SOME DEMOGRAPHIC MEASUREMENTS FOR EGYPT BASED ON THE STABILITY OF CENSUS AGE DISTRIBUTIONS

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Introduction

THERE is clearly some relation between the relative sizes of successive age groups in a population and the risks of death. When, for a considerable number of years, the population has been closed to migration and the age schedules of fertility and mortality have been relatively constant, the rate of growth of the population is also relatively constant and the proportional distribution of the population by age assumes a relatively fixed character known as "stable." These relations will be considered below. For the time being the essential point to note is that under such circumstances if the age of the population is accurately counted, it is a simple matter to compute the risks of death implicit in the age distribution.

It is the purpose of this paper to utilize the near stability of the Egyptian age distributions from 1907 to 1947 to obtain a life table and certain other measures of mortality and fertility. Before doing so, however, it will be necessary (1) to show that the age distribution is indeed approximately stable and (2) to correct the most obvious distortions in the census reporting of age. With this accomplished we can proceed to construct a life table representing the mortality conditions in Egypt during the period 1907–1947 and utilize the stability of demographic conditions to secure some measures of fertility as well.

The Stability of the Demographic Conditions in Egypt

If we confine ourselves to the crude birth rate as a measure of fertility in order to avoid the distortions which result from the erroneous age reporting of mothers, we find that this rate fluctuated haphazardly without any indication of a downward

[1] From the Office of Population Research, Princeton University.

trend between 1917 and 1946. The birth rate was 40.1 in 1917 and 42.7 in 1946 and the average rates in the intervals 1917–1926, 1927–1936, and 1937–1946 were 41.8, 43.6, and 41.7 respectively. It is true that the available birth rates are below reality because of under-reporting of births, especially in the areas without health bureaus; but it is also true that no indication of declining fertility can be traced in the incomplete data available. In fact, it seems very unlikely that there has been any considerable change in the people's customs regarding fertility, except perhaps among limited classes in the urban areas.

The situation is the same in the case of mortality, where the average crude death rates over the periods 1917–1926, 1927–1936, and 1937–1946—again deficient because of under-reporting—have been constant and equal to about 27.0.[2] (There has been a consistent downward trend in the death rates since 1946 but this is irrelevant to our discussion.)

The population can also be considered as "closed," since there has been virtually no emigration on the part of Egyptians and the movements of foreigners can have only a trivial effect on the age distribution of the population because, as can be seen from the accompanying table, they make up a very small percentage of total numbers.

Year	*No. of Foreigners*	*Proportion of Total Population Per Cent*
1927	225,600	1.6
1937	186,515	1.2
1947	146,001	.8

The stability of fertility and mortality and the negligible amount of migration in the period 1907–1947 is also illustrated by the great similarity between the reported age distributions for both males and females as shown by Tables 1 and 2 and

[2] In computing the average for 1917–1926, the effect of the 1918 influenza epidemic was eliminated. The death rate rose from 29.4 in 1917 to 39.6 in 1918 and then dropped back to 29.4 in 1919.

Table 1. Population age distribution by decennial age intervals (in thousands).

Year	0–9	10–19	20–29	30–39	40–49	50–59	60–69	70–79	80–89	90–99	100 and Over	Total
A. Males												
1907	1,664	1,200	816	740	509	688						5,617
1917	1,771	1,407	924	853	575	377	230	139	55	21		6,352
1927	1,937	1,545	1,099	991	664	392	245	120	47	15	3	7,058
1937	2,135	1,748	1,159	1,161	822	476	274	128	46	14	4	7,967
1947	2,495	2,132	1,367	1,283	1,000	594	337	132	40	12		9,392
1947[1]	2,378	2,032	1,303	1,223	953	566	321	126	38	11		8,951
B. Females												
1907	1,678	942	918	757	515	763						5,573
1917	1,797	1,182	1,043	875	571	378	263	142	72	27		6,350
1927	1,964	1,338	1,234	1,017	657	411	275	138	64	18	4	7,120
1937	2,192	1,515	1,261	1,178	787	471	305	151	68	21	5	7,954
1947	2,505	1,995	1,498	1,348	985	624	382	162	58	18		9,575
1947[1]	2,343	1,866	1,401	1,261	921	584	357	152	54	17		8,956

[1] Adjusted for over-reporting. (*See* text.)

Table 2. Reported proportional age distributions.

Year	0–9	10–19	20–29	30–39	40–49	50–59	60–69	70–79	80–89	90–99	100 and Over	Total
A. Males												
1907	2,962	2,136	1,453	1,317	906	1,225						9,999
1917	2,788	2,215	1,455	1,343	905	594	362	219	87	33		10,001
1927	2,744	2,189	1,557	1,404	941	555	347	170	67	21	4	9,999
1937	2,680	2,194	1,455	1,457	1,032	597	344	161	58	18	5	10,001
1947	2,657	2,270	1,456	1,366	1,065	632	359	141	42	13		10,001
B. Females												
1907	3,011	1,690	1,647	1,358	924	1,369						9,999
1917	2,830	1,861	1,643	1,378	899	595	414	224	113	43		10,000
1927	2,758	1,879	1,733	1,428	923	577	386	194	90	25	6	9,999
1937	2,756	1,905	1,585	1,481	989	592	383	190	85	26	6	9,998
1947	2,616	2,084	1,564	1,408	1,029	652	399	169	60	19		10,000

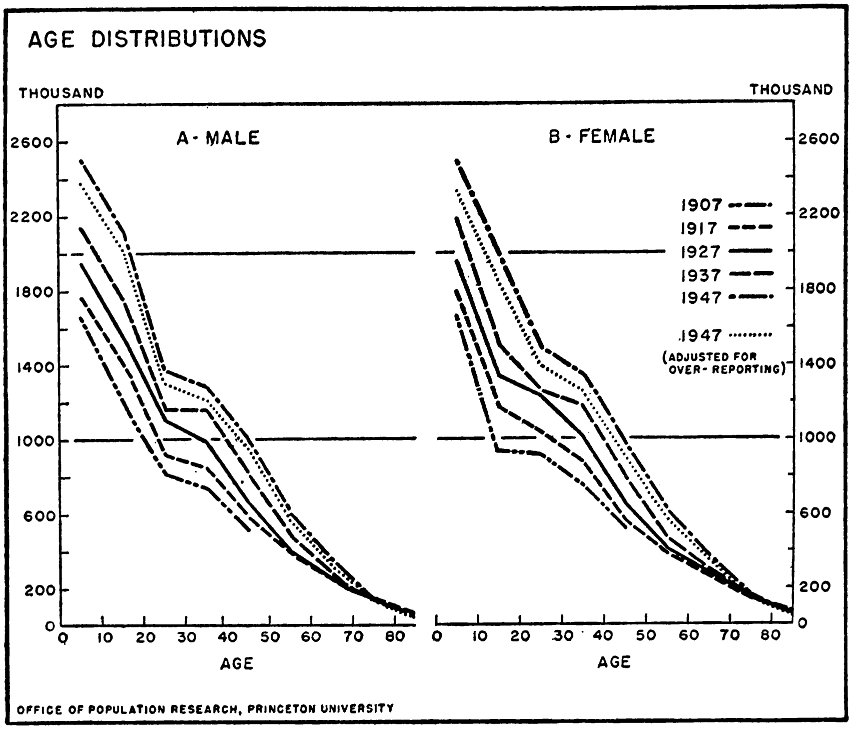


Fig. 1. Reported age distributions, by sex, 1907–1947.

Figures 1 and 2. Apart from a systematic improvement in the reporting of children within the age groups 0–9 and 10–19, which will be demonstrated later, and a systematic reduction in the over-estimation of old ages, the age distributions remain practically unchanged. They do exhibit, however, the effect of an unusually large cohort aged 0–9 in 1907 which maintains outstandingly high proportions from 1907 through 1947 among both males and females, as can be seen clearly from Table 2 and Figure 2. The fact that this cohort can be so readily identified in each of the five censuses itself tends to support the assumption of the stability of the age distribution throughout this period and testifies to the underlying accuracy of the census reports once they are corrected for systematic biases. In addition, the five censuses gave approximately stable growth rates during 1907–1937; the stability is broken only by the over-enumerated 1947 census, as will be shown in the next section.

