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OCCUPATIONAL HAZARDS TABLE FOR DETERMINING THE PERIOD OF DEVELOPING DISEASE

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ABSTRACT: A table related to a life table, called ‘Occupational Hazard Table’ is proposed and developed to enable us estimate the expected period of exposure before the ailment due to the specific occupation sets in. A set of data from a textile industry where byssinosis is the common occupational hazard is used. For the considered company we obtained the expected period of a new employee to be six years and eight months.

INTRODUCTION

In any country, if the economy should grow, the concerned government must be ready to encourage liberalization and permit private participation. However, there is rarely any production activity, which does not require the use of raw-materials, which mostly undergo processing. It is this art of processing that often exposes the workers to occupational hazards. Some of these hazards come as a result of contact with toxic substances, unsafe machinery, unhealthful noise levels, poor ventilation, excessive heat (or cold), or by inhalation of particulates such as asbestos, silicon, cotton, which lead to respiratory problems. For example, the textile industry often makes use of cotton whose processing leads to breathing complication simply tagged byssinosis. Byssinosis is a disease, which is contractible as a result of inhalation of cotton particles by persons who work in cotton spinning or textile industry. Once one inhales cotton particles especially in a poor ventilated environment, the trachea is blocked, and there is difficulty in breathing. With this, if no urgent medical attention is given to the infected, death is imminent.

In many workplaces in developing nations, the problem of these hazards is made worse by a lack of protective clothing or equipment and is even compounded by lack of payment of compensation for work place injuries, as well as lack of sufficient occupational health care facilities (Choon-Nam Ong et al, (1993) and Jorge Hardoy et al (1992).

World Health organization, in one of their surveys in October 2005 found that 96% of global burdens are due to occupational Risk Factors, (RF) total deaths per year from various occupational RF was estimated to be 777,000 while 19.8million disability adjusted life years (DALYS) were also as a result of occupational RF. International Labour Organization (ILO) also observed that the Gross Domestic Products (GDP) is lost to work related disease and injuries, (Disease Control Priorities Project 2007). It is on the foregoing we deemed it necessary to be part of this project in order to save the society from risking most of its active population to these hazards.

In this work, we have constructed occupational hazards table via life table and obtained the expected period of developing ailment due to the hazard.

METHODOLOGY

Life table was initially applicable in actuarial science whereby the computation of insurance premiums was the main concern. Later, after a rigorous advancement in both theoretical statistics and stochastic processes, life tables became more relevant to demographers, epidemiologists, biologists and researchers in other fields, (Chin 1984).

In actuarial science, a life table, (also referred to as mortality table or actuarial table) is a table showing, for an individual at each age, what probability is that he dies before their next birthday.

From this view, a number of statistics can be derived and included in the table. Such statistics include:

- The probability of surviving any particular year of age.
- The remaining life expectancy for people of different ages.
- The proportion of the original birth cohort still alive.
- Estimates of a cohort's longevity characteristic.

Life tables are usually constructed separately for men and for women because of their different mortality rates, smoking-status, occupation, socio-economic class etc. However, life tables are mainly used in describing age-specific mortality and survival rates for a population.

TYPES OF LIFE TABLES

There are two forms of life tables. These are:

- i. The cohort (or generation or age-specific or dynamic) life table; and
- ii. The current (or time-specific or cross-sectional/or static) life table.

For a cohort life table, it accounts for the actual mortality experience of a certain group of individuals' right from the birth of the first to the death of the last member of the group. It is more useful in the study of animal populations, assessment of the durability of objects like engines, electric bulbs and other mechanical objects. It is equally relevant in the analysis of chance and duration of patient-survival in studies of treatments effectiveness. When modified, this table is useful in epidemiological, sociological, medical and paramedical studies of human subjects, Keyfitz, (1996) and Mould, (1976).

The current life table gives a cross-sectional view of the mortality and survival experience of a population during a particular year (e.g. Nigeria Population of 1991). It depends on the age-specific death rates prevailing in the year under consideration. Tables of this form project the life span of an individual in hypothetical cohort on the basis of the actual death rates in a given population. The current life table is therefore a reflection of the mortality experience of a real population, during a calendar year. It is at the same time the most effective means of summarizing the mortality and survival experience of a population, and forms a strong basis for statistical inferences about the population under study. It is a useful tool for comparing international mortality data and for assessing mortality trends at the national level.

