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INTERPOLATION METHODS ELANDT-JOHNSON TO ESTIMATE THE COMPLETE MORTALITY TABLE OF THE INDONESIAN YOUTH POPULATION BASED ON THE MORTALITY TABLE COALE-DEMENY

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ABSTRACT

The growth of the productive age population has continued to increase since 1971 and looks more significant in 2020. In 2010, the youth age group (16-30 years) reached 62.343.755. The population consists of 31.244.215 men and 31.099.540 women. In 2020, the youth age group will increase to 64.470.655 people, with 32.949.184 men and 31.529.270 women. The number of male youth is greater than the number of female youth. However, in 2020, youth health conditions worsened. Many young people experience severe stress and commit suicide due to depression. This will be one of the causes of the decline in young people in Indonesia. Since the Elandt-Johnson interpolation method provides reliable estimates for adult mortality, this study aims to obtain a more accurate, complete life table for Indonesian youth by applying the Elandt-Johnson interpolation method based on the Coale-Demeny West model a-bridged life table, using secondary data from the 2010 and 2020 Population Censuses provided by Statistics Indonesia. From the research results, it is known that the number of young men who survive until the age of 30 is 94.444 and young women who survive until the age of 30 is 95.724, meaning that the number of young women who survive is higher than young men, this means that the number of deaths of young men is higher than that of young women.

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1. INTRODUCTION

Mortality information is usually displayed in a mortality table format, namely a table that contains mortality data based on age [1]. This table is used to calculate various demographic parameters, including life expectancy, crude death rate, crude birth rate, and probability of reaching age 40. It shows that around 65,82 million or 24.00% of Indonesia's total population in 2022 will enter the 16-30 year age group, which means that almost a quarter of the population is youth. This percentage has decreased by 0.79% compared to 10 years ago (24.79%) [2]. However, the percentage of youth has increased in the last three years. Shows that youth health has worsened in recent years. This can be seen from young people who have experienced an increase in the percentage of health complaints by 5.98% in the last seven years. However, the morbidity rate among youth decreased from 10.23% to 9.51% compared to 2021. This figure remains higher than in previous years [3]. According to Fransiska's research, the age between 16 and 24 is crucial. Based on the results of the survey, 95.4% of respondents stated that they had experienced symptoms of anxiety, while 88% also showed indications of depression when dealing with problems during that period. In addition, 96.4% of respondents admitted that they did not understand sufficient strategies for dealing with the stress they often felt. Most likely, young people who experience severe stress may commit suicide due to depression, which can play a role as one of the factors causing the decline in youth in Indonesia [4].

Various methods are applied to estimate the death table (life table) with the interpolation method, namely the Elandt-Johnson, Brass-Logit, Kostaki, and Heligman-Pollard methods [5]. The research conducted by Zulkarnaen used the Kostaki interpolation method. This study concluded that the best interpolation methods recommended include the Kostaki method, a modified Kostaki method using Lagrange, and the Elandt-Johnson method. Since the Kostaki method only requires standard data, it is recommended to choose either the Elandt-Johnson method or the modified Kostaki method with Lagrange. However, the Elandt-Johnson method is most strongly recommended due to its more practical application [6].

In this research, the author chose the interpolation method Elandt-Johnson because this method is necessary in order to create a complete death table by referring to the concise death table. The death table model used is the Coale-Demery West model because this model is suitable for estimates in Indonesia, which still lacks accurate and complete mortality statistics data. Based on research conducted by Puspita [1], the estimation of the death table for the Indonesian male population is based on 2010 and 2020 population census data by applying the survival probability method, which is smoothed with the death table—Coale-Demeny model west. However, inaccurate calculations are used to determine the level of Mortality. Meanwhile, on the average level Mortality will later be applied to determine the survival probability value in creating a concise mortality table. Likewise with similar research by Khasanah [7] n estimating a brief death table for the Indonesian female population based on 2010 and 2020 population censuses data by applying the death table Coale-Demeny The western model has inaccurate calculations in determining the survival ratio of cohorts based on the 50-54 year age group and in calculating mortality levels which use two-level intervals.

According to the various data described previously, the researcher intends to estimate a brief death table for men and women in Indonesia, followed by estimating a complete death table for Indonesian youth based on a brief death table, to determine the number of young people who are still alive at the right age x. Considering this, the researcher conducted research titled, "Use of Interpolation Methods Elandt-Johnson for Estimation of Mortality Tables Complete Indonesian Youth Based on a Brief Mortality Table Coale-Demeny".

2. RESEARCH METHODS

This research uses quantitative methods, namely data covering all field information that can be expressed numerically or quantified qualitative data [8]. This research uses discrete data that can be separated into specific groups and is not in the form of fractional numbers [9]. Indonesian youth data is used as quantitative data in this research. The type of research used in this research is applied research. The data source used in this research is secondary data. This research's secondary data source is youth data from the 2010 and 2020 population census obtained from the Indonesian Central Statistics Agency.

