臺灣居民生命表

（第二回）

LIFE TABLES OF TAIWAN

(SECOND ISSUE)

1936—1940

臺灣省政府統計處出版

中華民國三十六年六月

DEPARTMENT OF STATISTICS

PROVINCIAL GOVERNMENT OF TAIWAN

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序

生命表係以人口統計數字爲基礎，應用機率論原理，將有關生命之各種函數，如死亡率，生存率，生存數，死亡數，死力，平均餘命等，以種種統計數學公式計算所得之函數表冊。

生命表不僅能使吾人洞悉某地居民壽命之長短，保健狀況之良否，並可爲計算或訂立養老金，撫恤金，年金等制度，或人壽保險事業以及其他裁判上決定生命損害賠償問題之依據。至於爲社會衛生設施之檢討，暨有關學術之研究，亦有其特殊之價值。故生命表之應用範圍極爲廣泛，而於人口統計學中則爲一重要而湛深之部門。

歐美諸國，此項研究，以一六九三年英國天文學者 Halley 氏爲最早，所著 Breslan Table of Mortality 可謂爲生命表之嚆矢。此書問世後，多數學者卽從事於此項研究。時至今日，文明國家，皆有此項生命表之編製。

嘗考各國人壽保險事業得有堅固基礎，且有今日之隆盛者，端賴基礎科學之保險數學特別發達，而爲保險數學之根基者，則非編製生命表不爲功。抑有進者，人壽保險事業之發達與否，足以覘其國之强弱。蓋其功效，不僅能使個個國民之危險負擔，分散於全體人民，且可使各個人之損害，能獲社會普遍之救濟。更推而廣之，國家可運用此項保險事業之低利資金，經營各種建設事業，其有補於財政經濟者當非淺鮮。東西各國競競從事於生命表之研究與編製者，要亦不外促保險事業之健全耳。

臺灣於日本統治時期，曾以民國十五年至民國十九年間之人口統計數字，編成「臺灣住民之生命表（第一回）」，於民國二十五年公佈于世。客歲臺省慶告光復，植泉奉命接收前總督府統計課，得見該書原稿，知爲臺胞前任該課屬官林君開煥所作。內容固富有參考價值，惟因資料係用十餘年前統計，稍嫌陳舊。爰經請准聘請林君任本室專員職務，計劃編製第二回臺灣居民生命表，先由林專員從事補整式之研究，藉以糾正以往所用公式之缺陷。

本表于去年十二月間開始編製，根據民國二十五年至二十九年有關本省人口之最新統計，集二十餘人年餘之辛勤工作，始告完成。玆篇所載，不僅爲本省同胞之各種生命函數，且爲唯一研究我漢民族生命之參考資料。現爲便於國際觀摩，表中加用英文附註，兼供外人參考。尙祈社會賢達，不吝敎政。

臺灣省行政長官公署統計室主任李植泉謹識

民國三十五年十二月一日

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PRELIMINARY NOTES

I. This life table represents various aspects of life of the inhabitants of the Taiwan Province, for the computation of which, the life functions (i. e. rate of mortality q_x, rate of living p_x, number living l_x, number dying d_x, force of mortality μ_x and complete expectation of life $\mathring{e}_x$) were individually taken up. It should, therefore, be called a national life table.

So far as the life table of inhabitants of Taiwan was concerned, the Japanese Government of Taiwan had made it public for the first time in 1936. The Japanese had then taken all the data of population statistics during the five years from 1926 to 1930 as the compiling bases. In 1936 when the Japanese-made life table was published, the necessary materials to make the second compilation of the same for another five years from 1931 to 1935 were fully arranged, but the aggressive wars started by the Japanese themselves against our country in 1937 and the United Nations in 1941 respectively had restrained them from the work of compilation.

Since the restoration of Taiwan, the Provincial Government has begun in December, 1945 to compile a new life table of the inhabitants of Taiwan for the five-year period from 1936 to 1940 in order to show the recent vital movements. This life table is the result of our efforts during the past twelve months.

