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A COMPARATIVE STUDY OF THE MODIFIED IV MORTALITY TABLE AND THE U.S. STANDARD: IMPLICATIONS FOR SHARIA LIFE INSURANCE USING THE MAN-WHITNEY METHOD

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Abstract**:** *The mortality table, sometimes referred to as the life table, displays the likelihood of death for each age group's population members. Actuaries use this table to determine precise life insurance contributions. The mortality table of a country is influenced by several demographic factors of the country itself, such as birth rates, education, economy, socio-cultural aspects, and lifestyle, which can affect the mortality rate. This research employs a quantitative approach, utilising secondary data and the Mann-Whitney method to examine significant differences between the Indonesian IV Modified mortality table and the 1980 CSO mortality table. Additionally, it analyses the impact of education on the mortality table. There is no significant difference in the average mortality rate, and there is an influence of education. The results of the comparative analysis show the impact of education on the mortality table in a country, and there is no significant difference in the average mortality rate between the modified TMI IV and the CSO 1980.*

Keywords: *Insurance, Mortality Table, Mann-Whitney.*

INTRODUCTION

The mortality table plays a crucial role in the Sharia life insurance industry as it serves as the foundation for risk assessment, determining participants' contributions, and ensuring the sustainability of the tabarru' fund. Through the mortality table, insurance companies can estimate the probability of survival and death of participants at certain ages, enabling them to design protection schemes that are fair and aligned with the principle of mutual assistance (ta'awun). The accuracy of the mortality table ensures a balance between the contributions paid by participants and the benefits they will receive, thereby preventing injustice and gharar, which are prohibited in Sharia. Furthermore, the mortality table is an essential instrument for maintaining the stability of the collective fund, as it allows for adequate calculation of technical reserves to cover future claims.

A mortality table, or life table, is a fundamental instrument in actuarial science that records the probability of death at each age, serving as the basis for insurance pricing, risk assessment, and solvency planning (Jamil et al., 2024; Pavlov & Mihova, 2018). In Syariah life insurance (Takaful), which operates under the principles of cooperation and adherence to Islamic law, mortality tables are equally crucial in determining fair contributions and benefits. Unlike conventional insurance, Takaful emphasises risk-sharing among participants, and the accurate use of mortality tables ensures that no party is disadvantaged while aligning with Islamic prohibitions against riba and maysir (Abdeen et al., 2019; Konak & Demir, 2023; Naz et al., 2025). In Indonesia, the Indonesian Mortality Table has been developed to reflect demographic and epidemiological conditions, with advanced methods such as the linear hazard and proportional hazard transforms used to improve accuracy in predicting future mortality (Aalaei & Ebrahimnezhad, 2025; Permana et al., 2023; Riaman et al., 2018). These tables play a vital role in calculating premiums and benefits in Syariah life insurance while ensuring the financial stability and sustainability of Takaful institutions. Moreover, mortality tables help mitigate adverse selection and support equitable distribution of risks and returns, making them indispensable for both operational and ethical aspects of Syariah insurance (Salhi & Thérond, 2018).

A mortality table or life table is a table that depicts the life history of an individual or person, with the assumption that the mortality rate gradually decreases. The mortality table presents the probability of death, containing a list of lx, dx, and $qx,$ where lxIs the number of people alive at age x, dxIs the number of people who die after reaching age x, That is, between the ages x and $x + 1$ year, and qxWhat is the probability of death within a specific age range? (Nor et al., 2018). The mortality table is created based on several factors according to the demographics of the region itself. Demography is the science that studies the population, which includes fertility (number of births), mortality (number of deaths), and migration (number of population movements. (Utomo & Aris Setyo Budi, 2024). Donald J.Bogue (1973) states that demography is a field that studies the statistics and mathematics of the size, composition, and distribution of populations and their changes over time, considering five demographic elements: population, population structure, education, economy, and social mobility.