2.1 Definition of Youth

According to Law Number 40 of 2009 concerning Youth (Youth Law), specifically Article 1 Paragraph 1, youth is defined as Indonesian citizens in a significant phase of growth and development, namely those aged between 16 and 30 year [10]. The large number of individuals in this productive age group presents both current and future opportunities for Indonesia, as this generation has the potential to become the main driving force in the development process that will shape the nation's future.

The United Nations explains that as a vital human resource, youth play a crucial role in development and serve as key agents of social, economic, and technological innovation [11]. States that with the changing demographic structure, the role of youth is becoming increasingly significant [3]. Therefore, young people must be equipped with education and skills, adequate nutrition, and quality reproductive health services, ultimately producing a healthy and productive workforce. Enhancing the quality of youth is a part of strategic programs aimed at preparing a future generation capable of actively contributing to national development. The success of youth development is a key factor in reaping the benefits of the demographic dividend.

2.2 Life Table

The life table is used to measure the mortality rate of a population and is not affected by the population's age distribution [12]; thus, it does not require a standard population to compare mortality rates across different populations. There are two types of life tables, the period life table and the cohort life table [13]. Both types can be presented as a complete life table or an abridged life table. The abridged life table covers all ages without annual details, but is based on age categories with five or ten-year intervals [14]. Meanwhile, the complete life table is more detailed, using one-year age intervals [15]. In this study, only the first type of period (population) life table will be constructed, as the aim is to develop a life table that reflects the mortality conditions of the population at a specific point in time.

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

$$_n d_x = l_x - l_{x+n} \tag{2}$$

$$q_x = \frac{d_x}{l_x} = \frac{l_x - l_{x+1}}{l_x} \tag{3}$$

$$_n q_x = \frac{_n d_x}{l_x} = \frac{l_x - l_{x+n}}{l_x} \tag{4}$$

$$L_x = l_x - \frac{1}{2} d_x = \frac{1}{2}(l_x + l_{x+1}) \tag{5}$$

$$_n L_x = l_x - \frac{n}{2} \quad {}_n d_x = \frac{n}{2}(l_x + l_{x+n}) \tag{6}$$

$$T_x = \sum_{x}^{(1)} L_x \tag{7}$$

$$e_x = \frac{T_x}{l_x} \tag{8}$$

$$m_x = \frac{d_x}{L_x} \tag{9}$$

Symbols and their uses applied to calculate death tables include:

x : fixed age x

l_x : a population that still survives

d_x : the number of deaths between ages x until $x + 1$

and $_n d_x$: the number of deaths between ages x until $x + n$

q_x : the probability that an individual is of the correct age x will die before reaching age $x + 1$

$and\ _n q_x$: the probability that an individual is of the correct age x will die before reaching age $x + n$

and ${}^{L_x}_{X+1}$: sum elapsed time l_x between ages x until age $x+1$

and ${}^{nL_x}_{X+n}$: sum elapsed time l_x between ages x until age $x+n$

T_x : sum elapsed time l_x from the right age x

e_x : life expectancy for the aged population x

and m_x : death rate for the aged population x [16].

2.3 Life Table Coale-Demeny

Model life tables designed based on analyses of mortality rates in real populations include the United Nations Model Life Tables, the Coale-Demeny Regional Model Life Tables, Ledermann's System of Model Life Tables, and the Logit System of Model Life Tables [17]. Applying the Coale-Demeny model life tables is commonly used to correct the underestimated mortality rates in China [18]. The formulas and life tables from the Coale-Demeny model have proven consistent and effective in various demographic analyses for more than 30 years [19].

The Coale-Demeny life table system consists of four distinct regional models: South, East, North, and West [20]. The Coale-Demeny model life table considered more suitable for mortality estimation in Indonesia is the West model, which is commonly applied in countries that still lack complete and accurate mortality statistics, such as Indonesia [21].

2.3.1 Smoothed with the Coale-Demeny Life Table

Several steps need to be taken to estimate the probability of survival, including the following.

1. Regulate net migration and area coverage.
2. Categorize cohort data from two censuses.
3. Set the time interval by shifting forward or backward to approximate the number of years corresponding to the nearest census date. Sum of the population at the initial (first) census N_1, sum of the population at the final (second) census N_2, actual census period in years t.

$$r = \frac{\ln(N_2) - \ln(N_1)}{t} \tag{10}$$

If there is data whose age category is unknown or Unanswered Data (TT), then it is necessary to prorate the data.

$$P_i = \left(\frac{N_{total}}{N_{total} - N_{TT}}\right) N_i \tag{11}$$

Where, sum population census data N_{total}, number of missing population data N_{TT}, sum population according to age N_i, prorated by age P_i. To determine value adjusted, there are two steps that need to be taken, namely reduce or increase the time interval between censuses. If you increase the time interval between censuses you can multiply the number of times between censuses $k = exp[r(y-1)]$ with the initial census [17].

4. Determine the cohort survivorship.

$$tS_{x,x+4} = \frac{N^2_{x+t}}{N^1_x} = \frac{L_{x+t}}{L_x} \tag{12}$$

Information, t interval sense adjusted, for ${}_tN^1_{x+4}$ population aged from x the $x+4$ at the initial census, and ${}_tN^2_{x+4}$ population aged from x the $x+4$ at the final census, and $\frac{L_{x+t}}{L_x}$ western model stationary population survival ratio [22].

