

By using the values obtained the partial birth rates N(x) / N(x+) will be calculated. (See columns 4, 5, 8 in tables 3.6 to 3.8).

**Calculating partial death rate**

Partial death rate calculated as the ratio of deaths ages x and over to the population of the same ages. To calculate, D(x+) / N(x+), we need to calculate D(x+) is a total number of deaths after an exact age.

$$D(x+) = \sum_{j=x}^{75} {}_5D_j + D(80+) \qquad (3.10)$$

So D(20+) for male can be calculated by applying equation (3.10)

$$D(20+) = \sum_{j=20}^{75} {}_5D_j + D(80+) = 215 + 128 + \dots.. + 224 + 150 = 1710$$

D (40+) for female will be

$$D(40+) = \sum_{j=20}^{75} {}_5D_j + D(80+) = 36 + 43 + 59 + \dots. + 244 + 436 = 1462$$

And similarly by using the same equation, we can obtain all values for males, females, and both sexes of age x up to 80.

By using the values obtained the partial death rates D(x+) / N(x+) will be calculated. (See columns 5, 6, 7 in tables (6) to (8)).

## Table 6
## Correction for the under-reporting of deaths of above 4 years age group, males in Gaza strip (2006)

| Exact age (years) | Population | Registered death | Population at exact age x | Population at exact age x and above | Death at exact age x and above | Partial death rates | Partial birth rate | Adjusted deaths |
|---|---|---|---|---|---|---|---|---|
| x | $_5N_x$ | $_5D_x$ | N(x) | N(x+) | D(x+) | D(x+)/N(x+) | N(x)/N(x+) | Adj. $_5$Dx |
| (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) |
| 0 | 140,325 | 633 | | | | | | |
| 5 | 118,578 | 50 | 25890.3 | 590903 | 2012 | 0.0034 | 0.0438 | 55.5 |
| 10 | 100,173 | 56 | 21875.1 | 472325 | 1962 | 0.0042 | 0.0463 | 63 |
| 15 | 82,510 | 196 | 18268.3 | 372152 | 1906 | 0.0051 | 0.0491 | 221 |
| 20 | 64,243 | 215 | 14675.3 | 289642 | 1710 | 0.0059 | 0.0507 | 242 |
| 25 | 51,040 | 128 | 11528.3 | 225399 | 1495 | 0.0066 | 0.0511 | 144 |
| 30 | 40,706 | 88 | 9174.6 | 174359 | 1367 | 0.0078 | 0.0526 | 99 |
| 35 | 32,720 | 62 | 7342.6 | 133653 | 1279 | 0.0096 | 0.0549 | 70 |
| 40 | 29,816 | 68 | 6253.6 | 100933 | 1217 | 0.0121 | 0.0620 | 77 |
| 45 | 21,851 | 80 | 5166.7 | 71117 | 1149 | 0.0162 | 0.0727 | 90 |
| 50 | 15,501 | 82 | 3735.2 | 49266 | 1069 | 0.0217 | 0.0758 | 92 |
| 55 | 11,536 | 124 | 2703.7 | 33765 | 987 | 0.0292 | 0.0801 | 140 |
| 60 | 7,068 | 122 | 1860.4 | 22229 | 863 | 0.0388 | 0.0837 | 137 |
| 65 | 5,237 | 147 | 1230.5 | 15161 | 741 | 0.0489 | 0.0812 | 166 |
| 70 | 4,792 | 220 | 1002.9 | 9924 | 594 | 0.0599 | 0.1011 | 248 |
| 75 | 2,845 | 224 | 763.7 | 5132 | 374 | 0.0729 | 0.1488 | 252 |
| 80 | 2,287 | 150 | 513.2 | 2287 | 150 | 0.0656 | 0.2244 | 169 |