Life tables (either cohort or current) may be complete or abridged. In a complete life table, the functions are computed for each year of life. Whereas, an abridged life table deals with age intervals above 1 year, except for the first years of life, Chin (1984).

DESCRIPTION OF THE LIFE TABLE

Both current and cohort life table though appear the same, differ in their construction. Here is the complete current life table.

Column 1: Age interval $(x, x+I)$.

Column 2: Proportion of those alive at age x , dying in the interval $(x, x+I)$, q_x .

Column 3: Number alive at age x , l_x . The first number in the column l_0 is called the radix.

Column 4: Finite rate of survival, p_x , during age interval $(x, x+I)$.

Column 5: Number of years lived by the total (or entire) cohort in the interval $(x, x+I)$, L_x .

Column 6: Total number of years lived beyond age x , T_x . It equals the sum of the number of year lived in each age interval beginning with age x . $T_x = \sum_{j=x}^{\infty} L_j$.

Column 7: Expectation of life at age x , e_x . It is the mean expectation of the further life for individual alive at the beginning of age interval $(x, x+I)$.

Thus e_x is given by: $e_x = \frac{T_x}{l_x}$, $x = 0,1,2,\dots$

Note: x represents age, measured in years or some other convenient units.

LIMITATIONS OF LIFE TABLES

There are some major limitations of a life table. These include:

- I. Opportunities to follow-up cohorts for long periods of time are rare.
- II. Critical assumption of a stable age distribution used in constructing a life table is so difficult to meet especially, in cohort life table; therefore we made use of time-specific life tables, Chin (1984) and Keyfitz, 1996).

OCCUPATIONAL HAZARDS VIA LIFE TABLE

In analyzing occupational hazards there is need to obtain a table similar to a life table, which would estimate the period before the advent of a disease. In this regard, the following are required.

Column 1: Time interval from the date of employment to the date of onset of a disease ($x, x+I = X'$).

Column 2: Proportion of those employed at a period x , developing a disease within the time interval of time ($x, x+I = X'$), q_x . That is, rate of developing disease.

Column 3: Number of those free from disease at a period x , l_x . That is, those surviving disease, the first number in the column, l_0 is called the radix.

Column 4: Finite rate of survival, p_x , during the periods ($x, x+I$).

Column 5: Number of years lived by the total employed together within the interval of time ($x, x+I = X'$), L_x .

Column 6: Total number of years lived beyond the period x , T_x . It equals to the sum of the number of years stayed in each time intervals from the time x . $T_x = \sum_{j=x}^{\infty} L_j$.

Column 7: Expectation period of infection at time x , e_x . $e_x = \frac{1}{l_x} \sum_{j=x}^{\infty} L_j$

CONSTRUCTION OF LIFE TABLE

In constructing a life table, one is mainly concerned with the computation of the estimate of the probability of death in the age interval ($x, x+I$) from the corresponding age-specific death rate, M_x .

However, specifically, there is a need to determine the interval to be used and calculate the Age-Specific Death Rate (ASDR) or the mortality experience for each age group of the population.

$$\begin{aligned}
 M_x &= \text{ASDR/mortality experience for age } x \\
 M_x &= \frac{\text{Number of deaths in the interval}(x, x+1)}{\text{People aged between } (x, x+1)} \\
 &= \frac{\text{Number of people who develop a disease}}{\text{Population at risk}} \\
 &= \frac{D_x}{P_x} \text{ or } \frac{D_x}{L_x} \quad P_x \text{ (People ages } x \text{ at mid-year calendar)}
 \end{aligned}$$

- I. Calculate the probability of dying.