II. The materials from which this life table is made are as follows:

(1) The population classified by age obtained from the Census of October 1, 1935 and the Census of October 1, 1940.

(2) The number of births and deaths obtained for the five-year period from 1936 to 1940.

As mentioned above, these censuses were taken on October 1, while the vital statistics were made by the end of each year. In order to make up the discrepancy, the difference in time caused by the dates of observation has been adjusted by the method of Alfred C. Waters. That is, the data from Census of October 1, 1935 and of October 1, 1940 have been converted into the population estimate for the beginning of 1936 and 1941. The formulas used are as follows:

$$p_{\frac{1}{4}} = p_0 + \frac{r^{\frac{1}{4}} - 1}{r^5 - 1}(p_5 - p_0)$$

$$= p_0 + M_0(p_5 - p_0),$$

$$p_{5\frac{1}{4}} = p_5 + \frac{r^5(r^{\frac{1}{4}} - 1)}{r^5 - 1}(p_5 - p_0)$$

$$= p_5 + M_1(p_5 - p_0).$$

Then we have the following formulas:

$$p_{\frac{1}{4}} = p_0 + 0.047136462\,(p_5 - p_0),$$

$$p_{5\frac{1}{4}} = p_5 + 0.053298496\,(p_5 - p_0).$$

(NOTES)

p_0 Population classified by years of age, October 1, 1935.

p_5 Population classified by years of age, October 1, 1940.

$p_{\frac{1}{4}}$ Population classified by years of age, beginning of 1936.

$p_{5\frac{1}{4}}$ Population classified by years of age, beginning of 1941.

It should be noted that the constituents of the population surveyed in the censuses and represented in the vital statistics consist of:

(1) The pure Chinese, the majority of the provincial inhabitants, and

(2) The Kao Shan Race, aborigines, residing in the common administrative districts.

While the other Kao Shan Race, aborigines, residing in the specified districts in the mountain areas is not included.

III. Here let us explain the method of computation.

First of all, in calculating the rate of mortality, we have to deal with the mortality under one year of age and those above separately.

(1) For the computation of the rate of mortality under one year of age, the total number of years of age of those surviving during the period under compilation, S_x, was calculated by the following formula:

$$S_x = \frac{t}{2}(E_x + E_{x+t})$$

where E_x and E_{x+t} denote the number of persons surviving to age x and $x+t$

respectively, and they are calculated from the population statistics at the beginning of 1936 and 1941, and the statistics of births and deaths from 1936 to 1940.

And then, dividing D_x (the number of deaths) by S_x (the total number of years of age), the central death rate m_x may be derived:

$$m_x = \frac{D_x}{S_x} = \frac{D_x}{\frac{t}{2}(E_x + E_{x+t})} = \frac{2\,D_x}{t\,(E_x + E_{x+t})}\ .$$

Thus we can have the rate of mortality $|t\,q_x$ from the following formula:

$$|t\,q_x = \frac{t\,m_x}{1+\frac{1}{2}m_x}\ . \qquad \text{(See Table 51)}$$

(2) Referring to the first approximate values of the mortality rate above one year of age, first of all, we have to compute S_x, the total number of years of age. And for the sake of convenience, we should deal with the computation of S_x in two ways. The one indicates the number less than 11 years of age, and the other 11 years of age and over.

(a) Using the estimation formula of the population at the beginning of 1941, S_x of 11 years of age and over may be calculated by the following formula:

$$S_x = \int_h^{h+5} p_t\,dt = \frac{p_0 P_0}{P_5 - P_0}\int_h^{h+5}(r^5 - r^t)\,dt + \frac{p_5 P_0}{P_5 - P_0}\int_h^{h+5}(r^t - 1)\,dt$$

$$= \frac{5\,p_0 P_0}{P_5 - P_0}\left\{ r^5 - \frac{r^h(r^5-1)}{\log_e r^5}\right\} + \frac{5\,p_5 P_0}{P_5 - P_0}\left\{\frac{r^h(r^5-1)}{\log_e r^5} - 1\right\}\ ,$$

where $$g_0 = \frac{5\,P_0}{P_5 - P_0}\left\{ r^5 - \frac{r^h(r^5-1)}{\log_e r^5}\right\}\ ,$$

$$g_1 = \frac{5\,P_0}{P_5 - P_0}\left\{\frac{r^h(r^5-1)}{\log_e r^5} - 1\right\}\ .$$

Therefore, we have the following formula:

$$S_x = 2.300411400\,p_0 + 2.699588597\,p_5$$

By the use of this formula, Tables 9 and 10 were calculated.

