# Expected Time To Developing Work-Related Hazard In Textile Industry.

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**Abstracts:** A work-related hazard table, called 'Occupational Hazard Table,' as proposed earlier, was used to estimate the expected period of exposure ($e_x$),before the ailment due to the specific occupation sets in. Subsequently, the variance and confidence interval are derived for $e_o$ , the expected time for a newly employed worker to have stayed before developing the disease. A set of data from a textile industry where byssinosis is the common occupational hazard is used. The expected period of a new employee of the considered company was obtained to be 6.701 years with the variance, standard error and the 95% confidence interval(C.I.), of 0.8439, 0.0267 and [6.5985, 6.804] respectively.

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**Key words**: Incidence rate, occupational hazard, probability of developing disease, expected period of developing disease.

## Introduction

The growth of any nation's economy is largely hinged on the readiness of the concerned government to encourage liberalization and permit private participation. However, there is rarely no industrial/production activity, which does not require the use of raw-materials, which mostly undergo processing. It is this art of processing that often expose the workers to one occupational hazard or the other. 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 whoever works in either 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 especially, the problem of these hazards is made worse by a lack of protective clothing or equipment[2,6] and is even compounded by lack of payment of compensation for work place injuries, as well as lack of sufficient occupational health core facilities[2].

World Health organization (WHO), in one of their surveys in October 2005 found out 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[4].

It is on the foregoing we deemed it necessary to be part of this discussion in order to save the society from risking most of its active population to these hazards.

Specifically in this work, we hope to construct occupational hazards table via life table, obtain the expected period $(e_x)$ of developing ailment due to the hazard, derive its variance and obtain the confidence interval for $(e_x)$ . Thus, this article has been grouped into six (6) sections. Section 1 introduces the topic, section 2 is dedicated to methodology; wherein the proposed table; occupational hazards table is discussed. Section 3 focuses on the derivation of the variance of expected period of developing the disease, section 4 has the confidence interval for the expected period of acquiring the disease, section 5 deals with the analysis while section 6 presents the results, observation and recommendation in brief.

## *Methodology*

### Occupational Hazards Table Via Life Table

In analyzing occupational hazards there is a need to obtain a table similar to a life table, which would enable us estimate the expected 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+1=* $x'$ *).*
**Column 2:** 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.
**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, $l_o$ is called the radix.
**Column 4:** Finite rate of survival, $p_x$ , during the periods *(x, x+1).*
**Column 5:** Number of years-persons stayed by the employees, who were considered together within the interval of time *(x, x+1=* $x'$ *),* $L_x$.
**Column 6:** Total number of years stayed 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:** Expected period of developing a disease at time *x*, $e_x$.

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

***Construction Of Occupational Hazards Table***

To construct the occupational hazard table, life table/mortality table, commonly used to determine life expectancy of an individual is used. As we know there are seven columns in a life table so we have in the proposed 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

$m_x$ is the ASDR/mortality experience for age *x; and*

$$m_x = \frac{\text{Number of deaths in the interval}(x, x+1)}{\text{People aged between } (x, x+1)}$$

$$= \frac{\text{Number of people who develop a disease}}{\text{Population at risk}}$$

$$= \frac{D_x}{P_x} \text{ or } \frac{D_x}{L_x} \quad \text{-------------------------- (2.1)}$$

$P_x$ (People aged *x* at mid-year calendar).
*Then,*

$$q_x = \frac{m_x}{1+\frac{1}{2}m_x} = \frac{2m_x}{2+m_x} \quad \text{------------ (2.2)}$$

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, $I_x = m_x$

$$= \frac{\text{Number of persons developing a disease}}{\text{Population at risk}}$$

$$= \frac{D_x}{P_x} \text{ or } \frac{D_x}{L_x}$$

Hence (2.2) becomes:

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

$$= \frac{2I_x}{2+I_x} \quad \text{--------------------------- (2.3)}$$

So, in the proposed table, we have the following as its columns:
**Column 1**: Time interval from employment till the day of the onset the day of 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.