5. Align with the appropriate mortality level in the Coale-Demeny life tables. Cohort survivorship are in between $level\ v$ and $level\ v+1$, if the interval distance between levels is one level. When the cohort ratio is between $level\ v$ and $level\ v+2$, then the interval distance between levels is two

levels and the term to be added is multiplied by two. Inappropriate ratio or outlier (outside) must be deleted [1].

$$z(x) = v + \frac{tS_{x,x+4} - \left[\frac{L_{x+t}^{v}}{L_x^{v}}\right]}{\left[\frac{L_{x+t}^{v+1}}{L_x^{v+1}}\right] - \left[\frac{L_{x+t}^{v}}{L_x^{v}}\right]} \tag{13}$$

Where, interval census 5-year $\frac{L_{x+t}^{v}}{L_x^{v}}$ stationary survival ratio level v and interval census 5-year $\frac{L_{x+t}^{v+1}}{L_x^{v+1}}$ stationary survival ratio level v+1.

6. Determine the total survival probability value from the obtained level.

2.4 Interpolation method Elandt-Johnson

Interpolation is a method used to estimate the value of missing or unavailable data between existing data points. The Elandt-Johnson method is a popular approach for developing a complete life table from an abridged life table. This method applies smoothing and three interpolation approaches based on specific age groups: infants and children aged 0–10 years, adolescents and adults aged 10–74 years, and those aged over 74 years. The method begins with the number of individuals still alive ${}^{A}l_{xi}$ at age x which is obtained from the abridged life table [15].

At ages 0-74 years, interpolation is applied Lagrange degree five with six data points [23]. The Interpolation formulation Lagrange is as follows.

$$Cl_x = \sum_{i=1}^{6} \frac{\prod j \neq i\,(x - x_j)}{\prod j \neq i\ (x_i - x_j)} Al_{xi} \tag{14}$$

According to Equation (14), the coefficients required to calculate a complete death table can be determined with an interpolation basis function, Lagrange, as follows.

$$L_i(x) = \sum_{i=1}^{6} \frac{\prod j \neq i\,(x - x_j)}{\prod j \neq i\ (x_i - x_j)} \qquad ; i = 1,2, \dots \dots ,6 \tag{15}$$

3. RESULTS AND DISCUSSION

3.1 Data Description

The data used is the number and percentage of the Indonesian population according to age group and gender based on the results of the Indonesian population census in 2010 and 2020 [24].

Table 1. Population of Indonesia by Age Group in 2010 and 2020

Age	SP2010			SP2020		
	Male	Female	Sum	Male	Female	Sum
0-4	11,662,369	11,016,333	22,678,702	7,996,762	7,456,932	15,453,694
5-9	11,974,094	11,279,386	23,253,480	12,054,557	11,293,112	23,347,669
10-14	11,662,417	11,008,664	22,671,081	12,248,242	11,501,707	23,749,949
15-19	10,614,306	10,266,428	20,880,734	11,890,104	11,232,889	23,122,993
20-24	9,887,713	10,003,920	19,891,633	11,799,983	11,151,534	22,951,517
25-29	10,631,311	10,679,132	21,310,443	10,983,136	10,594,469	21,577,605
30-34	9,949,357	9,881,328	19,830,685	10,678,855	10,444,990	21,123,845
35-39	9,337,517	9,167,614	18,505,131	11,127,884	11,030,421	22,158,305

Age	SP2010			SP2020		
	Male	Female	Sum	Male	Female	Sum
40-44	8,322,712	8,202,140	16,524,852	10,363,207	10,340,154	20,703,361
45-49	7,032,740	7,008,242	14,040,982	9,259,566	9,271,800	18,531,366
50-54	5,865,997	5,695,324	11,561,321	8,066,156	8,083,777	16,149,933
55-59	4,400,316	4,048,254	8,448,570	6,445,652	6,617,735	13,063,387
60-64	2,927,191	3,131,570	6,058,761	5,104,332	5,169,843	10,274,175
65-69	2,225,133	2,468,898	4,694,031	3,445,786	3,340,480	6,786,266
70-74	1,531,459	1,924,872	3,456,331	1,943,260	2,205,321	4,148,581
75-79	842,344	1,135,561	1,977,905	2,221,406	2,805,338	5,026,744
80-84	481,462	661,708	1,143,170	-	-	-
85-89	182,432	255,529	437,961	-	-	-
90-94	63,948	106,951	170,899	-	-	-
95+	36,095	68,559	104,654	-	-	-
TT	-	-	-	1,033,011	1,001,516	2,034,527
Total	119,630,913	118,010,413	237,641,326	136,661,899	133,542,018	270,203,917

***Data source**: (*Indonesian Central Statistics Agency *(BPS),* Indonesian population census in 2010 and 2020*)*

In 2010, the youth age group (16–30 years) reached 62,343,755 people, consisting of 31,244,215 young males and 31,099,540 young females [24]. By 2020, this number had increased to 64,470,655 people, comprising 32,949,184 males and 31,529,270 females [2]. The number of youths increased in 2020 compared to 2010.