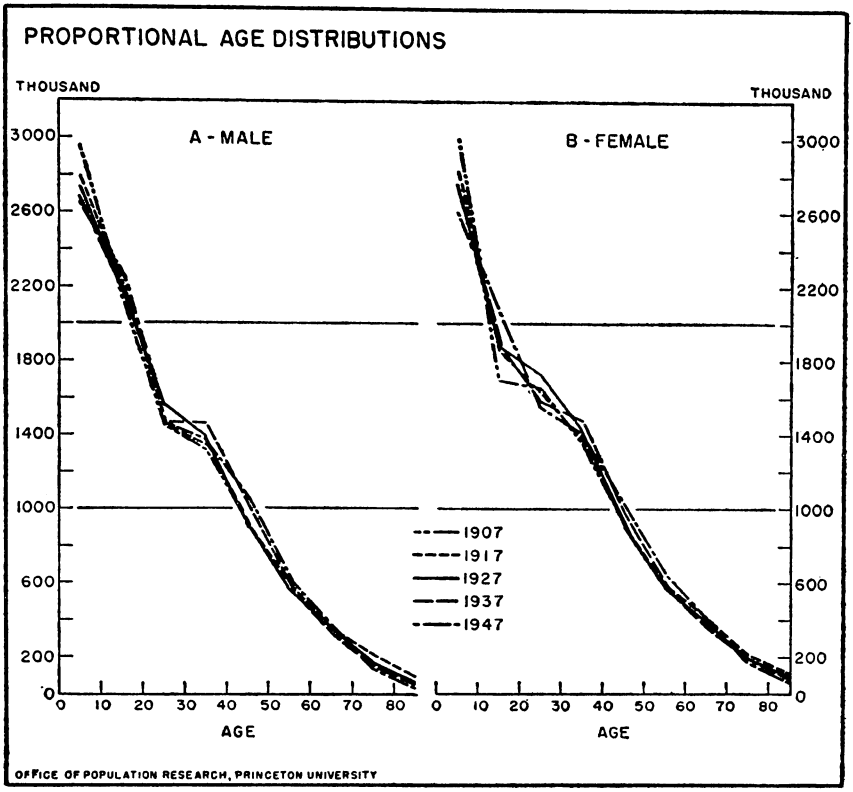


Fig. 2. Reported proportional age distributions, by sex, 1907–1947.

The fixed nature of mortality risks and the triviality of migration (two of three necessary components of a stable age distribution) can be seen from a simple measure like the ratio of the population aged 20 and over to the whole population 20 years earlier. (Age 20 was preferred to age 10 to avoid the above-indicated systematic shift from the age group 0–9 into the group 10–19.) These ratios are found to be practically constant:

Year	*Males*	*Females*
1927	.637	.685
1937	.643	.669
1947*	.643	.667

*The 1947 proportions were calculated after correcting for over-reporting in 1947 as will be shown in the following section.

One may conclude that there are substantial reasons for considering that the age distributions are essentially stable.

Basis of the Correction Procedure

The distortion in the age distribution of a country can be repaired by statistical evidence secured either from the country itself or from other countries, or by a combination of such kinds of evidence.

The correction procedure adopted here is confined wholly to evidence obtained from Egyptian data. It is true that the corrected age distributions would have looked more satisfactory had external evidence also been utilized, but it was preferred to limit the corrections rather than include external experience in a study of mortality in Egypt.

Distortion has frequently been corrected by fitting a curve to the reported age distribution. This method has the drawback that the shape of the fitted curve is affected by the systematic errors in age reporting, such as tendencies to mention or avoid certain ages, under-enumeration of certain ages and over-enumeration of others, and under-estimation or over-estimation of the individual's age.

Instead of this method, we shall apply here a procedure which secures indicators of necessary corrections from the five census age distributions along with evidence obtained from Egyptian statistics illustrating the practically unchanged mortality and fertility conditions in Egypt in 1907–1947 and the triviality of migration. This procedure will lead us to five essential corrections necessitated by the following systematic biases:

(1). Over-reporting in 1947.
(2). Erroneous reporting of children aged 10–19 as being in the 0–9 age group.
(3). Erroneous reporting of males 20–29 as 10–19.
(4). Under-estimation of females aged 40–59.
(5). Over-estimation of old ages.

Adjustment of Over-Reporting in the 1947 Census

The 1947 census gave total population figures which considerably exceeded expectations, especially in the case of the females. This can be seen from the table of growth rates:

Interval	*G.R. of Males*	*G.R. of Females*
1907–17	.012	.013
1917–27	.011	.011
1927–37	.012	.011
1937–47	.016	.019

This sharp increase in the 1947 growth rates can only be attributed to over-reporting since there is no evidence that it has been accompanied by changes in mortality, fertility, or migration. In fact, the large difference between the relative increases in the growth rates of females and males suggests the existence of over-reporting. This over-reporting was stimulated by a rationing census undertaken in 1945 which gave a total population of 24 million, or six and a half million over what one would expect on the basis of the 1927–1937 growth rate.

To adjust for this over-reporting, a continuation of the 1907–1937 growth rates, namely .01165 for males and .01186 for females, will be assumed here, giving a 1947 population of 8,951,000 males and 8,956,000 females—i.e. an over-reporting amounting to one million, or 5.6 per cent. It will also be assumed here that the degree of over-reporting is constant among the various age groups. There is certainly some error in this assumption, the effect of which would be negligible compared to the other distortions existing in the age distribution. The assumption was found to be satisfactory, however, in that it gave sex ratios in the various age groups which were consistent

Table 3. Reported sex ratios (males per female).

Year	0–9	10–19	20–29	30–39	40–49	50–59	60–69	70–79	80–89	90 and Over
1907	.991	1.274	.889	.977	.989					
1917	.986	1.190	.886	.975	1.007	.997	.875	.979	.764	.778
1927	.986	1.155	.891	.974	1.011	.954	.891	.870	.734	.817
1937	.974	1.154	.919	.986	1.044	1.011	.898	.848	.676	.692
1947	.996	1.069	.913	.952	1.015	.952	.882	.815	.690	.667
1947[1]	1.015	1.089	.930	.970	1.035	.969	.899	.829	.704	.647

[1] Adjusted for over-reporting. (*See* text.)

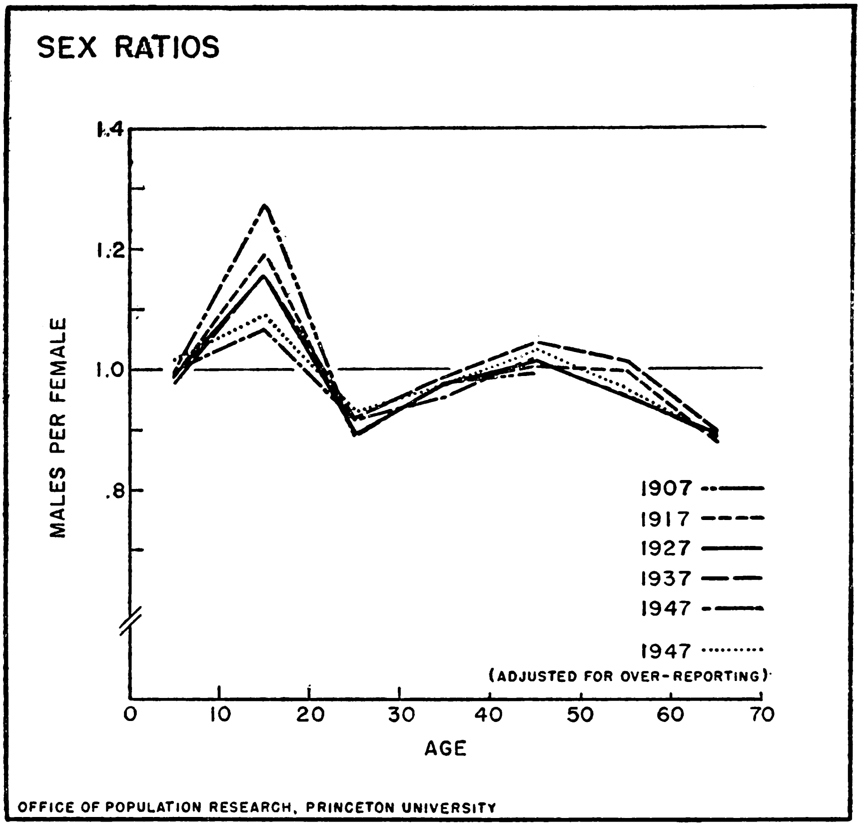


Fig. 3. Reported sex ratios, 1907–1947.

with the corresponding values calculated from the preceding censuses, as can be seen from the last row in Table 3 and from Figure 3. The slightly higher sex ratio in the group 0–9 and lower sex ratio in the group 10–19 in the adjusted census compared to the earlier censuses are due to the fact that the ratios given by the preceding censuses still need correction for erroneous reporting of children aged 10–19 as being in the 0–9 group. The plausibility of the adjusted frequencies is also illustrated by the fact that the cohort survival rates of the various groups from 1937 to 1947 (Table 4) are much nearer to the averages of the corresponding rates in the preceding censuses than the high rates given by the reported 1947 data. This is a direct result of the reduction of the 1947 frequencies.

Table 4. Reported cohort decennial survival rates.