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

$$= \frac{2I_x}{2+I_x}$$

Where
**Column 4**: probability of surviving a disease $p_x$

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

$$= \frac{2-I_x}{2+I_x} \quad \text{---------------------- (2.4)}$$

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

$$L_j = \frac{l_j + l_{j+1}}{2} \quad \text{------------------ (2.5)}$$

**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*.

$$T_x = \sum_{j=x}^{\infty} L_j \quad \text{------------------------------- (2.6)}$$

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

$$e_x = \frac{1}{l_x}\sum_{j=x}^{\infty} L_j \quad . \quad \text{-------------- (2.7)}$$

In fact, 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.

**Derivation Of Variance Of Expected Period ($e_x$) Of Acquiring Occupational Hazards**

Note; $e_x = \frac{T_x}{l_x}$ x = 0, 1, 2 …………….. 3.1

Where;

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

$$e_x = \frac{1}{l_x}\sum_{j=x}^{\infty} L_j \quad ………….. \quad 3.2$$

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

Then,

$$e_x = \frac{1}{l_x}\sum_{j=x}^{\infty}\left(\frac{l_j + l_{j+1}}{2}\right) \quad …………… \quad 3.3$$

Recall,

$$l_{j+1} = l_j P_j$$

$$e_x = \frac{1}{2l_x}\sum_{j=x}^{\infty}\left(l_j + l_j P_j\right) \quad …………… \quad 3.4$$

$$= \frac{1}{2}\sum_{j=x}^{\infty}\left(1+P_j\right)\frac{l_j}{l_x} \quad …………………….. \quad 3.5$$

Where,

$$\frac{l_j}{l_x} = \prod_{j=x}^{\infty} P_j$$

And $l_j = P_{j-1} l_{j-1}$ ……………. 3.6

For j = $x + i$

$l_j = P_{x+i-1} l_{x+i-1}$

$= P_{x+i-1} P_{x+i-2} l_{x+i-2}$

$= P_{x+i-1} P_{x+i-2} P_{x+i-3} \text{------------} l_x$ -----3.7

So, for

$j > x$

$$\frac{l_j}{l_x} = \prod_{j=x}^{\infty} P_j \cong P_j. \quad ……………………3.8$$

Therefore,

$$e \cong \frac{1}{2}\sum_{j=x}^{\infty}(1 + P_j)P_j \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 3.9$$

$$e_x \cong \frac{1}{2}\sum_{j=x}^{\infty}\left(P_j + P_j^2\right)$$

$$V(e_x) \cong \frac{1}{4}\sum_{j=x}^{\infty} V\left(P_j + P_j^2\right) \ldots\ldots\ldots\ldots\ldots\ldots 3.10$$

$$\approx \frac{1}{4}\sum_{j=x}^{\infty}\left[V(P_j) + V(P_j^2) + 2Cov(P_j, P_j^2)\right]$$

*where*

$$Cov(P_j P_j^2) = 0$$

$$V(e_x) \approx \frac{1}{4}\sum_{j=x}^{\infty}\left[\frac{P_j(1-P_j)}{l_j} + \frac{P_j(1-P_j)}{l_j} + P_j^2\right]$$

$$q_j = 1 - P_j$$

$$V\left(\hat{e}_x\right) \approx \frac{1}{4}\sum\left[\frac{\hat{p}_j \hat{q}_j}{l_j} + \frac{\hat{P}_j \hat{q}_j}{l_j} + \hat{P}_j^2\right]$$

$$\approx \frac{1}{4}\sum_{j=x}^{\infty}\left[\frac{2\left(\hat{p}_j \hat{q}_j\right) + l_j \hat{p}_j^2}{l_j}\right] \ldots\ldots\ldots\ldots\ldots\ldots 3.11$$

Underline assumptions:

(i) In (3.15), if j=x,

$$e_x = \frac{1}{2}\sum_{j=x}^{\infty}\left(1+P_j\right)$$

(ii) For j>x, (3.7), which is the product of proportions stops at the second product because beyond this point, the proportion reduces to zero. So based on this, (3.8)

$$\frac{l_j}{l_x} = \prod_{j=x}^{\infty}\hat{P}_j \approx P_j$$ is hereby obtained.

Consequently, (3.9) is arrived at.