(b) S_x of less than 11 years of age may be calculated by the following formula:

$$S_x = \tfrac{1}{2}(E_x + E_{x+1})$$

where E_x and E_{x+1} denote the number of persons surviving to age x and $x+1$ respectively, and they are calculated from the population statistics at the beginning of 1936 and that of 1941, and the statistics of births and deaths from 1936 to 1940 (see Table 11).

Then dividing D_x, the number of deaths at x years of age, by S_x, it gives the central death rate m_x:

$$m_x = \frac{D_x}{S_x} .$$

The first approximate value of the mortality rate was calculated by the following formula:

$$q_x = \frac{m_x}{1 + \frac{1}{2} m_x} .$$

(3) Computing the second approximate value of the mortality rate, the following steps had to be taken:

(a) First of all, the first approximate value of the living rate by calendar year should be calculated from the first approximate value of the mortality and the living rate as derived above, in accordance with the following formula:

$$\bar{p}_x = \frac{1 - \frac{1}{2} q_{x+1}}{1 - \frac{1}{2} q_x} p_x ,$$

where $\bar{p}_x$ represents the first approximate value of the living rate by calendar year.

Let $L_{1.x}$ be the number of persons of age x at the beginning of 1936 and let $L_{6.x+5}$ be that of age $x+5$ at the beginning of 1941, then we have the following expressions:

$\mathfrak{L}_{2.x+1} = L_{1.x} \times \bar{p}_x$ denotes the number of persons of age $x+1$ at the beginning of 1937.

$\mathfrak{L}_{3.x+2} = L_{1.x} \times \bar{p}_x \times \bar{p}_{x+1} = \mathfrak{L}_{2.x+1} \times \bar{p}_{x+1}$ denotes the number of persons of age $x+2$ at the beginning of 1938.

$\mathfrak{L}_{4.x+3} = L_{1.x} \times \bar{p}_x \times \bar{p}_{x+1} \times \bar{p}_{x+2} = \mathfrak{L}_{3.x+2} \times \bar{p}_{x+2}$ denotes the number of persons of age $x+3$ at the beginning of 1939.

$\mathfrak{L}_{5.x+4} = L_{1.x} \times \bar{p}_x \times \bar{p}_{x+1} \times \bar{p}_{x+2} \times \bar{p}_{x+3} = \mathfrak{L}_{4.x+3} \times \bar{p}_{x+3}$ denotes the number of persons of age $x+4$ at the beginning of 1940.

$\mathfrak{L}_{6.x+5} = L_{1.x} \times \bar{p}_x \times \bar{p}_{x+1} \times \bar{p}_{x+2} \times \bar{p}_{x+3} \times \bar{p}_{x+4} = \mathfrak{L}_{5.x+4} \times \bar{p}_{x+4}$ denotes the number of persons of age $x+5$ at the beginning of 1941.

As there exist some differences between $\mathfrak{L}_{6.x+5}$, and $L_{6.x+5}$, the expression should be written as:

$$\mathfrak{L}_{6.x+5} + \delta_x = L_{6.x+5}$$

Now comes the correct value. Let $\bar{\mathfrak{L}}_{2.x+1}$ $\bar{\mathfrak{L}}_{3.x+2}$, ...be the correct value of the number of persons at the beginning of each year respectively, we have the following expressions:

$$\bar{\mathfrak{L}}_{2.x+1} = \mathfrak{L}_{2.x+1} + \frac{1}{5}\delta_x ,$$

$$\bar{\mathfrak{L}}_{3.x+2} = \mathfrak{L}_{3.x+2} + \frac{2}{5}\delta_x ,$$

$$\bar{\mathfrak{L}}_{4.x+3} = \mathfrak{L}_{4.x+3} + \frac{3}{5}\delta_x ,$$

$$\bar{\mathfrak{L}}_{5.x+4} = \mathfrak{L}_{5.x+4} + \frac{4}{5}\delta_x ,$$ (See Tables 16 and 17).