3.2 Data Analysis

1. Since there is no grouping of migration by age and sex, net migration adjustment was not carried out.
2. The time interval between the first census in 2010 and the second census in 2020 is 9.75 years or about 10 years minus 3 months so, $\boldsymbol{t}$ = 9.75.
3. In 2020, the male population was 136,661,899. In 2010, the male population was 119,630,913. Therefore, the male population growth rate for the census period from 2010 to 2020 is as follows. Can be used **Equation (10)** so, $r_{lk} = \frac{\ln(136{,}661{,}899\ ) - \ln(119{,}630{,}913)}{9.75}$ = 0.013651149. The same steps are used to calculate the population growth rate of females $\mathbf{r_{pr}}$ = 0.012681364. The growth factor k to adjust the census interval from 9.75 years to exactly 10 years can be obtained through the following steps. The growth factor k for young males $\boldsymbol{k_{lk}} = \boldsymbol{exp}[0.013651149(9.75\text{-}10)]$ = 0.99659303 and $\boldsymbol{k_{pr}}$= 0.996834679.
4. Next, prorating is carried out for male and female data from the SP2020 census due to some unanswered data that need to be distributed into existing age groups. Can be calculated using **Equation (11)**.

   $$\text{Male } (0-4) = \left(\frac{136{,}661{,}899}{136{,}661{,}899 - 1{,}033{,}011}\right) \times 7{,}996{,}762 = 8{,}057{,}669$$

   $$\text{Female } (0-4) = \left(\frac{133{,}542{,}018}{133{,}542{,}018 - 1{,}001{,}516}\right) \times 7{,}456{,}932 = 7{,}513{,}279$$

   Because the time interval value is less than 10, it is necessary to add an interval. Hence, we apply adjusted and smoothing can be use $k = exp[r(y-1)] \times$ first census, adjusted $(15-19)$ male $= 0.99659303 \times 10{,}614{,}306 = 10{,}578{,}143$.
5. The youth male cohort survivorship value over 10 years, from the 15–19 age cohort in SP2010 (the first census) who would be aged 25–29 in SP2020 (the second census), is 1,04619393, which can be used in **Equation (12)**.

$$\text{male } {}_{10}S_{15,19} = \frac{11,066,789}{10,578,143} = 1.04619393$$

$$\text{female } {}_{10}S_{15,19} = \frac{10,674,524}{10,233,931} = 1.043052129$$

The calculation results can be seen in **Table 2**.

Table 2. The Male and Female Population Ratio Cohorts After Prorating and Adjusted

Age	Male			Female		
	SP2010 Adjusted	SP2020 Prorate	Rasio	SP2010 Adjusted	SP2020 Prorate	Rasio
0-4	11,622,636	8,057,669	-	10,981,463	7,513,279	-
5-9	11,933,299	12,146,370	-	11,243,683	11,378,446	-
10-14	11,622,683	12,341,530	1.061852922	10,973,818	11,588,617	1.055289012
15-19	10,578,143	11,980,664	1.003969145	10,233,931	11,317,768	1.006589022
20-24	9,854,026	11,889,857	1.022987291	9,972,254	11,235,798	1.023873182
25-29	10,595,090	11,066,789	1.046193930	10,64,.329	10,674,524	1.043052129
30-34	9,915,460	10,760,190	1.091958759	9,850,050	10,523,915	1.055319549
35-39	9,305,704	11,212,639	1.058286338	9,138,596	11,113,770	1.044004359
40-44	8,294,357	10,442,138	1.053116850	8,176,178	10,418,287	1.057688697
45-49	7,008,780	9,330,091	1.002620651	6,986,059	9,341,861	1.022242525
50-54	5,846,012	8,127,591	0.979894041	5,677,296	8,144,860	0.996169653
55-59	4,385,324	6,494,745	0.926658420	4,035,440	6,667,741	0.954435300
60-64	2,917,218	5,143,209	0.879780780	3,121,658	5,208,908	0.917497972
65-69	2,217,552	3,472,031	0.7917 38763	2,461,083	3,365,722	0.834040902
70-74	1,526,241	1,958,061	0.671208322	1,918,779	2,221,985	0.711796520
75+	1,600,808	2,238,325	1.009367537	2,221,255	2,826,536	1.148492689
Total	119,223,334	136,661,899	-	117,636,872	133,542,018	-

6. The survival probability ratio is equivalent to the stationary population ratio in the West model when the male survival probability ratio is 1.04619393; then, at age 15, the cohort value is 1.04619393. The stationary population ratio for the range of mortality levels in the West model life tables is included in the cohort ratio obtained from adjustments among the model values. If the cohort ratio at levels v and $v+2$ indicates that the interval between levels is two steps, then the term to be added should be multiplied by 2.