Interval	0–9	10–19	20–29	30–39	40–49	50–59	60–69	70–79	80–89
A. MALES									
1907–1917	.846	.770	1.045	.777	.741				
1917–1927	.872	.781	1.073	.778	.682	.650	.522	.338	.327
1927–1937	.904	.750	1.056	.829	.717	.699	.522	.383	.383
1937–1947	.999	.782	1.107	.861	.723	.708	.482	.313	.196
1937–1947[1]	.952	.745	1.055	.821	.689	.674	.460	.297	.196
B. FEMALES									
1907–1917	.704	1.107	.953	.754	.734				
1917–1927	.745	1.044	.975	.751	.720	.728	.525	.451	.306
1927–1937	.771	.942	.955	.774	.717	.742	.549	.493	.406
1937–1947	.910	.989	1.069	.836	.793	.811	.531	.384	.221
1937–1947[1]	.851	.925	1.000	.782	.742	.758	.498	.358	.206

[1] Adjusted for over-reporting in 1947. (*See* text.)

Naturally the proportional age distribution, upon which most of the following discussion is based, will not be altered by this adjustment. The adjusted 1947 frequencies are shown in the last rows of Tables 1(A) and 1(B).

Correction of Female Frequencies Under 20 Years of Age

The discussion in this article is confined to ten-year age groupings in order to avoid some of the distortions resulting from the digit biases on the part of the respondents. The only available single-year age distribution, that of the 1927 census, reveals not only a concentration on ages ending with zero and five and a preference for even ages, but also outstanding popularity of certain middle ages. In that census the first ten most frequent ages were:

Males: 35, 30, 25, 40, 12, 10, 8, 0, 50, 15
Females: 30, 25, 40, 35, 20, 50, 8, 10, 0, 12

in which the ages of 35, 30, 25, 40 take leading positions and age 8 outnumbers all ages from 0 to 9.

Now the female proportional age distributions [Table 2(B)] show that:

(a). The proportion of females under 20 years of age has been practically constant, ranging unsystematically between 46.4 per cent and 47.0 per cent.

(b). The proportion of the group 0–9 had a consistent downward trend while that of the group 10–19 maintained a consistent upward trend.

(c). These trends are toward reducing the distortion in the age distribution that existed at the mid-value of the group 10–19 from 1907 through 1937 and which has disappeared in 1947, as can be seen from Figure 2(B), in which the line for 1947 is free from the trough which existed at age 15 in the other censuses.

(d). Table 4(B) also shows cohort decennial survival rates[3] which are too low for the group 0–9 and absurdly high rates for the group 10–19, with a consistent upward trend in the rates of the first group accompanied by a consistent downward trend among those of the second group.

[3] The cohort decennial survival rate for the group aged 0–9 in 1907, for example, is defined as the ratio of the group 10–19 in 1917 to the group 0–9 in 1907.

It is not possible to account for these relations in terms of decreasing fertility or increasing mortality, or increasing under-enumeration of children under 10. Therefore, one would be justified in assuming the existence of an increasingly accurate reporting of age from one census to the next, within the first two age groups. In this situation a sensible procedure would be to adopt the 1947 proportions in these groups as the most plausible.

To correct for this systematic improvement the excess in the 0–9 female proportions over that of 1947 will be shifted into the 10–19 group. This will be done for all of the censuses except 1907 which, as we noted above, has an extraordinarily large cohort 0–9. In that case it is perhaps more plausible to allow for the cohort size as follows: (1) A straight line is fitted to the 1937, 1927, and 1917 reported proportions through the 1947 proportion; (2) the 1907 proportion is estimated from this straight line; (3) the excess of this estimated proportion over the 1947 proportion is then shifted into the 10–19 group in 1907. The frequencies and proportions thus obtained will be as given in the first two columns of Tables 5(B) and 6(B).

As can be seen by comparing the first two columns of Tables 4(B) and 8(B), this correction improves the decennial survival rates of the first two age groups by increasing the rates of the 0–9 group and decreasing those of the group 10–19.

The new proportions and frequencies straightened out the trough which existed at age 15 in both the frequency and the percentage curves and also were consistent with the 20–29 points on both curves. We will therefore not endeavor to undertake further correction in the 20–29 female group.

Correction of Male Frequencies in the First Three Age Groups

The situation is more complicated in the case of the males. Here we notice again [Table 2(A) and Figure 2(A)] the existence of a downward trend in the proportions of the group 0–9 similar to that of the females and an upward trend in the group

Table 5. Corrected age distributions (in thousands).

Year	0–9	10–19	20–29	30–39	40–49	50–59	60–69	70–79	80–89	90–99	100 and Over	Total
A. Males												
1907	1,579	1,151	950	740	509	688						5,617
1917	1,694	1,345	1,063	853	575	377	230	139	55	21		6,352
1927	1,882	1,453	1,246	991	664	392	245	120	47	15	3	7,058
1937	2,125	1,643	1,274	1,161	822	476	274	128	46	14	4	7,967
1947	2,387	1,900	1,426	1,223	953	566	321	126	38	11		8,951
B. Females												
1907	1,508	1,112	918	753	519	763						5,573
1917	1,661	1,318	1,043	861	581	382	263	142	72	27		6,350
1927	1,863	1,439	1,234	1,002	672	411	275	138	64	18	4	7,120
1937	2,081	1,626	1,261	1,150	814	472	305	151	68	21	5	7,954
1947	2,343	1,866	1,401	1,226	956	584	357	152	54	17		8,956

Table 6. Corrected proportional age distributions.

YEAR	0–9	10–19	20–29	30–39	40–49	50–59	60–69	70–79	80–89	90–99	100 AND OVER	TOTAL
A. MALES												
1907	2,811	2,049	1,691	1,317	906	1,225						9,999
1917	2,667	2,117	1,673	1,343	905	594	362	219	87	33		10,000
1927	2,667	2,059	1,765	1,404	941	555	347	170	67	21	4	10,000
1937	2,667	2,062	1,599	1,457	1,032	597	344	161	58	18	5	10,000
1947	2,667	2,123	1,593	1,366	1,065	632	359	141	42	13		10,001
B. FEMALES												
1907	2,706	1,995	1,647	1,351	931	1,369						9,999
1917	2,616	2,075	1,643	1,356	915	602	414	224	113	43		10,001
1927	2,616	2,021	1,733	1,407	944	577	386	194	90	25	6	9,999
1937	2,616	2,045	1,585	1,446	1,023	593	383	190	86	26	6	9,999
1947	2,616	2,084	1,564	1,369	1,067	652	399	169	60	19		9,999

10–19 interrupted only by the 1917 proportion which belongs to the above-mentioned large cohort aged 0–9 in 1907. We also notice from Table 3 and Figure 3 that the reported sex ratios (males per thousand females) in the group 0–9 have been practically constant from 1907 to 1947, indicating that the improvement in the age reporting among the females 0–9 was accompanied by a similar improvement among the males. The new sex ratios which result from carrying out the corrections among the females are:

Year	*0–9*	*10–19*	*20–29*
1907	1.103	1.079	.889
1917	1.066	1.068	.886
1927	1.040	1.074	.891
1937	1.026	1.074	.919
1947	1.015	1.089	.930

The downward trend in the 0–9 group is due to the above-indicated downward trend in the proportions of the males 0–9 which has not yet been corrected. If this correction is carried out (by moving the surplus of 1947 into the 10–19 group) the 10–19 sex ratios will increase so much that it will be noticed immediately that there was mis-reporting of those aged 20–29 as being aged 10–19. This erroneous reporting is also reflected by the low survival rates of the 10–19 group and the impossibly high rates of the 20–29 group in Table 4(A).

Therefore there are two necessary corrections in the three age groups under consideration: (a). shifting a proportion of the male population aged 0–9 into the 10–19 group in order to correct for the downward trend in the proportions of the former group, (b). shifting a proportion from the 10–19 group into the 20–29 group to correct for the wrong statement of ages 20–29 as 10–19.

Regarding the first correction, the 1947 proportion will be used again as a basis for correction after modifying it very slightly in order to maintain non-increasing sex ratios in the groups 0–9, 10-19, and 20–29 in 1947. This requires shifting a

YEAR	0–9	10–19	20–29	30–39	40–49	50–59	60–69	70–79	80–89	90 AND OVER
1907	1.047	1.035	1.035	1.035	.983	.981				
1917	1.020	1.020	1.019	1.019	.991	.990	.987	.979	.764	.778
1927	1.011	1.010	1.010	1.010	.989	.988	.954	.870	.734	.817
1937	1.021	1.010	1.010	1.010	1.010	1.010	1.008	.848	.676	.692
1947	1.019	1.018	1.018	1.018	.998	.997	.969	.829	.704	.647

Table 7. Corrected sex ratios.

frequency of 9,000 from the 10–19 group into the 0–9 group. This shift changes the 0–9 proportion to .2667 rather than the reported .2657. As in the case of the females, the excess over this proportion will be shifted from 0–9 into 10–19 for all the censuses except 1907, where it is preferred to allow for the large cohort size by following the same procedure used for the females.