In the field of demography, population mortality can be directly obtained using the calculation of the Age Specific Death Rate (ASDR). One of the three demographic components that influence population structure is mortality or death; the other two components are birth (fertility) and population mobility. The mortality indicator is a number or index used to determine whether the death rate for a population is low or high. There is no single number that can indicate a person's mortality condition (B. Utomo, 2019). Creating a mortality table involves complex mathematical and statistical modelling (MacDonald et al., 2018). Indonesia itself currently has four mortality tables known as the Indonesian Mortality Table (TMI) I, II, III, and IV. TMI IV is the latest mortality table published by AAJI (*Asosiasi Asuransi Jiwa Indonesia*) in 2019. However, insurance companies in Indonesia have their own guidelines for the mortality table IV, which the companies themselves have modified. Meanwhile, the United States has three mortality tables known as the CSO (Commissioners Standard Ordinary) 1941, CSO 1958, and the latest table, the CSO 1980, issued by the Centres for Disease Control and Prevention (CDC).

The update of this mortality table is also in line with the demographic structural changes occurring in each population region, but does the TMI IV Indonesia Modified Mortality Table? The 1980 CSO Mortality Table reveals significant differences in average mortality rates between males and females. Does the influence of educational factors on mortality rates differ between the two countries? A nonparametric statistical test called the Mann-Whitney test is used to determine if two independent groups with regular or non-normal distributions differ significantly from one another. (Silaban et al., 2014). The Mann-Whitney method, also known as the Wilcoxon rank sum test, is used to test the difference between two groups on one ordinal variable without a specific distribution. (McKnight et al., 2010). This statistical approach focuses on the comparative analysis of average mortality rates between two populations, namely Indonesia and the United States.

Numerous academics have studied the comparison of mortality statistics between Indonesia and CSO, as well as the use and comparison of the Mann-Whitney and Kruskal-Wallis tests, including (Lita, 2022) The study found that the average mortality rate for people aged 0-111 years did not significantly differ between the Indonesian Mortality Table 2011 (TMT, 2011) and the Taspen Mortality Table 2012 (TMT, 2012), as indicated by the nonparametric Mann-Whitney test (p-value = 0.867). H. Utomo (2021) Explains that the average mortality rates of the four TMI death tables I through IV published throughout the 26 years from 1993 to 2019 did not differ significantly based on the results of nonparametric tests and a one-way ANOVA on ranks. The results in the CSO mortality tables were not all the same. The average mortality rates in the CSO Mortality Tables of 1958 and 1980 were substantially different from the average mortality rate in the CSO Mortality Table of 1941. There was no discernible variation between the average mortality rates in the CSO 1958 and CSO 1980 mortality data.

In previous research, the researchers only measured the average mortality rate comparison within the population itself. Therefore, to expand their knowledge, the researchers will investigate whether there are significant differences in the cross-comparison of average mortality rates based on age and gender against the average mortality rates in two populations using the modified TMI IV table and the 1980 U.S. CSO Table. This study aims to use a statistical method employing the Mann-Whitney test to compare the mortality tables between the 1980 CSO and the Modified TMI IV. The average mortality rates and the impact of the education component on the Indonesian IV and 1980 CSO mortality data are examined using this method to see if there are any notable discrepancies. Finally, the data gathered from this study would help Islamic insurance firms better assess and control mortality risk and facilitate the creation of more precise and long-lasting contribution plans.

THEORETICAL FRAMEWORK AND HYPOTHESES

Sharia life insurance, also known as Takaful, operates on principles that differ from conventional insurance as it is grounded in Islamic law (Sharia), emphasising cooperation, mutual protection, and risk-sharing among participants who contribute to a collective fund (Siddiqui, 2013; Wahab et al., 2007). Sharia-compliant life insurance must avoid riba (interest), gharar (excessive uncertainty), and maisir (gambling), which requires that product design and operations adhere to transparency and ethical principles (Qadri et al., 2024). In terms of business models, several approaches exist, such as the mudharabah model based on profit-sharing, though it has been criticised for weaknesses in risk management (Tanuwijaya et al., 2022; Wahab et al., 2007); the wakalah model, which has gained wider acceptance as it positions the operator as an agent entitled to a service fee (Naz et al., 2025; Wahab et al., 2007); and the waqf model, which integrates charitable endowment with the wakalah framework to enhance sustainability and Sharia compliance (Naz et al., 2025). Governance in Takaful requires strict oversight through Sharia supervisory boards within Islamic financial institutions to ensure continuous compliance with Sharia principles, while, legally, regulations in countries such as Indonesia have provided Sharia insurance equal standing with conventional insurance under a dual system (Arianty et al., 2023; Muhaimin, 2018). In terms of sustainability, Sharia life insurance is expected to contribute to socially and environmentally responsible practices through the dual materiality principle, which accounts for both financial and social impacts (Cahyandari et al., 2023; Sakdiyah, 2025), and innovative models such as integrating productive waqf to support fishermen's welfare have been developed (Cahyandari et al., 2025). Nevertheless, challenges remain, including the limited range of products, which primarily focus on individual risks, and the need for stronger regulatory reinforcement to support macroeconomic goals, such as those outlined in Saudi Vision 2030 (Cahyandari et al., 2023; Jelili Amuda & Alabdulrahman, 2023). Thus, the theoretical framework of Sharia life insurance is founded on mutual assistance, ethical values, and robust governance, with the potential to grow further through product diversification, social innovation, and regulatory strengthening.