   Since the cohort ratio for males aged 0 to 35 has already exceeded one, 40 is selected. At age 40, the male cohort ratio is 0.979894041. At this ratio value, if we refer to the male ten-year survival probability table in the Coale-Demeny West model life table (as shown in the appendix), it has already exceeded level 24. Therefore, the appropriate level is chosen between level 22 and level 24, where the value for level 22 is 0.94709 and for level 24 is 0.96922 using **Equation (13)**.

$$z(40)male = 22 + \frac{2 \times {}_{10}S_{40,40+4} - \left[\frac{L_{40+10}^{22}}{L_{40}^{22}}\right]}{\left[\frac{L_{40+10}^{22+2}}{L_{40}^{22+2}}\right] - \left[\frac{L_{40+10}^{22}}{L_{40}^{22}}\right]} = 24.96466706$$

   For females, the cohort ratio at age 40 is 0.996169653, falling between level 22 (with a value of 096125) and level 24 (with a value of 0.97832), so,

$$z(40)\text{female} = 22 + \frac{2 \times (0.996169653 - 0.96125)}{0.97832 - 0.96125} = 26.09134774$$

7. To determine the average level of mortality, we need to eliminate the high and low values. By removing these outliers, an estimate of the overall level can be obtained by averaging the remaining values. Level of mortality male 22.31, falling between level 22 and level 23. The calculation for the age group of 15 years at level 22 is 0.95734, and at level 23 is 0.97119; therefore

$$l(15)\text{male} = 0.95734 + \frac{31\ (0.97119 - 0.95734)}{100} = 0.9616335$$

As for females, since the mortality level of 22.03 is still considered 22 due to the digit after the decimal point being zero, it remains at level 22. The value for the age group of 15 years at level 22 is 0.96898, so no further calculation is needed to find the survival probability, unlike the case for the male age group.

The survival probability from age x to age x+5 is calculated as $l_{15} = \frac{l_{x+5}}{l_x} = \frac{l_{20}}{l_{15}} = \frac{0.9570644}{0.9616335} = 0.995248606$ male. $l_{15} = 0.997069083$ female. The calculation l_x as determined by the level of mortality can be seen in **Table 3**.

Table 3. Survival Probability Values of l_x for Males Based on the West Model Mortality Level

Age	l_x Male				l_x Female	
	Level 22	Level 23	Level 22,31	Level 22,31 l_{x+5} / l_x	Level 22	Level 22,31 l_{x+5} / l_x
0	-	-	-	-	0	0
1	0.96925	0.97856	0.9721361	0.994736951	0.97738	0.995375391
5	0.96334	0.97521	0.9670197	0.996946494	0.97286	0.997800300
10	0.96004	0.97303	0.9640669	0.997475901	0.97072	0.998207516
15	0.95734	0.97119	0.9616335	0.995248606	0.96898	0.997069083
20	0.95234	0.96758	0.9570644	0.993386756	0.96614	0.995880514
25	0.94540	0.96261	0.9507351	0.993379334	0.96216	0.994886505
30	0.93847	0.95773	0.9444406	0.992531134	0.95724	0.993617066
35	0.93070	0.95227	0.9373867	0.990318723	0.95113	0.991431245
40	0.92076	0.94512	0.9283116	0.985525227	0.94298	0.987751596
45	0.90621	0.93416	0.9148745	0.976298061	0.93143	0.981190213
50	0.88314	0.91556	0.8931902	0.961616686	0.91391	0.971507041
55	0.84717	0.88503	0.8589066	0.937233455	0.88787	0.956513904
60	0.79148	0.83508	0.8049960	0.901716033	0.84926	0.930963427
65	0.71057	0.75995	0.7258778	0.847132672	0.79063	0.885091636
70	0.59846	0.65154	0.6149148	0.764236444	0.69978	0.808782760
75	0.45378	0.50591	0.4699403	0.646534038	0.56597	0.692298178
80	0.29018	0.33422	0.3038324	-	0.39182	0

8. The construction of an abridged life table using specific demographics can be seen in **Table 4** and **Table 5**. For example, at age 15 years,

a. l_{15} = radiks $l_0 \times l(15)\text{male} = 100.000 \times 0.9616335 = 96{,}163$ and female $l_{15} = 96{,}898$

b. By using **Equation (1)**, $d_{15} = l_{15} - l_{15+5} = 96{,}163 - 95{,}706 = 457$ males and 284 females.

c. By using **Equation (3)**, $q_{15} = \frac{d_{15}}{l_{15}} = \frac{457}{96.163} = 0.004751394$

d. By using **Equation (5)**, male ${}_5L_{15} = \frac{5}{2}(l_{15} + l_{15+5}) = \frac{5}{2}(96{,}163 + 95{,}706) = 479{,}674$

e. By using **Equation (7)**, $T_{15} = \sum_{15}^{(75)} L_{15} = 479{,}674 + \ldots + 193{,}443 = 5{,}316{,}686$ males.

f. By using **Equation (8)**, $e_{15} = \frac{T_{15}}{l_{15}} = \frac{479{,}674}{96{,}163} = 55.28806739$ males.