The sex ratios in the groups 0–9 and 10–19 are then recalculated and the corrections in the 10–19 and 20–29 groups are carried out by requiring that, for each census, the sex ratio in the group 20–29 should not be higher than that in the group 10–19. The result of this procedure is to shift certain frequencies from 10–19 into 20–29.

The resulting frequencies, proportions, and sex ratios in the three groups are shown in the first three columns of Tables 5(A), 6(A), and 7 respectively.

One can check on the plausibility of the whole procedure by comparing the new survival rates as given by the first three columns of Table 8(A) with the reported ones [Table 4(A)]. The improvement on the low rates of the 10–19 group and the unreasonably high rates of the 20–29 group is quite obvious.

After carrying out these corrections we have the age distributions given in Tables 5(A) and 6(A) and Figures 4(A) and 5(A). The distributions appear to be reasonably satisfactory, despite the fact that the decennial survival rates of the cohorts 20–29 are still high.

Correction for Under-Estimation of Female Ages 40–59

Going back now to the sex ratios in the groups 30–39, 40–49, and 50-59 in Table 3, we see that these ratios, when compared

Table 8. Corrected decennial survival rates.

Interval	0–9	10–19	20–29	30–39	40–49	50–59	60–69	70–79	80–89
A. MALES									
1907–1917	.852	.924	.898	.777	.741				
1917–1927	.858	.926	.932	.778	.682	.650	.522	.338	.327
1927–1937	.873	.877	.932	.829	.717	.699	.522	.383	.383
1937–1947	.894	.868	.960	.821	.689	.674	.460	.297	.196
B. FEMALES									
1907–1917	.874	.938	.938	.772	.736				
1917–1927	.866	.936	.961	.780	.707	.720	.525	.451	.306
1927–1937	.873	.876	.932	.812	.702	.742	.549	.493	.406
1937–1947	.897	.862	.972	.831	.717	.756	.498	.358	.206

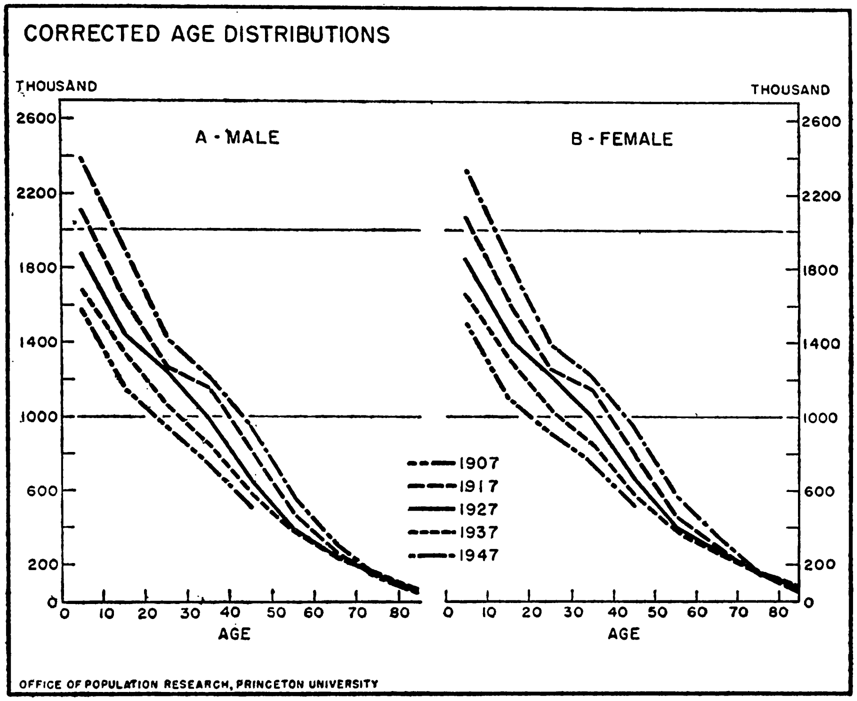


Fig. 4. Corrected age distributions, by sex, 1907–1947.

with those in the group 20–29 as given by column 4 of Table 7, reveal over-reporting of females 30–39 as compared to the males and under-reporting of those in the 40–49 group and, to a smaller extent, in the 50–59 group. This suggests that the trough at age 35 in Figures 1(B) and 2(B) is in fact due to under-estimation of female ages 40–59.

To correct this distortion we are going to satisfy ourselves with the requirement that the sex ratios in the three groups—30–39, 40–49, and 50–59—should not be increasing, and correct the female age distributions accordingly, thus getting the corrected data given in the corresponding columns of Tables 5(B), 6(B), 7, and 8(B) and also in Figures 4(B), 5(B), and 6. Again it should be stated that this correction is incomplete as shown by the fact that the decennial survival rates of the group 20–29 are still high, though more plausible than the reported ones.

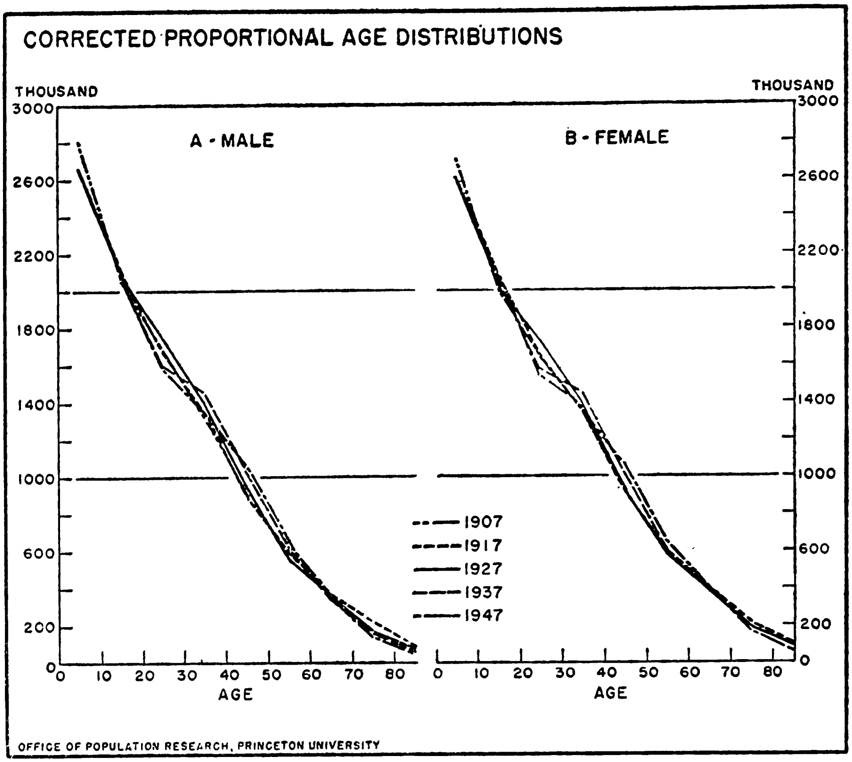


Fig. 5. Corrected proportional age distributions, by sex, 1907–1947.

It is preferred to terminate the corrections at this stage of very essential corrections rather than go further into a more elaborate correction procedure. Regarding the old ages, Table 2 and Figure 2 indicate a systematic improvement over time in the over-estimation of ages 70 and over for both males and females. We can therefore partially correct this over-estimation by adopting the 1947 proportions in the tail of the age distribution starting from age 60. This will be done later when we construct a model age distribution for the interval 1907–1947.