## Table 7
## Correction for the under-reporting of deaths of above 4 years age group, females in Gaza strip (2006)

| Exact age (years) | Population | Registered death | Population at exact age x | Population at exact age x and above | Death at exact age x and above | Partial death rates | Partial birth rate | Adjusted deaths |
|---|---|---|---|---|---|---|---|---|
| x | $_5N_x$ | $_5D_x$ | N(x) | N(x+) | D(x+) | D(x+)/N(x+) | N(x)/N(x+) | Adj. $_5$Dx |
| (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) |
| 0 | 134,616 | 457 | | | | | | |
| 5 | 113,866 | 35 | 24848.2 | 577970 | 1683 | 0.0029 | 0.0430 | 36 |
| 10 | 97,422 | 38 | 21128.8 | 464104 | 1648 | 0.0036 | 0.0455 | 39 |
| 15 | 80,047 | 41 | 17746.9 | 366682 | 1610 | 0.0044 | 0.0484 | 42 |
| 20 | 61,212 | 26 | 14125.9 | 286635 | 1569 | 0.0055 | 0.0493 | 27 |
| 25 | 49,623 | 23 | 11083.5 | 225423 | 1543 | 0.0068 | 0.0492 | 24 |
| 30 | 40,074 | 30 | 8969.7 | 175800 | 1520 | 0.0086 | 0.0510 | 31 |
| 35 | 31,546 | 28 | 7162 | 135726 | 1490 | 0.0110 | 0.0528 | 29 |
| 40 | 26,363 | 36 | 5840.9 | 104180 | 1462 | 0.0140 | 0.0561 | 37 |
| 45 | 20,030 | 43 | 4689.3 | 77317 | 1426 | 0.0184 | 0.0607 | 44 |
| 50 | 15,061 | 59 | 3509.1 | 57287 | 1383 | 0.0241 | 0.0613 | 61 |
| 55 | 12,302 | 111 | 2736.3 | 42226 | 1324 | 0.0314 | 0.0648 | 115 |
| 60 | 8,876 | 134 | 2117.8 | 29924 | 1213 | 0.0405 | 0.0708 | 138 |
| 65 | 7,619 | 206 | 1649.5 | 21048 | 1079 | 0.0513 | 0.0784 | 213 |
| 70 | 6,209 | 193 | 1382.8 | 13429 | 873 | 0.0650 | 0.1030 | 199 |
| 75 | 4,171 | 244 | 1038 | 7220 | 680 | 0.0942 | 0.1438 | 252 |
| 80 | 3,049 | 436 | 722 | 3049 | 436 | 0.1430 | 0.2368 | 450 |

**Table 8**
**Correction for the under-reporting of deaths of above 4 years age group, both sexes in Gaza strip (2006)**

| Exact age (years) | Population | Registered death | Population at exact age x | Population at exact age x and above | Death at exact age x and above | Partial death rates | Partial birth rate | Adjusted deaths |
|---|---|---|---|---|---|---|---|---|
| x | $_5N_x$ | $_5D_x$ | N(x) | N(x+) | D(x+) | D(x+)/N(x+) | N(x)/N(x+) | Adj. $_5Dx$ |
| (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) |
| 0 | 274941 | 1090 | | | | | | |
| 5 | 232444 | 85 | 50739 | 1168873 | 3695 | 0.0032 | 0.0434 | 94 |
| 10 | 197595 | 94 | 43004 | 936429 | 3610 | 0.0039 | 0.0459 | 104 |
| 15 | 162557 | 237 | 36015 | 738834 | 3516 | 0.0048 | 0.0487 | 263 |
| 20 | 125455 | 241 | 28801 | 576277 | 3279 | 0.0057 | 0.0500 | 268 |
| 25 | 100663 | 151 | 22612 | 450822 | 3038 | 0.0067 | 0.0502 | 168 |
| 30 | 80780 | 118 | 18144 | 350159 | 2887 | 0.0082 | 0.0518 | 131 |
| 35 | 64266 | 90 | 14505 | 269379 | 2769 | 0.0103 | 0.0538 | 100 |
| 40 | 56679 | 104 | 12095 | 205113 | 2679 | 0.0131 | 0.0590 | 115 |
| 45 | 41881 | 123 | 9856 | 148434 | 2575 | 0.0173 | 0.0664 | 137 |
| 50 | 30562 | 141 | 7244 | 106553 | 2452 | 0.0230 | 0.0680 | 157 |
| 55 | 23838 | 235 | 5440 | 75991 | 2311 | 0.0304 | 0.0716 | 261 |
| 60 | 15944 | 256 | 3978 | 52153 | 2076 | 0.0398 | 0.0763 | 284 |
| 65 | 12856 | 353 | 2880 | 36209 | 1820 | 0.0503 | 0.0795 | 392 |
| 70 | 11001 | 413 | 2386 | 23353 | 1467 | 0.0628 | 0.1022 | 458 |
| 75 | 7016 | 468 | 1502 | 12352 | 1054 | 0.0853 | 0.1459 | 519 |
| 80 | 5336 | 586 | 1235 | 5336 | 586 | 0.1098 | 0.2315 | 650 |