Table 4. Abridge Life Table of Indonesian Male Population with Model *Coale-Demeny West*

Age	Male					
	l_x	d_x	q_x	L_x	T_x	e_x
0	100,000	2,786	0.027863900	98,607	6,767,320	67.67320
1	97,214	512	0.005263049	387,831	6,668,714	68.59856
5	96,702	295	0.003053506	482,772	6,280,883	64.95093
10	96,407	243	0.002524099	481,425	5,798,111	60.14220
15	96,163	457	0.004751394	479,674	5,316,686	55.28807
20	95,706	633	0.006613244	476,950	4,837,011	50.54008
25	95,074	629	0.006620666	473,794	4,360,061	45.85990
30	94,444	705	0.007468866	470,457	3,886,268	41.14888
35	93,739	908	0.009681277	466,425	3,415,811	36.43972
40	92,831	1,344	0.014474773	460,797	2,949,386	31.77151
45	91,487	2,168	0.023701939	452,016	2,488,590	27.20143
50	89,319	3,428	0.038383314	438,024	2,036,573	22.80112
55	85,891	5,391	0.062766545	415,976	1,598,549	18.61144
60	80,500	7,912	0.098283967	382,718	1,182,574	14.69043
65	72,588	11,096	0.152867328	335,198	799,855	11.01914
70	61,491	14,497	0.235763556	271,214	464,657	7.556444
75	46,994	16,611	0.353465962	193,443	193,443	4.116335
80	30,383	-	-	-	-	-

Table 5. Abridge Life Table of Indonesian Female Population with Model *Coale-Demeny West*

Age	Female					
	l_x	d_x	q_x	L_x	T_x	e_x
0	100,000	2,262	0.022620000	98.869	7,009.187	70.09187
1	97,738	452	0.004624609	390.048	6,910.318	70.70247
5	97,286	214	0.002199700	485.895	6,520.270	67.02167
10	97,072	174	0.001792484	484.925	6,034.375	62.16391
15	96,898	284	0.002930917	483.780	5,549.450	57.27105
20	96,614	398	0.004119486	482.075	5,065.670	52.43205
25	96,216	492	0.005113495	479.850	4,583.595	47.63859
30	95,724	611	0.006382934	477.093	4,103.745	42.87060
35	95,113	815	0.008568755	473.528	3,626.653	38.12993
40	94,298	1,155	0.012248404	468.603	3,153.125	33.43788
45	93,143	1,752	0.018809787	461.335	2,684.523	28.82152
50	91,391	2,604	0.028492959	450.445	2,223.188	24.32611
55	88,787	3,861	0.043486096	434.283	1,772.743	19.96624
60	84,926	5,863	0.069036573	409.973	1,338.460	15.76031
65	79,063	9,085	0114908364	372.603	928,488	11.74364
70	69,978	13,381	0.191217240	316.438	555,885	7.943711
75	56,597	17,415	0.307701822	239.448	239,448	4.230745
80	39,182	-	-	-	-	-

9. From value l_x in table 1 of brief deaths, then interpolation will be carried out by Elandt-Johnson. A complete life table can be made from a death table, which is concise in how to apply it. Smoothing uses three interpolation techniques based on specific age groups, namely 0-10 years, 11-74 years, and 74 years and over. For the age range 0-74 years, method Elandt-Johnson applies the interpolation method Lagrange of degree five with six interpolant points. Because youth are in the 16-30 year age group, the age interval 11-74 years will be used, and the coefficients that will be used will be the coefficients in **Table 6**.

Table 6. Coefficient Values for Calculating $^{c}l_x$, with age $10 < x \leq 74$ year

	$^{A}l_{5m-10}$	$^{A}l_{5m-5}$	$^{A}l_{5m}$	$^{A}l_{5m+5}$	$^{A}l_{5m+10}$	$^{A}l_{5m+15}$
$^{c}l_{5m+1}$	0.008064	-0.073920	0.887040	0.221760	-0.049280	0.006336
$^{c}l_{5m+2}$	0.011648	-0.099840	0.698880	0.465920	-0.087360	0.010752
$^{c}l_{5m+3}$	0.010752	-0.087360	0.465920	0.698880	-0.099840	0.011648
$^{c}l_{5m+4}$	0.006336	-0.049280	0.221760	0.887040	-0.073920	0.008064
$^{c}l_{5m+5}$	0.000000	0.000000	0.000000	1.000000	0.000000	0.000000

***Data source**: (BPS, 2011)*

Information:

$^{A}l_{5m-10}$: number of people surviving at age $5m + j$ from a concise death table with $j = -10, -5, 0, -5, 10, 15$

$^{c}l_{5m-10}$: the number of people surviving at age $5m + i$ to calculate a complete death table with $i = 1,2,\ldots.,5$

$m = 2,3,\ldots,14$.