Life Tables for Egypt

Attempts to construct life tables for Egypt started in 1936 when El-Shanawany, (1), constructed the "First National Life Tables for Egypt" for the period 1917–1927. Confronted

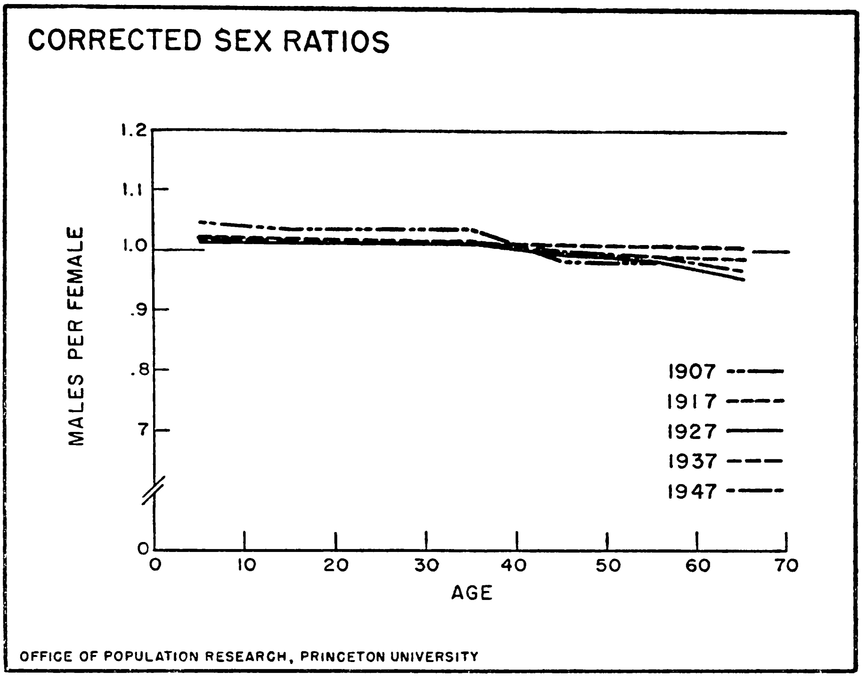


Fig. 6. Corrected sex ratios, 1907–1947.

with unreliable death registration and age reporting at death, El-Shanawany used the method of comparing the age distributions at two censuses, of which the underlying theory is that if P_x^t is the population aged x at time t and if, after an interval of length a, P_{x+a}^{t+a} is the population aged x + a then, in the absence of migration and assuming that P_x^t and P_{x+a}^{t+a} are accurate or subject to the same degree of error, P_{x+a}^{t+a} would be the survivors of P_x^t after the interval t and, consequently, ${}_ap_x$ the probability of surviving a years for an individual aged x would simply be the quotient $\frac{P_{x+a}^{t+a}}{P_x^{t+a}}$. The method has also been applied for the construction of Indian life tables, (4). The application of this method is generally preceded by a process of smoothing the age distributions at the two censuses under consideration because the age distributions under the circumstances where the method is applicable are usually distorted by erroneous age reporting and probably by under-enumeration.

El-Shanawany used the Pearson Type IX curve to smooth the data. Pearson Types IX and I have been applied to Indian census age distributions.

Another life table for Egypt was constructed by Kiser, (2), for the period 1927–1937. His procedure was similar to El-Shanawany's with the addition of some correction for under-enumeration of children under 5 and redistribution of the population in the other age groups in order to reduce some of the more prominent irregularities. The latter amendment consisted chiefly in systematically consigning given proportions of persons reporting ages divisible by five to the preceding five-year group. The single-year proportions within every age group of the 1927 census were applied to the 1937 age groupings.

A different line was followed by Abdel Rahman, (3), in constructing the 1936–1938 life tables for Egypt. He applied the mathematically rigorous method of comparing deaths in an age group with the population in that group. He followed mainly King's method which is used in constructing British life tables.

The application of the census differencing method is subject to the drawback that, since the smoothing is done by curve fitting which supplies the "best" possible fit to the distorted census data, the smooth curves may not maintain adequate representation of the correct age distributions, thus giving rise to errors in ${}_ap_x$ resulting from the estimation errors in P_x^t and P_{x+a}^{t+a} and becoming more serious when the latter errors are in opposite directions. This is reflected in the fact that in the two attempts (1) and (2) the differences between the estimated P_x^t and P_{x+a}^{t+a} were too small in the ages below 10 to give rise to reasonable values of p_x, thus obliging the two writers to discard these estimates of p_x. El-Shanawany, (1), started his life table at age 10 and Kiser, (2), reconstructed ${}_1q_0$, ${}_4q_1$, ${}_5q_5$ from the age-specific mortality rates in the health bureau areas.

The mathematically rigorous method applied in (3), used with various modifications in all countries that have reliable mortality data, has the drawbacks—when applied to Egypt—

of relying heavily on the frequencies and age distributions of deaths and also on a mathematically smoothed census age distribution. The death reporting in the country is far from adequate and varies according to whether or not the areas have health bureaus and also according to the distance between an area and the bureau to which it belongs. To mention an example, the following table is quoted from a report, (5), on a health survey undertaken in a rural area 30 kilometers north of Cairo, comprising a number of villages which are essentially the same in physical and environmental characteristics. The third column in the table gives the crude death rates in the villages in 1948 as calculated from the records of the health bureau and the fourth column gives the death rates in 1951 as calculated from the returns of the survey. The deficiency of the former rates and the dependence of this deficiency on the distance from the bureau are obvious.

Village	Distance from Health Bureau in Kilometers	Crude Death Rates per 1,000	
		1948	1951
Sindbis	0	32	38
Quaranfil	2	19	33
Barada	2	23	28
Aghour El-Sughra	6	12	29

These deficiencies in the death rates would certainly inflate the p_x's and the life expectation in the life table.

The validity of the results of this method also depends upon the accuracy of the age reporting of the deceased which has the same sources of distortion as the census age distribution.

Apart from the above drawbacks inherent in the two methods that have been applied in life table construction for Egypt, the methods have the disadvantage of being techniques which are too elaborate in view of the accuracy of the utilized data. Having in mind that the results of such procedures can at best be approximate when applied to distorted and deficient data, it seems more appropriate to look for a method which is admittedly approximate but at the same time has a simple procedure that suits the quality of the available data. This is the aim of the following attempt which is based upon the approximate stability of the age distributions.

A Life Table Based on the Notion of Stable Population

As pointed out by Lotka (6), if mortality and fertility in a closed population remain unchanged then the age distribution of the population will eventually reach a stable stage, called the stable age distribution, regardless of the initial age distribution and the initial mortality and fertility rates. The proportion of the population aged x will be

$$c\ (x) = b\ e^{-rx} \frac{l_x}{l_0}, \qquad (1)$$

where b is the birth rate of the eventual stable population, r is the rate of increase of that population, l_x the number of individuals surviving to age x out of a cohort l_0 individuals starting life and going through the mortality experience of the population. In other words, $\frac{l_x}{l_0}$ is the probability that an individual will attain the age x. If the stable age distribution and the rate of increase r are known, then (1) gives the relationship

$$\frac{l_{x_2}}{l_{x_1}} = \frac{c\ (x_2)\ e^{rx_2}}{c\ (x_1)\ e^{rx_1}}, \qquad (2)$$

which enables us to calculate the survivors l_x at any age x. Once the l's are available, we can calculate the probabilities of surviving a year for an individual aged x from the relation

$$_ap_x = \frac{l_{x+a}}{l_x}, \qquad (3)$$

and consequently construct the whole life table.

Now since the mortality and fertility conditions in Egypt in the period 1907–1947 remained practically unchanged and since the age distributions during that period were quite similar, and having in mind that the population was virtually "closed," we can assume that the age distribution in that period was practically stable and thus use the relationship (2) to construct a life table representing the mortality conditions in Egypt in the same period.[4]

The calculation process will consist of the following steps:

(1). Calculating the stable age distribution. This will be done here by averaging the proportion age distributions which we assume to be approximately stable.

(2). Estimating the proportions c (x) of the population at any desired pivotal points either by simple methods like taking one-tenth of the proportion in a decennial age to represent the proportion at the middle of that group, or taking the average of two adjacent groups as an estimate of the proportion at their mid-point, or by a more refined method of interpolation.

(3). Evaluating the rate of increase r from the populations under consideration. The rates which will be applied here are those calculated for the period 1907–1937 by applying the Malthusian population formula

$$N_t = N_o e^{rt} \qquad (4)$$

which gives rates of increase equal to .01165 for males and .01186 for females.

(4). To get the l_x column of the life table, the exponential e^{rx} is then calculated at the pivotal points and multiplied by the estimated c (x) to give $l'_x = \frac{b}{l_o} l_x$ at the same points. l'_x at any other desired points can then be calculated by interpolation.

(5). Once we have l'_x we can calculate ${}_a p_x$ from the formula

$${}_a p_x = \frac{l'_{x+a}}{l'_x} \qquad (5)$$

and consequently fill in the ${}_a p_x$ and ${}_a q_x$ columns of the life table.

[4] Lotka mentions on pages 20–22 of his book, (6), three cases where the life table l_x's were multiplied by e^{-rx} and then used to calculate an age distribution which was then compared with the actual age distribution. The procedure followed here is the converse, namely to start with an age distribution and then multiply the proportions by e^{rx} in order to get a life table.

(6). ${}_aL'_x = \frac{b}{l_0}\,{}_aL_x = \frac{b}{l_0}\int_x^{x+a} l_x\, d_x$, which is proportional to the stationary life table population aged x to x + a is obtained from the l'_x values either by simple averaging or by simple or refined numerical integration. $T'_x = \frac{b}{l_0} T_x = \frac{b}{l_0}\int_x^{\infty} l_x\, dx$, which is proportional to the number of years of life remaining to survivors at age x, can be calculated by summing ${}_aL'_x$ or by numerical integration of l_x.