## Adjustment of death rate

This technique estimates the completeness of reporting of deaths over age 5 years in relation to information on population (Brass, 1975). It compares the distribution of deaths in relation to the distribution of population, both by age.

Fitting a line by using least square (LS) method provides a best fit if the data only affected by random error. But real populations often diverge from the ideal conditions for applying this technique. Populations usually are not precisely stable, there is often age misreporting of the population and of deaths, and there is often differential completeness in the registration of population and of deaths by age, therefore demographers suggested another technique, separating the points into two groups, computing the average birth rate and death rate in each, and then fitting a straight line to the pairs of a points. The slope of the adjusted line would thus represent an average adjustment factor for registered deaths.

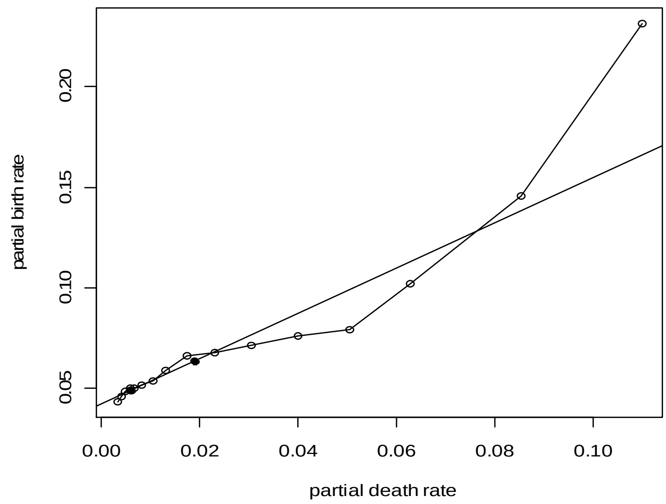


**Figure 2**
**Plot of partial birth rates against partial death rates, both sexes**

**Adjustment of both sexes death rate**

For total population, examination of the points shown in figure (2) suggests that there is diverge from linearity, therefore the points are divided into two equally sized groups, one comprising points for ages ranging from 10 to 34, the other from 35 to 59. The average partial death rate for the 5 age groups between 10 and 34 years (X1) is 0.00586 and the average partial birth rate for the 5 age groups between 10 and 34 years (Y1) is 0.0493. The average partial death rate for the 5 age groups between 35 and 59 years (X2) is 0.0188 and average partial birth rate for these groups (Y2) is 0.0638, therefore the slope of the fitted line is calculated according to the equation:

$$K = \frac{(Y_2 - Y_1)}{(X_2 - X_1)} = \frac{(0.0638 - 0.0493)}{(0.0188 - 0.00586)} = 1.11$$

This adjusted number of deaths should be used to calculate the age-specific mortality rates. by multiplying the number of deaths by the estimated adjustment factor for deaths. See column 9 in table (8)

The value of C implies that the completeness of death registration is

$$C = \frac{1}{K} = \%90$$

## Adjustment of males' death rate

For males, examination of the points shown in figure (3) suggests that there is diverge from linearity, therefore the points are divided into two equally sized groups, one comprising points for ages ranging from 15 to 39, the other from 45 to 69. The average partial death rate for the 5 age groups between 15 and 39 years (X1) is 0.00701 and the average partial birth rate for the 5 age groups between 15 and 39 years (Y1) is 0.0517. The average partial death rate for the 5 age groups between 45 and 69 years (X2) is 0.0310 and average partial birth rate for these groups (Y2) is 0.0787, therefore the slope of the fitted line is calculated according to the equation