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

- II. Calculate the probability of surviving. $p_x = 1 - q_x$
- II. Determine number alive at age x , l_x

- III. Obtain number of years lived by the entire cohort in the interval $(x, x+1)$, L_x .
- IV. Obtain total number of years lived beyond age x , $T_x = \sum_{j=x}^{\infty} L_j$.
- V. Obtain the expectation of live, which is given as $e_x = \frac{1}{l_x} \sum_{j=x}^{\infty} L_j$ where $L_x = \frac{l_x + l_{x+1}}{2}$

CONSTRUCTION OF OCCUPATIONAL HAZARDS TABLE

In constructing a life table, the main concern is the computation of the estimate of the probability of death, q_x in the age interval $(x, x+1)$ from the corresponding age-specific death rate, M_x . Where

$$\begin{aligned}
 M_x &= \text{ASDR/mortality experience for age } x \\
 M_x &= \frac{\text{Number of deaths in the interval } (x, x+1)}{\text{People aged between } (x, x+1)} \\
 &= \frac{\text{Number of people who develop a disease}}{\text{Population at risk}} \\
 &= \frac{D_x}{P_x} \quad \text{or} \quad \frac{D_x}{L_x}
 \end{aligned} \tag{1}$$

P_x (People ages x at mid-year calendar)

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

Where q_x is the estimate of the probability of developing a disease (or an ailment), in the time interval $(x, x+1)$

However in our proposed table, the main interest is to also compute this estimate from the corresponding incidence rate, I_x , where the incidence rate, $I_x = M_x$

$$= \frac{\text{Number of persons developing a disease}}{\text{Population at risk}} = \frac{D_x}{P_x} \quad \text{or} \quad \frac{D_x}{L_x}$$

Hence equation 2 becomes:

$$\begin{aligned}
 q_x &= \frac{I_x}{1 + \frac{1}{2}I_x} \\
 &= \frac{2I_x}{2 + I_x}
 \end{aligned} \tag{3}$$

So, in the proposed table, we have the following as its columns:

Column 1: Time interval from data of employment to onset of the disease, $(x, x+1 = x')$.

Column2: Number of those free from disease at a period x , l_x . That is, those surviving disease, the first number in the column, l_o is called the radix.

Column3: Proportion of those employed at a period x , developing a disease within the time interval of time $(x, x+1 = x')$, q_x , that is, rate of developing disease.

Where

$$\begin{aligned}
 q_x &= \frac{I_x}{1 + \frac{1}{2}I_x} \\
 &= \frac{2I_x}{2 + I_x}
 \end{aligned}$$

Column 4: Probability of surviving a disease p_x

$$p_x = 1 - q_x = 1 - \frac{2I_x}{2 + I_x} = \frac{2 - I_x}{2 + I_x} \quad 4$$

Column 5: Number of person-year stayed by the entire persons employed in the interval $(x, x + 1)$

$$L_j = \frac{l_j + l_{j+1}}{2} \quad 5$$

Column 6: Total number of years lived beyond the period x , T_x . It equals to the sum of the number of years stayed in each time intervals from the time x .

$$T_x = \sum_{j=x}^{\infty} L_j \quad 6$$

Column 7: Expected period of developing occupational hazards, e_x .

$$e_x = \frac{1}{l_x} \sum_{j=x}^{\infty} L_j \quad 7$$

There is no significant difference between the components of this table and that of the life table only that the incidence rate, I_x replaces the mortality experience, M_x in the latter.

ANALYSIS

The data used was obtained from the clinic department, Spintex Textile industry, Lagos, Nigeria. It contains information on the dates of resumption of work, onset of the disease for twenty employees (treated as cohort) who have been diagnosed in this regard (Table 1).

The basic task in the development of this table is to compute the estimate of the probability of developing disease in the time interval $(x, x+1)$ from the corresponding incidence rate I_x . Therefore, it is essential to:

- I. Determine the time interval of the onset of the disease.
- II. Calculate the incidence rates for period x .

Table 1: Date of employments and the onset of byssinosis for 20 employees

S/N	DATE OF EMPLOYMENT	DATE OF ONSET
1	03/02/1978	21/05/1985
2	05/02/1978	03/04/1983
3	01/02/1978	15/05/1985
4	14/08/1981	03/02/1987
5	07/08/1981	06/07/1989
6	02/02/1980	01/01/1985
7	11/03/1983	02/05/1991
8	02/01/1991	03/02/1994
9	21/04/1989	04/04/1997
10	03/03/1989	03/09/1997
11	12/06/1990	03/05/1998
12	04/08/1995	10/01/2002
13	17/07/1996	04/09/2000
14	04/05/1999	03/10/2003
15	04/12/2000	14/06/2007
16	01/01/1984	13/02/1993
17	02/07/1999	14/08/2005
18	09/05/2001	12/06/2006
19	18/08/1998	11/07/2003
20	02/08/2000	15/03/2007

Table 2: Length of time taken to develop the disease by the 20 employees in Table 1.