(7). Finally, the life expectation at age x, $\mathring{e}_x = \frac{T_x}{l_x}$, will result from dividing T'_x by l'_x.

It is obvious that this method can be applied to countries and time intervals only if the assumption of an approximately stable population is justified. This situation is likely to arise in underveloped areas where the high mortality and fertility have not yet started to decrease and where the population does not suffer considerably from epidemics, wars, migration, or other disrupting factors.

The simplicity of the method is also very clear. This is an essential requisite of a method applied to data whose distortions and deficiencies do not justify the application of more theoretically refined methods and heavy calculations. As a matter of fact, given two census age distributions or one census and the growth rate, and even without attempting to correct the distortions in the age distributions, we can very quickly calculate the l_x's and the life expectations at the x's where the age distribution does not appear to be distorted. Going back to the reported census data of Egypt for the decennial age intervals 1907–1947 (Table 2) and calculating the average proportional age distribution without any corrections for over-enumeration in 1947, taking these averages as proportional to c (x) at the mid-values of the decennial intervals, giving r the approximate value of .012 for both males and females and taking ${}_{10}L_x = 5\,(l_x + l_{x+10})$, we get the following rough estimates for l_x's and $\mathring{e}_x$'s at ages 5, 35, 45, and 55:

Age	Males		Females	
	l_x	$\mathring{e}_x$	l_x	$\mathring{e}_x$
5	10,000	42.4	10,000	42.4
35	7,138	25.3	7,242	25.8
45	5,667	20.6	5,512	22.4
55	3,918	17.5	3,943	19.3

which, in spite of the crude and rapid method followed in their estimation, do not differ considerably from those obtained by more elaborate techniques, as can be seen by comparing them with their corresponding values in Figures 7 and 8.

To calculate a complete life table it is necessary, however, to correct the reported age distributions. The corrected age distributions in Table 6 are found adequate, despite the fact that the proportions in the 30–39 group are still high. When calculating the average proportional age distribution it was preferred to use the tail of the 1947 distribution from age 60 upward as the tail of the average distribution in order to utilize what is apparently a systematic improvement in the overestimation of old ages from one census to the next, as indicated before. The average proportional age distributions are as follows:[5]

Age Group	Male	Female
0–9	2,713	2,653
10–19	2,095	2,059
20–29	1,674	1,646
30–39	1,385	1,396
40–49	976	983
50–59	599	611
60–69	361	402
70–79	142	170
80–89	42	60
90–99	10.5	15.3
100 & Over	2.5	3.7
Total	10,000	9,999

[5] In this table the 1947 proportion 90 and over was split between two groups 90–99 and 100 and over according to the average of the ratios between the 90–99 and 100 and over groups in 1927 and 1937.

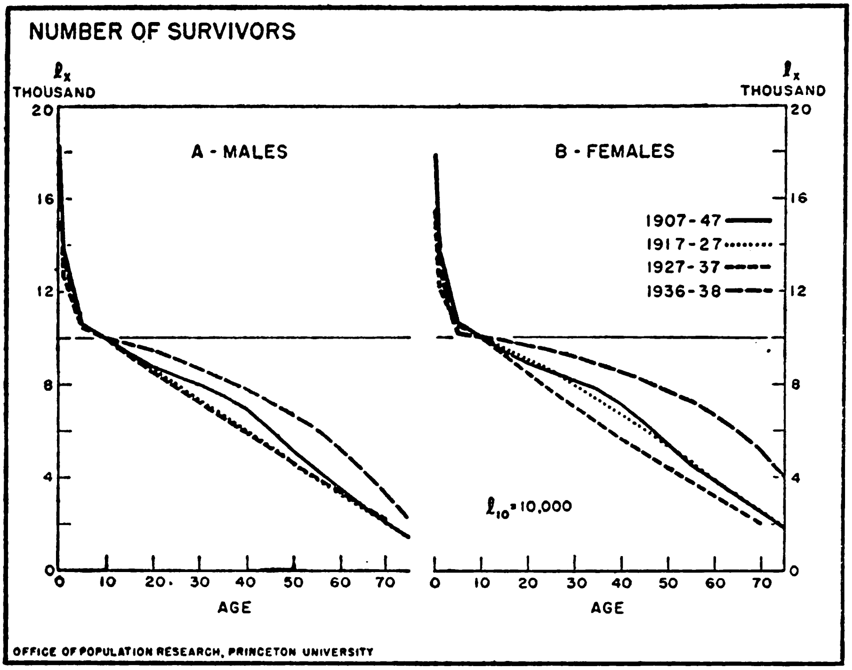


Fig. 7. Survivorship (l_x) values ($l_{10} = 10{,}000$) as given by life tables for Egypt, by sex, selected dates.

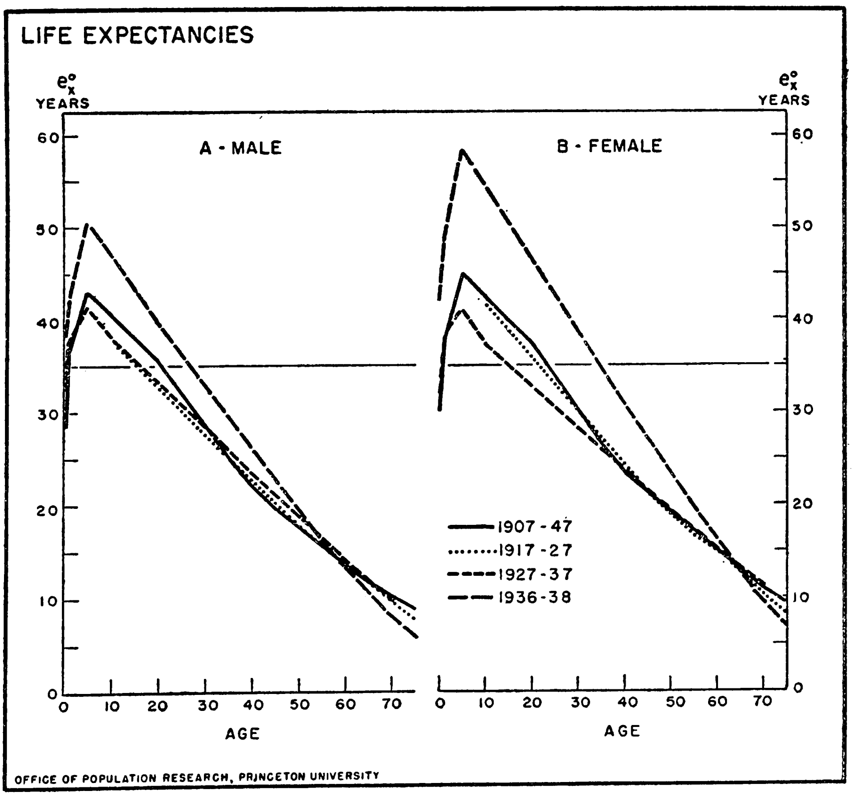
In the calculation of the proportions at the pivotal ages it was preferred, in order to get rid of the inflation in the group 30–39 and at the same time avoid further correction of the data, to estimate the proportion of the population at ages ending with zero by averaging the proportions in the two adjacent age groups. While this method smoothed out the inflation at the mid-value of the 30–39 group, it proved to be as accurate as concentrating the whole proportion in one decennial age group at the mid-value of that group because the l_x curve resulting from the former method was found to be practically identical with that given by the latter method at all ages ending with zero for both males and females. To extend the life table to age 5, one-tenth of the proportion in the first age group (0–9) was taken as an estimate of the proportion at age 5.

The resulting l'_5, l'_{10}, l'_{20}, . . . are transformed into l_5, l_{10}, l_{20}, . . . by taking $l_5 = 10{,}000$ and calculating l_{10}, l_{20}, . . . accordingly. The calculations are as follows:

Pivotal Age x	Males				Females			
	c (x)	$e^{.01165x}$	l'_x	l_x	c (x)	$e^{.01186x}$	l'_x	l_x
5	271.3	1.0599	287.6	10,000	265.3	1.0611	281.5	10,000
10	240.4	1.1236	270.1	9,392	235.6	1.1259	265.3	9,425
20	188.5	1.2624	238.0	8,275	185.3	1.2677	234.9	8,345
30	153.0	1.4184	217.0	7,545	152.1	1.4273	217.1	7,712
40	118.1	1.5936	188.2	6,544	119.0	1.6070	191.2	6,792
50	78.8	1.7905	141.1	4,906	79.7	1.8094	144.2	5,123
60	48.0	2.0117	96.6	3,359	50.7	2.0372	103.3	3,670
70	25.2	2.2603	57.0	1,982	28.6	2.2938	65.6	2,330
80	9.2	2.5396	23.4	814	11.5	2.5826	29.7	1,055
90	2.63	2.8534	7.5	261	3.77	2.9078	11.0	391
100	.65	3.2059	2.1	73	.95	3.2740	3.1	110

From the l_x's we get the ${}_ap_x$'s by consecutive divisions, and hence the ${}_aq_x$'s. T_x for ages between 10 and 70 is then calculated by the approximate Reed-Merrell formula (quoted from (7)).