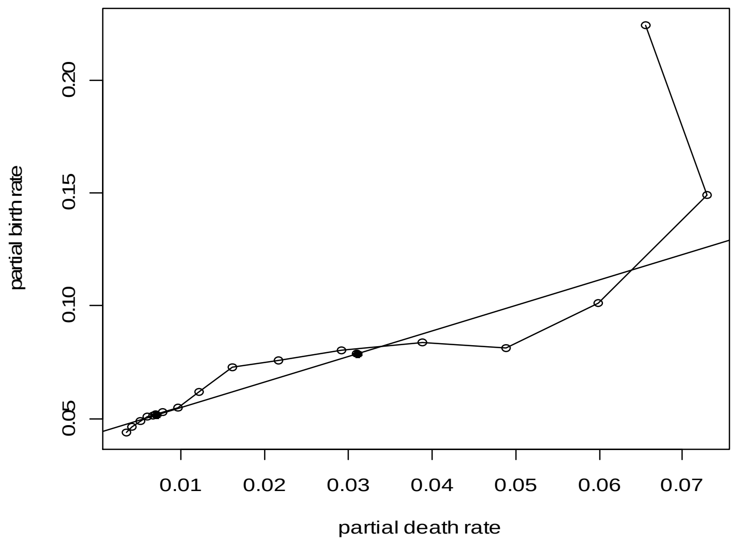


**Figure 3**
**Plot of partial birth rates against partial death rates, males**

$$K = \frac{(Y_2 - Y_1)}{(X_2 - X_1)} = \frac{(0.0787 - 0.0517)}{(0.0310 - 0.00701)} = 1.127$$

This adjusted number of deaths should be used to calculate the age-specific mortality rates, by multiplying the number of deaths by the estimated adjustment factor for deaths. See column 9 in table (6)

The value of C implies that the completeness of death registration is

$$C = \frac{1}{K} = \%88.7$$

## Adjustment of females' death rate

For females, examination of the points shown in figure (4) suggests that there is diverge from linearity, therefore the points are divided into two equally sized groups, one comprising points for ages ranging from 5 to 44, the other from 45 to 80 and up. The average partial death rate for the 8 age groups between 5 and 44 years (X1) is 0.00710 and the average partial birth rate for the 8 age groups between 5 and 44 years (Y1) is 0.0494. The average partial death rate for the 8 age groups between 45 and 80+ years (X2) is 0.0585 and average partial birth rate for these groups (Y2) is 0.1024, therefore the slope of the fitted line is calculated according to the equation

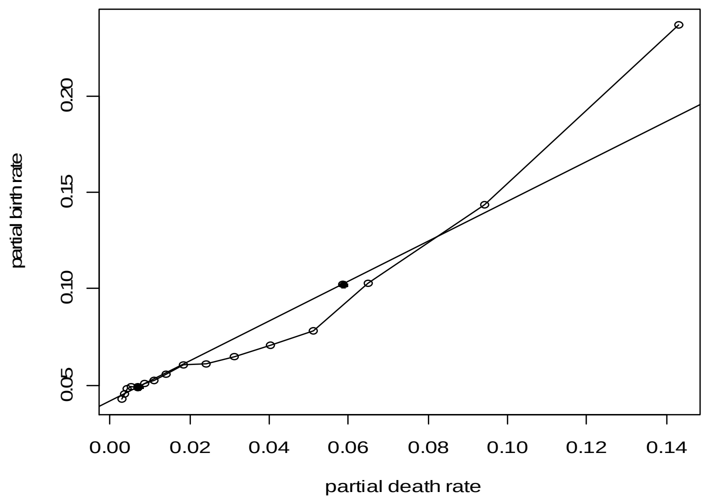


**Figure 4**
**Plot of partial birth rates against partial death rates, females**

$$K = \frac{(Y_2 - Y_1)}{(X_2 - X_1)} = \frac{(0.1024 - 0.0494)}{(0.0585 - 0.00710)} = 1.032$$

This adjusted number of deaths should be used to calculate the age-specific mortality rates, by multiplying the number of deaths by the estimated adjustment factor for deaths. See column 9 in table (7). The value of C implies that the completeness of death registration is

$$C = \frac{1}{K} = \%96.9$$

**Estimation of life expectancy by corrected deaths**

Applying abridged life table technique on the corrected deaths by using brass growth balance method, Tables 3.10, 3.11 and 3.12 show abridged life table based on corrected deaths and population distribution for Gaza Strip, for males, females and both sexes respectively.