S/N	X'	X
1	7.25	7
2	5.17	5
3	7.25	7
4	6.08	6
5	7.90	7
6	4.90	4
7	8.17	8
8	3.00	3
9	8.00	8
10	8.50	8
11	7.90	7
12	6.58	6
13	4.17	4
14	4.42	4
15	6.50	6
16	9.08	9
17	6.08	6
18	5.08	5
19	4.83	4
20	6.42	6

Where X' represents the length of stay before the onset of the disease. X represents the length of stay before the onset of the disease to the nearest last birth day (or years). However, for the time interval $(x, x+1)$, we considered the period between the resumption of duty and the onset of the disease and represented it as x .

We then compute the incidence rates, I_x and the probability of developing a disease, q_x .

Table 3: Incidence rates using data of 20 employees in Table 2.

X	0	1	2	3	4	5	6	7	8	9
Number contracting the disease	-	-	-	1	4	2	5	4	3	1
I_x	0	0	0	1/20	4/19	2/15	5/13	4/8	3/4	1/1
I_x	0	0	0	0.05	0.2105	0.1333	0.3846	0.5	0.75	1.0

We thereafter proceeded on to compute other components of the table (Table 4).

Table 4: Occupational Hazard Table for the employees under consideration

S/N	x	l_x	I_x	q_x	p_x	L_x	T_x	e_x
1	3	1000	0.05	0.0488	0.9512	972	3751	3.751
2	4	952	0.2105	0.1985	0.8015	858	2779	2.919
3	5	763	0.1333	0.1250	0.8750	716	1921	2.518
4	6	668	0.3846	0.3226	0.6774	561	1205	1.803
5	7	453	0.5	0.4000	0.6000	363	644	1.422
6	8	272	0.75	0.5455	0.4545	198	281	1.033
7	9	124	1.0	0.6667	0.3333	83	83	0.669

$$\text{For Example, } q_3 = \frac{2I_3}{2+I_3} = \frac{2(0.05)}{2+0.05} = 0.0488$$

$$p_x = 1 - q_x \quad \text{For } P_3 = 1 - 0.04 = 0.9512$$

$$l_3: \text{Radix} = 1000 \quad l_{x+1} = l_x p_x$$

$$\text{For } l_4 = l_3 p_3 = 1000 \times 0.9512 = 951.2 \approx 952$$

$$L_3 = \frac{l_3 + l_{3+1}}{2} = \frac{l_3 + l_4}{2} = \frac{1000 + 952}{2} = 972$$

$$T_x = \sum_{j=3}^{14} L_j \quad \text{For } T_3 = 3751 \quad \text{For } e_3 = \frac{T_3}{l_3} = 3.751$$

RESULT AND CONCLUSION

Table 4 constructed in the previous section, e_x , the expected length of time someone who would have stayed up to 3 years in the job before contracting the disease was three years and eight months. Meaning he has three years and eight months thereabout to stay more before the onset of the disease if still exposed to it. Going by this, it implies that for a newly employed, who would be fresh in the job would have the expected period e_0 , (expected period of onset for a newly employed person), of 6.751 years (i.e. $e_0 = 3 + 3.751$), to stay before the onset of the ailment. That is the person would have stayed for 6 and half years or close to 7 years before the onset of the disease. Comparing our estimate for $e_0 = 6.751$ with the arithmetic mean length of stay of the employees (\bar{X}) in Table 2, which was six years four months we observe no significant difference, giving us confidence that our estimate is approximate correct. However, we intend to derive standard error of our estimate in the future to be able to build a level of confidence on the estimate and for future comparison and further research in this direction.

So, the employer having had prior knowledge of this should take appropriate measures to prevent such situation to arise. It is therefore imperative on any employer of labour to understand the nature of the associated occupational hazard due to the job and be able to determine the expected period of developing disease and or provide necessary precautionary measures to minimize or to avoid it completely.

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