The theoretical framework of mortality tables encompasses their construction, application, and the underlying models used in their development. Life tables, or mortality tables, are fundamental tools in demography and actuarial science that present probabilities of death at specific ages, enabling calculations of life expectancy, age-specific mortality rates, and survival probabilities (Burch, 2018). The construction of mortality tables relies on mathematical and statistical approaches, including moment estimation, maximum likelihood estimation (MLE), and model-fitting methods such as the Lee-Carter model, state-space models, and maximum likelihood criteria (Atanc et al., 2021). In practice, mortality tables are applied in public health, social policy, insurance, and pension planning to determine premiums, price products, and ensure sufficient reserves for future claims. At the same time, actuaries use them to project insured events by analysing past and future trends (Pavlov & Mihova, 2018). A significant challenge in mortality projection lies in the uncertainty of future mortality trends, the influence of external factors, and data limitations at extreme ages, which are often addressed with approaches such as the threshold life table and extreme value theory (Jamil et al., 2024). Advanced mortality models, including stochastic models with long memory structures and dynamic life tables, improve the accuracy of forecasts and longevity risk management, using techniques such as Bayesian inference and Gibbs sampling (Blackburn & Sherris, 2013; Fung et al., 2015). Validation of mortality tables is conducted by assessing the fit between observed and predicted values, applying techniques like local likelihood and credibility approaches to enhance robustness even with limited data (Salhi & Thérond, 2018; Tomas & Planchet, 2014). Furthermore, mortality tables can be adapted to specific populations or insurance portfolios by integrating demographic variables and adjusting for biases to reflect better the target group's mortality experience (Grafféo et al., 2012). Thus, continuous research and model validation are essential to address uncertainties in mortality projections and ensure reliable applications across disciplines.

Based on the theoretical foundation, previous studies, and the conceptual framework described above, the hypotheses of this study are formulated as follows: there is an assumption of a significant effect of the average level of education on the mortality table (H0), while the alternative states that there is no significant effect (H1). Furthermore, the hypotheses also test whether there is a substantial difference in the average female mortality rate between the modified Indonesian mortality table and the U.S. CSO 1980 mortality table (H0), with the alternative hypothesis stating that there is no significant difference (H1). Finally, the last hypothesis posits a substantial

difference in the average male mortality rate between the modified Indonesian mortality table and the U.S. CSO 1980 mortality table (H0), while the alternative hypothesis indicates that there is no significant difference (H1).

RESEARCH METHODS

The study employed the Mann-Whitney method, using secondary data obtained from the Asosiasi Asuransi Jiwa Indonesia (AAJI) and the Centres for Disease Control and Prevention (CDC). The dataset consisted of variables such as age, mortality rate, gender, and participant survival, with the sample data being mutually independent. The mortality table used specific notations, where x represents a person's age, Lx indicates the number of people who lived up to age x, px shows the probability of a person aged exactly x surviving to age n with the formula px = (lx+1)/lx [1], and qx represents the probability that someone aged x will die, expressed as qx = 1 – px [2].

The decision-making criteria were based on the value of p. If p-value < α, then the null hypothesis (H0) is rejected, meaning there is a significant difference between the average mortality rates of TMI IV Modification and CSO 1980. Conversely, if p-value > α, the null hypothesis is accepted, implying that there is no significant difference between the average mortality rates of TMI IV Modified and CSO 1980.