Table (9) shows the point estimates and 95% uncertainty intervals (UI) of life expectancy at birth for the Gaza Strip in 2006 by sex. Life expectancy at birth was 72.5 years for the total population (95% UI: 72.14 to 72.87), 71.55 years for males (95% UI: 70.93 – 72.17), and 74.95 years for females (95% UI: 74.49 – 75.42).

**Table 9**
**Estimate life expectancy at birth for Gaza strip 2006**

| SEX | Life expectancy | 95 % C.I |
|---|---|---|
| Male | 71.55 | 70.93 – 72.17 |
| Female | 74.95 | 74.49 -75.42 |
| Overall | 72.50 | 72.14 - 72.87 |

### The statistical test for differences

Statistical test for differences in life expectancy at age x between two populations i and j is

$$z = \frac{e_{xi} - e_{xj}}{\left[\sqrt{(Var(e_{xi}) + Var(e_{xj}))}\right]} \qquad (3.11)$$

The hypotheses are:
H0: There is no difference, H1: There is a significant difference

We can obtain the statistical for the difference between two methods in estimate a life expectancy at birth by using equation (3.11).

The statistical test for the difference between two methods (before and after the correction of deaths registration) in life expectancy at birth for males is:
H0: There is no difference, H1: There is a significant difference

$$z = \frac{73.71 - 71.55}{\sqrt{[0.1187 + 0.10094]}} = 4.61$$

The value of the test statistic exceeds the critical value of 1.96, so we can conclude that this difference is statistically significant between the two methods.

The statistical test for the difference between two methods in life expectancy at birth for females is:

H0: There is no difference, H1: There is a significant difference

$$z = \frac{75.31 - 74.95}{\sqrt{[0.0565 + 0.05561]}} = 1.08$$

The value of the test statistic does not exceed the critical value of 1.96, and then we can't conclude that the difference is statistically significant between the two methods.

The statistical test for the difference between two methods in life expectancy at birth for both sexes is:

H0: There is no difference, H1: There is a significant difference

$$z = \frac{73.91 - 72.50}{\sqrt{[0.0370 + 0.0343]}} = 5.28$$

The value of the test statistic exceeds the critical value of 1.96, so we can conclude that there is a statistical significant difference between the two methods in life expectancy at birth for both sexes.

This was an evident and consistent finding of our study.