For example, for the age of 16 years for boys, namely $^{c}l_{16}$ using m is 3 and is on the complete table $^{c}l_{5m+1}$ where the value can be seen in table 4.16, when $m = 3$ then the summary table is at age $^{A}l_{5}$, $^{A}l_{10}$, $^{A}l_{15}$, $^{A}l_{20}$, $^{A}l_{25}$, And $^{A}l_{30}$. Where is the value $^{A}l_5$ and so on can be seen in the brief death table, following an example for a 16 years-old male youth. $^{c}l_{16} = 0.008064\ ^{A}l_5 - 0.073920\ ^{A}l_{10} + 0.887040\ ^{A}l_{15} + 0.221760\ ^{A}l_{20} - 0.049280\ ^{A}l_{25} + 0.006336\ ^{A}l_{30}$ for $^{c}l_{16} = (0.008064 \times 96{,}702) - (0.073920 \times 96{,}407) + (0.887040 \times 96{,}163) + (0.221760 \times 95{,}706) - (0.049280 \times 95{,}074) + (0.006336 \times 94{,}444) = 96{,}091$ males. Likewise for young women $^{c}l_{16} = 96{,}852$. l_x is the number of young people who survive to reach permanent age 30 year obtained from the calculation $^{A}l_x$ become $^{c}l_x$.

10. After getting the value Cl_x Next, compile a complete death table using **Equation (1)** to **Equation (8)**.

 a. $d_{16} = l_{16} - l_{16+1} = 96{,}091 - 96{,}009 = 82$

 b. $q_{16} = \frac{d_{16}}{l_{16}} = \frac{82}{96{,}091} = 0.000855051$

 c. $L_{16} = \frac{1}{2}(l_{16} + l_{16+1}) = \frac{1}{2}(96{,}091 + 96{,}009) = 96{,}050$

 d. $T_{16} = \sum_{16}^{(30)} L_{16} = 96{,}050 + 95{,}963 + \cdots \ldots.. + 94{,}378 = 1{,}428{,}797$

 e. $e_{16} = \frac{T_{16}}{l_{16}} = \frac{1{,}428{,}797}{96{,}091} = 14.86916145$

Following are the results of the calculations to obtain a complete death table for Indonesian youth.

Table 7. Complete Mortality Table for Indonesian Male Youth with Interpolation Elandt-Johnson

Age	Male					
	l_x	d_x	q_x	L_x	T_x	e_x
16	96,091	82	0.000855051	96,050	1,428,797	14.86916
17	96,009	92	0.000955481	95,963	1,332,747	13.88146

Age	Male					
	l_x	d_x	q_x	L_x	T_x	e_x
18	95,917	101	0.001056186	95,867	1,236,783	12.89426
19	95,816	110	0.00114428	95,761	1,140,917	11.90736
20	95,706	119	0.001239615	95,647	1,045,155	10.92043
21	95,588	125	0.001303928	95,525	949,508	9933362
22	95,463	128	0.001343847	95,399	853,983	8.945679
23	95,335	131	0.001369965	95,270	758,584	7.957044
24	95,204	131	0.001373446	95,139	663,314	6.967274
25	95,074	126	0.001323997	95,011	568,175	5.976168
26	94,948	125	0.001321364	94,885	473,165	4.983428
27	94,822	125	0.00131749	94,760	378,280	3.98936
28	94,697	126	0.001329641	94,634	283,520	2.993964
29	94,571	127	0.001345778	94,508	188,886	1.997284
30	94,444	132	0.001396141	94,378	94,378	0.999302
31	94,312	136	0.001441207	-	-	-

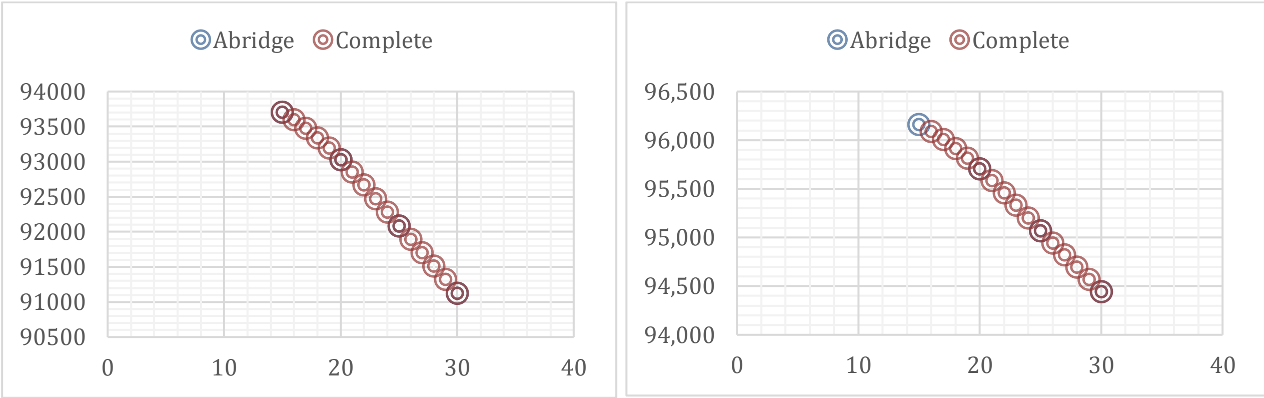
Table 8. Complete Death Table for Indonesian Female Youth with Interpolation Elandt-Johnson