The research flow for comparing the average mortality rates using the Mann-Whitney method included several stages. First, data were collected from the TMI IV Modification and CSO 1980 mortality tables. Second, the average mortality rate in each mortality table was grouped according to gender. Third, the influence of education on the average mortality rate was analysed for both TMI IV Modification and CSO 1980. Finally, the differences in average mortality rates were calculated using the Mann-Whitney method to test the hypotheses.

RESULTS AND DISCUSSION

Education, along with the Modified Indonesian Mortality Table IV and the U.S. CSO 1980 Mortality Table, serves as the primary population object in this study. These criteria represent samples from two countries that provide accessible mortality tables through insurance companies or official websites. Demography, which studies the structure, composition, and dynamics of populations, includes factors such as age, gender, education level, and occupation. Demographic influences are essential in assessing risks and determining contribution values used to construct mortality tables. A mortality table, or life table, illustrates the probability of death within each age group, which is shaped by a nation's mortality level.

Among the demographic factors considered, education plays a critical role. Education is defined as a conscious and structured effort to create a learning environment that not only imparts knowledge and skills but also develops individuals' needs, desires, and abilities, enabling them to lead fulfilling lives. Education significantly impacts individual and community health, ultimately influencing mortality rates. Higher education increases health awareness, allowing individuals to adopt healthy lifestyles, manage stress, maintain a balanced diet, and avoid risky behaviours such as smoking or alcohol abuse. Consequently, mortality rates tend to be lower in countries with higher education levels.

The relationship between education and mortality extends to healthcare access, maternal and child mortality, elderly health behaviours, and the Human Development Index (HDI). Educated individuals usually secure better jobs, granting them financial capacity and health insurance access, which reduces mortality. Women's education, in particular, lowers maternal and infant deaths through improved prenatal care, immunisation, and childcare practices. Likewise, educated elderly populations adopt healthier lifestyles, lowering degenerative disease risks and enhancing life expectancy. Countries with high HDI, like the United States, generally record lower mortality rates due to better access to education and healthcare. In contrast, Indonesia faces more variations due to uneven education levels.

In this study, we analyse the influence of the Education factor on the mortality table and compare the average mortality rates of the modified TMI IV mortality table (ages 0-111) and the CSO 1980 (ages 0-99) using the Mann-Whitney method with a confidence level of $\alpha = 0.05$.

1. Analysis of the influence of education on the mortality table

   Education significantly influences mortality tables because it affects the health levels of individuals and communities, thereby shaping death rates across countries. People with lower education levels generally have

less awareness of disease prevention, making them more vulnerable to infectious and chronic illnesses. In contrast, higher education is often linked to better jobs and financial capacity, which provide access to quality healthcare and reduce mortality rates. Women's education also plays a crucial role in lowering maternal and child mortality, as educated women are more aware of prenatal care, immunisation, environmental hygiene, and proper childcare practices, leading to reduced infant and toddler mortality rates. Among older people, education contributes to healthier lifestyle behaviours, resulting in more controlled mortality rates. Furthermore, education is strongly tied to a country's Human Development Index (HDI), with nations that have higher HDI typically exhibiting lower mortality rates due to broader access to healthcare and education services.

2. Mann-Whitney Test

After conducting a comparative analysis on the average mortality rate in TMI IV Modification and CSO 1980 using the Mann-Whitney test, with the testing criteria that if $p - value > a$ then accept H_0 and if $p - value < a$ then reject H_0 with a value of $a = 0.05$. Thus, the results obtained are as follows:

Table 1

Comparison of average mortality rates by male gender

Test Statistics	
	Average male mortality rate
Mann-Whitney U	5116.500
Wilcoxon W	11444.500
Z	-1.084
Asymp. Sig. (2-tailed)	.278

a. Grouping Variable: Mortality Table

The SPSS output results in Table 1 show that the average mortality rate for males between the Modified TMI IV and the CSO 1980 Table indicates an *asymptotic. Sig. (2-tailed)* value of (0.278), which means $p - value = 0.278 > a = 0.05$. Therefore, the decision is to accept H_0, This states that there is no significant difference in the average mortality rate between the Modified TMI IV and the CSO 1980 Mortality Table.