**Table 10**
**Abridged Life Table Based on Corrected Deaths and Population Distribution for Gaza Strip, male: 2006**

| Interval | Death Rate | Probability of dying | Standard error of ($_nq_x$) | Alive at start | Dying in interval | Fraction | Years in interval | Years beyond | Life expectancy | Variance of life expectancy | 95 % Confidence Interval | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | $_nm_x$ | $_nq_x$ | $SE_q$ | $l_x$ | $d_x$ | $_nf_x$ | $_nL_x$ | $T_x$ | $e_x$ | $Var(e_x)$ | LCI $(e_x)$ | UCI $(e_x)$ |
| (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) | (12) | (13) |
| 0 to 4 | 0.004511 | 0.0223 | 0.000377 | 100000 | 2230.326 | 0.5 | 494424.15 | 7155035.54 | 71.55 | 0.10004 | 70.93 | 72.17 |
| 5 to 9 | 0.000472 | 0.0024 | 0.000315 | 97769.67 | 230.5927 | 0.5 | 488271.89 | 6660609.35 | 68.13 | 0.10129 | 67.50 | 68.75 |
| 10 to 14 | 0.000629 | 0.0031 | 0.000395 | 97539.08 | 306.236 | 0.5 | 486929.82 | 6172337.47 | 63.28 | 0.10164 | 62.66 | 63.91 |
| 15 to 19 | 0.002678 | 0.0133 | 0.000889 | 97232.85 | 1293.511 | 0.5 | 482930.45 | 5685407.65 | 58.47 | 0.10169 | 57.85 | 59.10 |
| 20 to 24 | 0.003767 | 0.0187 | 0.001188 | 95939.33 | 1790.134 | 0.5 | 475221.33 | 5202477.20 | 54.23 | 0.10154 | 53.60 | 54.85 |
| 25 to 29 | 0.002821 | 0.0140 | 0.001159 | 94149.2 | 1318.821 | 0.5 | 467448.95 | 4727255.87 | 50.21 | 0.10168 | 49.59 | 50.84 |
| 30 to 34 | 0.002432 | 0.0121 | 0.001307 | 92830.38 | 1122.65 | 0.5 | 461346.32 | 4259806.92 | 45.89 | 0.10135 | 45.26 | 46.51 |
| 35 to 39 | 0.002139 | 0.0106 | 0.001265 | 91708.35 | 975.769 | 0.5 | 456102.32 | 3798460.60 | 41.42 | 0.09997 | 40.80 | 42.04 |
| 40 to 44 | 0.002553 | 0.0128 | 0.001453 | 90732.58 | 1161.072 | 0.5 | 450751.72 | 3342357.78 | 36.84 | 0.10061 | 36.22 | 37.46 |
| 45 to 49 | 0.004119 | 0.0204 | 0.002127 | 89565.51 | 1825.776 | 0.5 | 443278.10 | 2891605.06 | 32.28 | 0.10063 | 31.66 | 32.91 |
| 50 to 54 | 0.005935 | 0.0292 | 0.003004 | 87742.73 | 2565.74 | 0.5 | 432299.31 | 2448326.96 | 27.90 | 0.10051 | 27.28 | 28.52 |
| 55 to 59 | 0.012136 | 0.0589 | 0.004329 | 85176.99 | 5016.313 | 0.5 | 413344.15 | 2016027.65 | 23.67 | 0.10010 | 23.05 | 24.29 |
| 60 to 64 | 0.019383 | 0.0924 | 0.007524 | 80160.68 | 7409.765 | 0.5 | 382278.98 | 1602683.47 | 19.99 | 0.09970 | 19.37 | 20.61 |
| 65 to 69 | 0.031695 | 0.1469 | 0.010528 | 72751.91 | 10688.52 | 0.5 | 337045.77 | 1220404.48 | 16.78 | 0.09551 | 16.17 | 17.38 |
| 70 to 74 | 0.051753 | 0.2291 | 0.012774 | 62067.39 | 14220.91 | 0.5 | 274784.69 | 883358.71 | 14.23 | 0.05559 | 13.65 | 14.82 |
| 75 to 79 | 0.088576 | 0.3636 | 0.015236 | 47846.48 | 17348.65 | 0.5 | 195860.73 | 608574.02 | 12.72 | 0.05548 | 12.15 | 13.29 |
| 80 up | 0.073896 | 1.0000 | * | 30497.83 | 30497.83 | * | 412713.24 | 412713.24 | 13.53 | * | * | * |