Fig. 8. Life expectancies as given by life tables for Egypt, by sex, selected dates.



x	Males			Females		
	l_x	$_a p_x$	$\mathring{e}_x$	l_x	$_a p_x$	$\mathring{e}_x$
5	10,000	.9392	43.2	10,000	.9425	45.0
10	9,392	.8811	40.8	9,425	.8854	42.6
20	8,275	.9118	35.7	8,345	.9241	37.5
30	7,545	.8673	28.7	7,712	.8807	30.1
40	6,544	.7497	22.2	6,792	.7543	23.5
50	4,906	.6847	18.0	5,123	.7164	19.5
60	3,359	.5901	14.0	3,670	.6349	15.3
70	1,982	.4107	10.3	2,330	.4528	11.2
80	814	.3206	7.9	1,055	.3706	8.6
90	261	.2797	5.2	391	.2813	5.6
100	73			110		

Table 9. Abridged life table for Egypt, 1907–1947.

$$T_x = 4.1667\ l_x + .8333\ l_{x+10} + 10 \sum_{a=1}^{\infty} l_{x+10a} \qquad (6)$$

For ages 80 and 90, T_x is taken to be equal to the area under the second degree parabola through l_{80}, l_{90}, and l_{100} between these ages and 100. We thus find that

$$T_{80} = \frac{10}{3}\,(l_{80} + 4\ l_{90} + l_{100}) \qquad (7)$$

and

$$T_{90} = \frac{5}{6}\,(-\,l_{80} + 8\ l_{90} + 5\ l_{100}) \qquad (8)$$

To get $_5T_x$ we calculate $_5L_5$ and add it to $_{10}T_x$. Since the errors in calculating the area under the l_x curve between ages 5 and 10 would have a negligible effect on $\mathring{e}_5$, the simple estimate $_5L_5 = \frac{5}{2}\ (l_5 + l_{10})$ seems to be quite satisfactory (an estimate equal to the area under the parabola through the l_5, l_{10}, and l_{20} points, between ages 5 and 10, which will be given by $_5L_5 = \frac{1}{36}\ (16\ l_5 + 21\ l_{10} - l_{15})$ gave an almost identical result).

The resulting life table is given in Table 9.

Constructing a Complete Life Table

(*a*). *Life Table Values at Quinquennial Ages.* A life table with five-year age intervals can be readily calculated from the l_x column of Table 9 by interpolating for the l_x's at ages ending with 5. The interpolation is carried out for all ages from 25 through 85 by fitting a second degree moving parabola to four decennial l_x's, two on each side of the required age.[6] The interpolation formula will be:

$$l_{i+5} = \frac{9}{16}(l_i + l_{i+10}) - \frac{1}{16}(l_{i-10} + l_{i+20}) \qquad (9)$$

where i = 20, 30, . . . 80.

To get l_{15} a second degree parabola is fitted to l_5, l_{10}, l_{20}, and l_{25}. This curve gives

$$l_{15} = \frac{2}{3}(l_{10} + l_{20}) - \frac{1}{6}(l_5 + l_{25}) \qquad (10)$$

l_{95} is then obtained by fitting a second degree parabola to the logarithms of l_{70}, l_{80}, l_{90}, and l_{100} which leads to the formula

$$\log\ l_{95} = -\frac{9}{80}\log\ l_{70} + \frac{17}{80}\log\ l_{80} + \frac{33}{80}\log\ l_{90} + \frac{39}{80}\log\ l_{100} \qquad (11)$$

Having obtained the quinquennial l_x's, T_x can be calculated for all quinquennial ages from 10 to 90 by means of the Reed-Merrell formula which we quote from (7),

$$T_x = -.20833\ l_{x-5} + 2.5\ l_x + .20833\ l_{x+5} + 5 \sum_{\alpha=1}^{\infty} l_{x+5\alpha}, \qquad (12)$$

and T_{90} and T_{95} are obtained, as before, by fitting a second degree parabola to l_{90}, l_{95} and l_{100} in which case formulas 7 and 8 become

$$T_{90} = \frac{5}{3}(l_{90} + 4\ l_{95} + l_{100}) \qquad (13)$$

and

$$T_{95} = \frac{5}{12}(-l_{90} + 8\ l_{95} + 5\ l_{100}) \qquad (14)$$

(*b*). *Life Table Values at Ages Zero and One.* To extend the life table backward to ages one and zero it is not possible to follow the procedure which has been adopted so far, namely

[6] The results will in fact be identical with those obtained from a perfectly fitting curve because a third degree curve would still give the interpolation formula (9).

calculating c(x) and l'_x and from this p_x and $\mathring{e}_x$, because the proportions of children in the first five years of life cannot be calculated accurately from the census data. Kiser, (2), handled this point by calculating $_1q_0$, $_4q_1$, and $_5q_5$ from the vital statistics of the health bureau areas. In Indian life tables, as pointed out in (4), l_x values are projected for ages below 5 by fitting the curve $l_x = A + H x + B C^x + \frac{m}{nx+1}$.

Owing to the distortions and inadequacies in the data that have to be used for calculating $_1q_0$, $_4q_1$, it was preferred here to estimate upper and lower limits for these two values. No claim can be made, however, that the following estimates stand far above the level of "reasonable guessing."

In 1946 the infant mortality rates per live birth calculated from vital statistics were .1906 for males and .1834 for females. These rates can be used as minima for $_1q_0$ because the under-reporting of infant deaths is heavier than that of births, as indicated by Weir, (5). According to Table 32 of Weir's report, the reported infant rates are deficient by about 26 per cent. If we consider this as a maximum rate of deficiency, since Weir's survey area was utterly rural, we get as maximum values of $_1q_0$: .2402 for males and .2311 for females.

To estimate limits for $_4q_1$ we had to calculate first $_4m_1$ by dividing the deaths 1–4 obtained from the vital statistics of 1946 by estimates of the population 1–4 in the middle of the same year. This procedure gave $_4m_1$ equal to .0641 for males and .0607 for females, which we adopt as lower limits owing to the deficiencies in death reporting. To calculate an upper limit of $_4m_1$ it is necessary to estimate the degree of under-reporting of deaths in these ages. We have to be satisfied here with an estimate calculated from crude death rates given in Table 32 of Weir's report and belonging to dates before and after his survey. This estimated degree of deficiency amounts to 30 per cent. We then inflate the above $_4m_1$ by this percentage to get an upper limit of $_4m_1$ which will be .0833 for males and .0789 for females. Finally the Reed-Merrell equation

$$_4q_1 = 1 - \exp\{-4\ _4m_1\ (.9806 - 2.079\ _4m_1)\} \qquad (15)$$

was used to get the following estimates of $_4q_1$

lower limits: .1952 for males and .1873 for females

upper limits: .2359 for males and .2272 for females

The life table is then completed by calculating the limits of l_0 and l_1 which would end in $l_5 = 10{,}000$ after going through the mortality experience expressed by the above limits of $_1q_0$ and $_4q_1$. The limits of l_0 and l_1 will be:

	Males		*Females*	
	Upper Limit	*Lower Limit*	*Upper Limit*	*Lower Limit*
l_0	17,224	15,351	16,829	15,069
l_1	13,087	12,425	12,940	12,305

Table 10. Life table for Egypt, 1907–1947, by quinquennial age intervals.

x	MALES			FEMALES		
	l_x	$_5p_x$	$\mathring{e}_x$	l_x	$_5p_x$	$\mathring{e}_x$
0	(17,224)	(.8094)	(31.8)	(16,829)	(.8166)	(33.6)
	(15,351)	(.7598)	(28.5)	(15,069)	(.7689)	(30.2)
1	(13,087)	(.8048)	(38.2)	(12,940)	(.8127)	(40.0)
	(12,425)	(.7641)	(36.4)	(12,305)	(.7728)	(38.1)
5	10,000	.9392	43.2	10,000	.9425	45.0
10	9,392	.9366	40.8	9,425	.9384	42.6
15	8,797	.9407	38.4	8,844	.9436	40.2
20	8,275	.9550	35.7	8,345	.9608	37.5
25	7,903	.9547	32.3	8,018	.9618	33.9
30	7,545	.9412	28.7	7,712	.9488	30.1
35	7,101	.9216	25.3	7,317	.9282	26.6
40	6,544	.8800	22.2	6,792	.8821	23.5
45	5,759	.8519	19.9	5,991	.8551	21.3
50	4,906	.8390	17.9	5,123	.8540	19.5
55	4,116	.8161	15.9	4,375	.8389	17.4
60	3,359	.7880	13.9	3,670	.8144	15.2
65	2,647	.7488	12.0	2,989	.7795	13.1
70	1,982	.6796	10.2	2,330	.7082	11.1
75	1,347	.6043	8.9	1,650	.6394	9.7
80	814	.5848	8.1	1,055	.6265	8.8
85	476	.5483	7.3	661	.5915	
90	261	.5441	5.8	391	.5448	5.8
95	142	.5141	3.6	213	.5164	3.6
100	73			110		

from these values upper and lower limits of L_0 and ${}_4L_1$ (and consequently T_1 and T_0) are calculated by using the Reed-Merrel equations

$$L_0 = .276\, l_0 + .724\, l_1 \tag{16}$$

and

$${}_4L_1 = .034\, l_0 + 1.184\, l_1 + 2.782\, l_5 \tag{17}$$

The complete life tables are given in Table 10.