Likewise, the average mortality rate for females through the Mann-Whitney test was obtained:

Table 2

Comparison of average mortality rates by female gender

Test Statistics	
	Average Female Mortality Rate
Mann-Whitney U	5102.500
Wilcoxon W	11430.500
Z	-1.116
Asymp. Sig. (2-tailed)	.265

a. Grouping Variable: Mortality Table

In Table 2, the average mortality rate for the female gender was obtained as *Asymp. Sig. (2-tailed)* value of (0.265), thus, the $p - value = 0.265 > a = 0.05$ leading to the decision to accept H_0, This indicates that there is no significant difference in the average mortality rate for females between TMI IV Modification and the CSO 1980 Mortality Table.

The results of the analysis on the demographic influence—specifically the impact of education on mortality tables—show that education has a significant effect on mortality rates. Those with higher levels of education tend to have greater health awareness, better access to medical care, and make healthier lifestyle choices. Consequently, education can reduce mortality rates and increase the overall life expectancy of a population. Many factors, including education, influence mortality tables. Population mortality patterns are shaped by various

interrelated demographic elements such as age, gender, environment, socioeconomic status, lifestyle and daily behaviours, the presence of communicable or non-communicable diseases, general health conditions, and access to healthcare. Moreover, advancements in medical technology and science are crucial for improving life expectancy (Saretta, 2023).

In addition, lifestyle and stress levels among populations in both countries may explain significant differences between the Modified Indonesian Mortality Table IV and the CSO 1980. Habits such as unhealthy diets, smoking, alcohol consumption, lack of physical activity, and prolonged stress increase the risk of premature death. Stress levels in each country also affect mortality. Around 75% of Indonesians experience stress, according to a survey (Cigna, 2022). Although this is relatively high, it is still lower than in some other countries. However, a study conducted by the American Psychological Association (2022) revealed that people in the United States experience higher stress levels, primarily due to economic pressures and inflation. This elevated stress potentially contributes to higher mortality rates from stress-related illnesses. Furthermore, a report by Great Powers (2024) ranked Indonesia as the second-happiest country in the world with a score of 1.58, surpassing the U.S., which scored 0.98 and ranked tenth. Compared to developed nations like the U.S., Indonesia's higher happiness levels indicate better emotional and social well-being, which may help lower mortality rates.

The results of the Mann-Whitney U-test on the average mortality rate differences by gender (male and female) between the Modified Indonesian Mortality Table IV and the U.S. CSO 1980 showed no significant difference in average mortality rates. This finding aligns with research by H. Utomo (2021) titled "Comparison of Indonesian and U.S. Mortality Tables Using the Mann-Whitney and Kruskal-Wallis Tests," which also found no significant difference in average mortality between the TMI I and CSO 1980 tables. Similarly, Lita (2022), in "Comparison of Taspen Mortality Table 2012 (TMT, 2012) and Indonesian Mortality Table 2011 (TMI, 2011) Using the Mann-Whitney Test," reported that nonparametric Mann-Whitney tests showed no significant difference between TMT 2012 and TMI 2011, with average unisex mortality rates for ages 0–111 remaining unchanged. Both studies concluded that average mortality rates do not differ significantly, whether analysed unisex or by gender. These results are further supported by Dobson et al. (2023), who emphasised the importance of evaluating the completeness and validity of data in mortality tables. Although mortality tables in both countries show no significant quantitative differences, demographic factors such as social, cultural, economic, and behavioural conditions play an essential role in shaping mortality outcomes.

CONCLUSION

Research shows that education plays a crucial role in influencing mortality rates, as it impacts health awareness, access to healthcare, maternal and child health outcomes, and elderly lifestyle behaviours. Despite this, the Mann-Whitney test results reveal no significant difference between the Modified Indonesian Mortality Table IV and the U.S. CSO 1980 when comparing male and female mortality rates. This finding highlights that global health improvements may lead to converging mortality patterns across nations. In the context of Sharia life insurance, mortality tables are vital for risk assessment, contribution calculation, and maintaining the sustainability of the tabarru' fund. Since education is a key factor shaping mortality, Sharia insurers must consider demographic variations to ensure fairness, transparency, and the avoidance of gharar in their products. The similarity between Indonesian and U.S. tables also indicates that Sharia insurers can adopt international mortality standards, while still adjusting for local social, cultural, and economic conditions to achieve actuarial justice.

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