## Table 11
## Abridged Life Table Based on Corrected Deaths and Population Distribution for Gaza Strip, female: 2006

| Interval | Death Rate | Probability of dying | Standard error of (nqx) | Alive at start | Dying in interval | Fraction | Years in interval | Years beyond | Life expectancy | Variance of life expectancy | 95 % Confidence Interval | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | nmx | nqx | SEq | lx | dx | nfx | nLx | Tx | ex | Var(ex) | LCI (ex) | UCI (ex) |
| (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) | (12) | (13) |
| 0 to 4 | 0.00340 | 0.0168 | 0.00075 | 100000.00 | 1683.14 | 0.5 | 495792.16 | 7495988.41 | 74.95 | 0.030805 | 74.49 | 75.42 |
| 5 to 9 | 0.00032 | 0.0016 | 0.00026 | 98316.86 | 155.30 | 0.5 | 491196.08 | 6999596.25 | 71.19 | 0.051101 | 70.74 | 71.65 |
| 10 to 14 | 0.00040 | 0.0020 | 0.00032 | 98161.57 | 196.28 | 0.5 | 490317.15 | 6508100.17 | 66.30 | 0.053944 | 65.85 | 66.76 |
| 15 to 19 | 0.00050 | 0.0026 | 0.00040 | 97965.28 | 256.67 | 0.5 | 489184.74 | 6018083.04 | 61.43 | 0.05374 | 60.98 | 61.89 |
| 20 to 24 | 0.00044 | 0.0022 | 0.00042 | 97708.61 | 215.25 | 0.5 | 488004.92 | 5528898.51 | 56.59 | 0.053451 | 56.13 | 57.04 |
| 25 to 29 | 0.00048 | 0.0024 | 0.00049 | 97493.36 | 235.48 | 0.5 | 486878.10 | 5040893.38 | 51.70 | 0.053158 | 51.25 | 52.16 |
| 30 to 34 | 0.00077 | 0.0039 | 0.00069 | 97257.88 | 375.45 | 0.5 | 485350.77 | 4554015.28 | 46.82 | 0.052823 | 46.37 | 47.27 |
| 35 to 39 | 0.00092 | 0.0046 | 0.00085 | 96882.43 | 444.30 | 0.5 | 483301.40 | 4068664.51 | 42.00 | 0.052277 | 41.55 | 42.44 |
| 40 to 44 | 0.00138 | 0.0069 | 0.00112 | 96138.13 | 661.87 | 0.5 | 480535.99 | 3585363.10 | 37.18 | 0.051613 | 36.73 | 37.62 |
| 45 to 49 | 0.00220 | 0.0109 | 0.00164 | 95776.26 | 1046.22 | 0.5 | 476265.77 | 3104827.12 | 32.42 | 0.050766 | 31.98 | 32.86 |
| 50 to 54 | 0.00405 | 0.0200 | 0.00231 | 94730.05 | 1899.15 | 0.5 | 468902.37 | 2628561.34 | 27.75 | 0.049385 | 27.31 | 28.18 |
| 55 to 59 | 0.00935 | 0.0457 | 0.00416 | 92830.90 | 4239.86 | 0.5 | 453554.84 | 2159658.97 | 23.26 | 0.046965 | 22.84 | 23.69 |
| 60 to 64 | 0.01556 | 0.0748 | 0.00615 | 88591.04 | 6629.20 | 0.5 | 426382.19 | 1706104.13 | 19.26 | 0.042067 | 18.85 | 19.66 |
| 65 to 69 | 0.02796 | 0.1307 | 0.00835 | 81961.84 | 10708.38 | 0.5 | 383038.25 | 1279721.93 | 15.61 | 0.035342 | 15.25 | 15.98 |
| 70 to 74 | 0.03206 | 0.1484 | 0.00971 | 71253.46 | 10571.41 | 0.5 | 329838.77 | 896683.68 | 12.58 | 0.025788 | 12.27 | 12.90 |
| 75 to 79 | 0.06042 | 0.2624 | 0.01429 | 60682.05 | 15925.72 | 0.5 | 263595.95 | 566844.91 | 9.34 | 0.017344 | 9.08 | 9.60 |
| 80 up | 0.14759 | 1.0000 | * | 44756.33 | 44756.33 | * | 303248.98 | 303248.93 | 6.78 | * | * | * |

## Table 12
## Abridged Life Table Based on Corrected Deaths and Population Distribution for Gaza Strip, both sexes: 2006