Age	Female					
	l_x	d_x	q_x	L_x	T_x	e_x
16	96,852	52	0.000534548	96,826	1,444,630	14.91592
17	96,800	57	0.000586853	96,771	1,347,804	13.92363
18	96,743	62	0.000641823	96,712	1,251,033	12.93151
19	96,681	67	0.000691436	96,647	1,154,321	11.9395
20	96,614	71	0.000736265	96,578	1,057,673	10.94741
21	96,543	76	0.000784625	96505	961,095	9.95511
22	96,467	80	0.00082664	96,427	864,590	8.962534
23	96,387	84	0.000870466	96,345	768,163	7.969535
24	96,303	87	0.000908286	96,260	671,817	6.976043
25	96,216	91	0.000942869	96,171	575,557	5.98193
26	96,125	95	0.000984393	96,078	479,387	4.987104
27	96,031	98	0.001021586	95,982	383,309	3.991526
28	95,933	102	0.001066427	95,881	287,327	2.995096
29	95,830	106	0.001108701	95,777	191,446	1.99776
30	95,724	111	0.001155699	95,669	95,669	0.999422
31	95,613	116	0.001213813	-	-	-

After observing Table 7 and Table 8, we know the number of young males and young females who survive exactly 30 years. The number of male youths who died between the ages of 16 and 17 years reached 82, while the number of female youths was 52. From this, it appears that the number of deaths of young males exceeds that of young females.

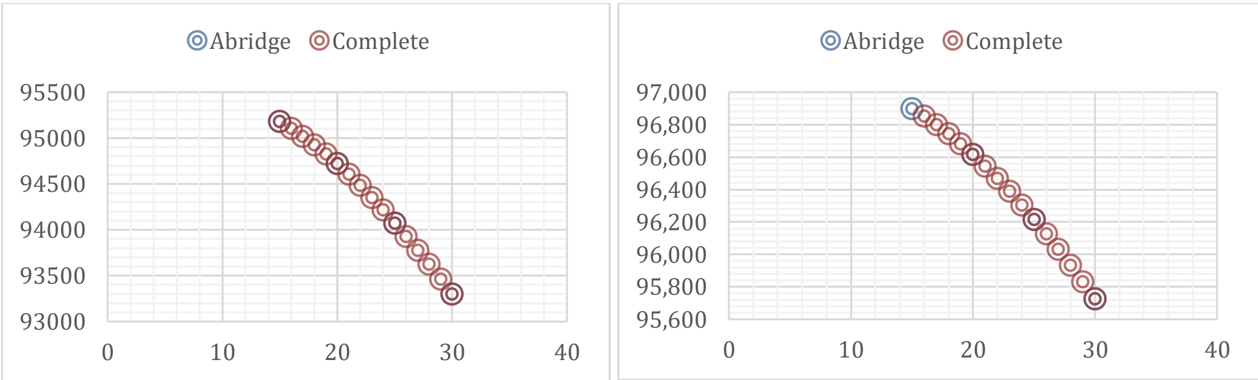
3.3 Graph Comparing Life Tables

The following is a graph of the West Model Coale-Demeny summary death table and the complete youth death table, which has been obtained by interpolation results using the method of Elandt-Johnson.



(a) (b)

Figure 1. Value Graph l_x Abridge and Complete Death Table for Indonesian Male. (a) BPS, (b) Coale-Demeny West Model and Interpolation Elandt-Johnson



(a) (b)

Figure 2. Value Graph l_x Abridge and Complete Death Table for Indonesian Female. (a) BPS, (b) Coale-Demeny West Model and Interpolation Elandt-Johnson

In Figure 1 and Figure 2, patterns the male and female youth curves obtained from this study are very similar to the curve patterns obtained by BPS. It can be seen that the curve l_x in the BPS death table or the death table obtained from research results tends to decrease consistently, meaning that the number of young people decreases as the age of young people increases due to death.

4. CONCLUSION

After compiling a concise death table Coale-Demeny with the western model it can be seen that the value l_x only for ages with a distance of 5 years, while using the interpolation method Elandt-Johnson mark l_x be 1 year apart. By interpolating, data on the age of an unknown number of youth can be obtained and can complement existing data. Graph curve l_x in an abridged life table with Coale-Demeny smoothing dan complete life table interpolation Elandt-Johnson, male and female youth curves obtained from this study are very similar to the curve patterns obtained by BPS. From the interpolation results, it is known that the number of male youths who survived to the age of 16 was 96,091, and up to the age of 30 was 94,444. Moreover, female youth amounted to 96,852 people, and 95,724 people aged 30. This means that the number of young women who survive is higher than that of young men, and the death rate for young men is higher than that of young women.

AUTHOR CONTRIBUTIONS

Novia Riningsih: Conceptualization, Data Curation, Formal Analysis, Funding Acquisition, Investigation, Methodology, Project Administration, Resources, Software, Validation, Visualization, Writing

- Original Draft, Writing - Review and Editing. Rina Widyasari: Supervision, Validation. Ismail Husein: Supervision. All authors discussed the results and contributed to the final manuscript.

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CONFLICT OF INTEREST

The authors declare that no conflicts of interest exist in the study.

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