Comments on the Life Table

The main advantage of the procedure which has been applied to calculate the life table values between ages 5 and 100 is its simplicity. A simple technique was utilized to correct the age distributions from the obvious distortions instead of the elaborate techniques of mathematical smoothing which are hard to justify in situations where systematic errors prevail. Once these obvious distortions are corrected, the proportions of the population at pivotal ages are calculated by simple methods and then multiplied by e^{-rx} to give l_x, from which the rest of the life table values will follow.

Nevertheless, a comparison between the l_x and the $\mathring{e}_x$ values of the above tables and the available Egyptian life tables, which are given in Figures 7 and 8, shows clearly that the results of the method we have followed here are similar to those of the census differencing life tables of 1917–1927 and 1927–1937. We naturally have no way of telling which of the life tables is nearer to reality, but the results do establish the fact that the above simple procedure leads to a life table which is not less accurate than those given by the more elaborate methods, thus satisfying the purpose of this work.

The new life table gave reasonable results when it was compared with those of some high mortality populations. Comparison with Mexico in 1930, (8), for example, where the crude death rate was 25.6, showed that the maximum difference between the corresponding life expectancies was about two years between ages 0 and 65, except at ages 5 and 10 where the differences were less than four years. The life expectancies in Mexico were higher up to age 50. Similarly it was found that the life expectancies of Egyptian males were higher than those of Indian males in 1941–1950, (4), by two years up to age 50, except at ages 0 and 1 where the Indian values were higher than the Egyptian maxima by less than one year. In the case of the females the Indian $\mathring{e}_0$ was about half way between the corresponding Egyptian limits and $\mathring{e}_1$ was less than one year below the corresponding Egyptian lower limit. In the rest of the table the Egyptian expectations were higher than the corresponding Indian values by between 3 and 4.5 years. It must be stated that the purpose of these comparisons is not to prove the validity of the new life table of Egypt but rather to demonstrate that this table falls, when compared with those of other countries, in a position which would be expected on the basis of the mortality situation.

As stated before, the life table values at ages 0, 1 can only be taken as approximations. This is why we thought it was perhaps more plausible to estimate lower and upper limits to those values.

The life table is far from perfect. It will be noted, for example, that the values of $_5p_x$ between ages 20 and 30 are high. This is a direct result of the inflation in c (30) caused by averaging the group 20–29 and the over-reported group 30–39 which was not completely corrected in the above correction procedure. In this respect we iterate that our purpose is not to calculate a perfect life table but rather to achieve the maximum possible accuracy on the basis of evidence obtained from the data without resorting to mathematical refinements.

It is also evident that the life table values given in Tables 9 and 10 are high for old ages. This inflation exists in life tables in general and results from over-estimation of old ages. It is dealt with sometimes by replacing the calculated values by extrapolated corresponding values (usually by means of a Gompertz curve). Needless to say, life table values for old ages are hardly trustworthy.

The life tables are taken to represent mortality at any time in the period 1907–1947 because of the above-discussed stability of mortality conditions in the country throughout this period. It is possible, if one so desires, to construct a life table based on one census, 1947 for example, and the rates of growth. The resulting life table would not show any real differences from the values given here, except in so far as the difference between the average age distribution that has been used in the above calculations and the desired census age distribution can give rise to. A life table based on the 1947 age distribution was calculated and, as expected, the life expectancies did not differ from those in Table 10 by more than one year. The resulting life expectancies at age 5, for example, were 44.1 for males and 45.9 for females as compared to 43.2 and 45.0 in Table 10.

Birth and Death Rates

The fact that the age distribution of Egypt is approximately stable can be utilized also to calculate the birth and death rates from the l_x column of the life table. This can be seen at once from equation (1), which gives by integration:

$$b = \frac{l_0}{\int_0^{\infty} e^{-rx} \, l_x \, dx}, \qquad (18)$$

where the denominator is the area under the $e^{-rx}\, l_x$ curve, whose ordinates at the ages x given in Table 10 are obtained by multiplying the l_x column by e^{-rx}. The area under the curve is then calculated by simple numerical integration. Once we know the birth rates, the death rates will follow directly from the relation $r = b - d$. In the present case one will naturally get maximum and minimum values of the birth rates by using the maximum and the minimum values of l_0, l_1. The results of the calculations were as follows:

	Maximum	*Minimum*
Birth rate of males (male births per 1,000 males) =	48.1	43.1
Birth rate of females (female births per 1,000 females) =	46.1	41.5
General birth rate (births per 1,000 population) =	47.1	42.3

The general birth rate is a weighted average of the male and female birth rates, the weights being the proportions of males and females in the total of the five censuses 1907–1947.

The maximum and minimum values of the death rates will be obtained by subtracting the rates of natural increase, namely $r = 11.7$ for the males and $r = 11.9$ for the females. The results will be:

	Maximum	*Minimum*
Death rate of males (male deaths per 1,000 males) =	36.4	31.4
Death rate of females (female deaths per 1,000 females) =	34.2	29.6
General death rate (deaths per 1,000 population) =	35.3	30.5

The general death rate was calculated in the same way as the general birth rate.

It is interesting to notice that the average reported birth rate in the period 1917–1946 is equal to 42.4, which is almost exactly equal to the above minimum value of 42.3, while the average reported death rate is lower than the calculated minimum by 3.5 per thousand. One could say, therefore, that on the basis of the evidence secured from the reported age distributions and from the above maximum and minimum values the deficiency in birth reporting can be up to 11 per cent while the deficiency in death reporting is between 13 and 31 per cent. One must note, however, that these limits are affected to some extent by the limits we have used before for the infant mortality rate and the death rate in the age group 1–4.

The Net Reproduction Rate and the Mean Length of a Generation

The stability of the age distribution enables us to calculate some measures of the combined effect of mortality and fertility. A first approximation to the net reproduction rate, for example, can be calculated from the approximate relation:

$$b = l_0 \frac{R_0}{L_0}$$

where R_0 is the net reproduction rate and L_0 is the area under the l_x curve of the females and b is the birth rate of the females. This relation gives $R_0 = 1.4$. A thousand women passing through the child-bearing ages are therefore replacing themselves by about 1,400 baby girls. This is equivalent to a 40 per cent increase per generation.

The mean length of a generation, which is the interval during which there has been a relative increase in the female population equal to the ratio between the female births of the two generations, can also be calculated by means of the relation

$$T = \frac{1}{r} \log R_0$$

which gives a mean length of a generation equal to 28.4 years.

Conclusion

The main motive behind this work was to look for simple methods approximating the essentials of the demographic position from data whose distortions and deficiencies do not justify the use of elaborate and detailed techniques.

The approximate stability of the age distribution furnished a useful foundation upon which the whole technique which dealt with various demographic characteristics was based. It was possible by comparing the reported age distributions to spot the obvious distortions and correct them to a reasonable extent without resorting to the more elaborate and probably unjustified methods of curve fitting. It was also possible to utilize the characteristics of a stable age distribution in constructing a life table representing mortality to a reasonable degree of accuracy by means of a simple, quick procedure. In addition, estimates of the crude birth and death rates were readily obtained.

It was even possible to estimate the mean length of a generation and a measure of replacement, namely the net reproduction rate, without using age-specific fertility.

Although the study was confined to Egypt, the technique should be applicable to populations where a stage of approximately stable fertility, mortality, and migration conditions exists. In the developed countries this stability can only be a past experience which has already been studied and the above methods will only be useful as a simple, rapid technique for obtaining demographic measurements. The main usefulness of the method, however, will be in the underdeveloped areas that have sufficiently stable demographic conditions. There it is hoped that this method will furnish the main demographic measurements with some approximation necessitated by the nature of the available data.

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