(b) The second approximate value of S_x may be calculated by the following formula:

$$S_x = \frac{1}{2}(L_{1.x} + L_{6.x}) + \bar{\mathfrak{L}}_{2.x} + \bar{\mathfrak{L}}_{3.x} + \bar{\mathfrak{L}}_{4.x} + \bar{\mathfrak{L}}_{5.x} .$$

With S_x we could calculate the second approximate value of the central death rate and the second approximate value of the mortality rate, in accordance with those formulas employed in case of first approximate value of the mortality rate.

By using the same method, the third approximate value of the mortality rate may be calculated.

(4) Nevertheless, the rates of mortality as mentioned above were crude, still far from usefulness, it should be smoothed by graduation.

For the part from 7 to less than 12 years of age, we graduated its rates by the empirical formula of seventh degree, $y = a_0 + a_1 x + \ldots\ldots\ldots\ldots\ldots + a_7 x^7$, the constants of which were determined by the method of Least Squares out of the crude rate of mortality from 5 to 19 years of age.

And for the part of 12 years of age and over, we graduated its rates by Mr. Blaschke's formula (see Vorlesungen ueber mathematische Statistik):

$$\begin{aligned} q_x = {} & 0.333333333\,\omega_x && + 0.277843931\,\omega_{x\pm1} \\ & + 0.138921966\,\omega_{x\pm2} && - 0.011113757\,\omega_{x\pm3} \\ & - 0.086131619\,\omega_{x\pm4} && - 0.037786775\,\omega_{x\pm5} \\ & + 0.072239422\,\omega_{x\pm6} && - 0.020639835\,\omega_{x\pm7} \end{aligned}$$

where ω_x denotes the crude rate of mortality.

We repeated the graduation four times by the empirical formula and Mr. Blaschke's graduation formula as mentioned above (see Tables 32—49).

As for the part more than 78 years of age, we calculated its rates by the use of Gompertz and Makeham's formula:

$$p_x = sg^{c^x(c-1)}$$

the constants of which were determined with the first graduated value of the mortality rate from 45 to less than 78 years of age, in accordance with King and Hardy's Method.

(5) The computation of the other life functions is as follows:

(a) Number living and number dying:

$$_xp_0 = \Pi p_x$$

$$100{,}000\ \Pi p_x = l_x$$

$$d_x = l_x - l_{x+1}$$

where $_xp_0$ denotes the rate of living from o to age x, p_x the rate of living, l_x the number living and d_x the number dying.

(b) Force of mortality of 2 years of age and over was calculated by the following formula:

$$\mu_x = \frac{8(l_{x-1} - l_{x+1}) - (l_{x-2} - l_{x+2})}{12\, l_x}$$

where μ_x denotes the force of mortality.

And force of mortality of less than 2 years of age was calculated by the following formula:

$$\mu_0 = \left(\frac{l_0 - l_{5\text{ days}}}{\frac{5}{365} - 0} - \frac{l_{10\text{ days}} - l_0}{0 - \frac{10}{365}} - \frac{l_{10\text{ days}} - l_{5\text{ days}}}{\frac{5}{365} - \frac{10}{365}} \right) \div l_0$$

$$\mu_b = \left(\frac{A-B}{b-a} + \frac{B-C}{c-b} - \frac{A-C}{c-a} \right) \div B\,.$$

where b denotes 5 days, 10 days, 15 days, 20 days, 25 days, 1 month, 2 months, ..., 12 months, etc. by yearly unit, and a and c denote the respective unit,