| Interval | Death Rate | Probability of dying | Standard error of (nqx) | Alive at start | Dying in interval | Fraction | Years in interval | Years beyond | Life expectancy | Variance of life expectancy | 95 % Confidence Interval | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | nmx | nqx | SEq | lx | dx | nfx | nLx | Tx | ex | Var(ex) | LCI (ex) | UCI (ex) |
| (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) | (12) | (13) |
| 0 to 4 | 0.00398 | 0.0196 | 0.0006 | 100000.00 | 1962.79 | 0.5 | 495093.03 | 7250424.26 | 72.50 | 0.034234 | 72.14 | 72.87 |
| 5 to 9 | 0.00040 | 0.0020 | 0.0002 | 98037.21 | 198.03 | 0.5 | 489690.98 | 6755331.59 | 68.91 | 0.033802 | 68.55 | 69.27 |
| 10 to 14 | 0.00053 | 0.0026 | 0.0003 | 97839.18 | 257.14 | 0.5 | 488553.05 | 6265640.56 | 64.04 | 0.033746 | 63.68 | 64.40 |
| 15 to 19 | 0.00162 | 0.0081 | 0.0005 | 97582.04 | 786.21 | 0.5 | 485944.68 | 5777087.51 | 59.20 | 0.03367 | 58.84 | 59.56 |
| 20 to 24 | 0.00214 | 0.0106 | 0.0006 | 96795.83 | 1028.40 | 0.5 | 481408.18 | 5291142.82 | 54.66 | 0.033407 | 54.30 | 55.02 |
| 25 to 29 | 0.00167 | 0.0083 | 0.0006 | 95767.44 | 795.83 | 0.5 | 476817.62 | 4809734.65 | 50.22 | 0.032915 | 49.87 | 50.58 |
| 30 to 34 | 0.00162 | 0.0081 | 0.0007 | 94971.61 | 766.96 | 0.5 | 472940.64 | 4332887.03 | 45.62 | 0.032539 | 45.27 | 45.98 |
| 35 to 39 | 0.00156 | 0.0078 | 0.0008 | 94204.65 | 730.09 | 0.5 | 469198.02 | 3859946.38 | 40.97 | 0.032123 | 40.62 | 41.33 |
| 40 to 44 | 0.00203 | 0.0101 | 0.0009 | 93474.56 | 943.50 | 0.5 | 465014.05 | 3390748.37 | 36.27 | 0.031716 | 35.93 | 36.62 |
| 45 to 49 | 0.00327 | 0.0162 | 0.0014 | 92531.06 | 1501.15 | 0.5 | 458902.43 | 2925734.32 | 31.62 | 0.031324 | 31.27 | 31.97 |
| 50 to 54 | 0.00514 | 0.0254 | 0.0020 | 91029.91 | 2308.50 | 0.5 | 449378.30 | 2466831.89 | 27.10 | 0.030655 | 26.76 | 27.44 |
| 55 to 59 | 0.01095 | 0.0533 | 0.0032 | 88721.41 | 4727.61 | 0.5 | 431788.04 | 2017453.58 | 22.74 | 0.029594 | 22.40 | 23.08 |
| 60 to 64 | 0.01781 | 0.0853 | 0.0048 | 83993.80 | 7161.72 | 0.5 | 402064.73 | 1585665.55 | 18.88 | 0.027767 | 18.55 | 19.20 |
| 65 to 69 | 0.03049 | 0.1417 | 0.0066 | 76832.09 | 10883.99 | 0.5 | 356950.47 | 1183600.81 | 15.41 | 0.024215 | 15.10 | 15.71 |
| 70 to 74 | 0.04165 | 0.1885 | 0.0079 | 65948.10 | 12433.82 | 0.5 | 298655.95 | 826650.35 | 12.53 | 0.019383 | 12.26 | 12.81 |
| 75 to 79 | 0.07397 | 0.3121 | 0.0114 | 53514.28 | 16704.10 | 0.5 | 225811.15 | 527994.40 | 9.87 | 0.01481 | 9.63 | 10.10 |
| 80 up | 0.12181 | 1.0000 | | 36810.18 | 36810.18 | * | 302183.23 | 302183.23 | 8.21 | * | * | * |

## 4. Conclusion

In this paper, we estimated the life expectancy of the population of Gaza strip according to registered deaths in MOH. In life tables analysis based on registered deaths the estimation of life expectancy for males at birth is 73.71 years with uncertainty limits (73.04 – 74.39), the estimation of life expectancy for females at birth is 75.31 with uncertainty limits (74.84 - 75.77), the estimation of life expectancy for both sexes at birth is 73.91 with uncertainty limits (73.54 - 74.29). The completeness of death registration for males is (88.7%), the completeness of death registration for females is (96.9%), and the completeness of death registration for both sexes is (90%). The underreporting of deaths above four years was corrected using the Brass growth balance method. According to corrected number of deaths, the life expectancy at birth for males is 71.55 years with (UI 95% :70.93–72.17), the life expectancy at birth for females is 74.95 years with uncertainty limits (UI 95% 74.49 – 75.42), and the life expectancy at birth for the total population is 72.50 years with (UI 95%:72.14-72.87). By using Brass growth balance method the uncertainty interval was much smaller than that computed without correcting underreporting. The estimate of life expectancy at birth for the total population of Gaza strip in 2006 is about 1.41 (73.91 minus 72.5) year higher than the estimation when correcting underreporting with Brass growth balance method. It is about 2.2 year higher for males and only 0.35 year for females. It is found that this difference is statistically significant for males and both sexes only.

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