**Construction Of 100 (1-$\alpha$) % Confidence Interval For Expected Period Of Acquisition By An Employee *($E_x$)***

By law of Central Limit Theorem (CLT), the 100(1-$\alpha$)% confidence interval (**C.I.**) for $e_x$ is given as:

$$\hat{e}_x \pm Z_{1-\alpha/2} S.E.(e_x) \quad \text{……………... 3.12}$$

Since $e_x$ is an aggregate of values; $S.E.(e_x) = \frac{s_{e_x}}{\sqrt{l_x}}$ Where $S_{e_x} = \sqrt{V(e_x)}$

**Analysis**

In this section, byssinosis, an occupational hazard common to textile or cotton spinning industry is considered. The data used were obtained from record of the clinic department of a textile industry, located in Lagos, Nigeria. The information on the dates of resumption of work and dates of onset of the disease by 30 different employees (treated as cohort) of the industry who have been diagnosed in this regard were obtained. Table 1 below has information on the length of time taken to develop the ailment.

Meanwhile, 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 $I_x$. Hence, it is necessary we;

I. Determine the time interval of the onset of the disease.

II. Compute the incidence rates for period *x*.

III.

**Table 1: Time taken to develop the disease by the 30 employees.**

| S/N | $X'$ | $X$ |
|---|---|---|
| 1 | 5.79 | 5 |
| 2 | 8.00 | 8 |
| 3 | 6.08 | 6 |
| 4 | 6.58 | 6 |
| 5 | 6.42 | 6 |
| 6 | 7.25 | 7 |
| 7 | 7.04 | 7 |
| 8 | 4.42 | 4 |
| 9 | 5.08 | 5 |
| 10 | 5.76 | 5 |
| 11 | 3.00 | 3 |
| 12 | 8.50 | 8 |
| 13 | 9.08 | 9 |
| 14 | 4.17 | 4 |
| 15 | 7.90 | 7 |
| 16 | 4.83 | 4 |
| 17 | 7.25 | 7 |
| 18 | 7.90 | 7 |
| 19 | 8.81 | 8 |
| 20 | 4.90 | 4 |
| 21 | 7.73 | 7 |
| 22 | 7.35 | 7 |
| 23 | 4.29 | 4 |
| 24 | 8.17 | 8 |
| 25 | 5.17 | 5 |
| 26 | 7.76 | 7 |
| 27 | 3.36 | 3 |
| 28 | 5.19 | 5 |
| 29 | 6.08 | 6 |
| 30 | 6.50 | 6 |

Where $X'$ stands for 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 full year. 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.

Incidence rates, $I_x$ as well as the probability of developing a disease, $q_x$ are thus computed.

**Table2: Incidence rates using data of 30 employees in Table 1.**

| $X$ | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|---|
| *Number contracting the disease* | - | - | - | 2 | 5 | 5 | 5 | 8 | 4 | 1 |
| $I_x$ | 0 | 0 | 0 | 2/30 | 5/28 | 5/23 | 5/18 | 8/13 | 4/5 | 1/1 |
| $I_x$ | 0 | 0 | 0 | 0.0667 | 0.1786 | 0.2174 | 0.2778 | 0.6154 | 0.8 | 1.0 |

Next we compute other components of the table as we have in the table3 below.

**Table 3: 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 | 0.0667 | 0.0645 | 0.9355 | 968 | 3701 | 3.701 |
| 2 | 4 | 936 | 0.1786 | 0.1640 | 0.8360 | 859 | 2733 | 2.920 |
| 3 | 5 | 782 | 0.2174 | 0.1961 | 0.8039 | 706 | 1874 | 2.396 |
| 4 | 6 | 629 | 0.2778 | 0.2439 | 0.7561 | 552 | 1168 | 1.857 |
| 5 | 7 | 475 | 0.6157 | 0.4708 | 0.5292 | 364 | 616 | 1.297 |
| 6 | 8 | 252 | 0.8 | 0.5714 | 0.4286 | 180 | 252 | 1.000 |
| 7 | 9 | 108 | 1.0 | 0.6667 | 0.3333 | 72 | 72 | 0.667 |

$$q_3 = \frac{2I_3}{2+I_3}$$

For Example, $\frac{2x\ 0.0667}{2+0.0667}$ = 0.0645

$p_x = 1 - q_x$ For $P_3 = 1 - 0.0645 = 0.9355$

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

For $l_4 = l_3 p_3$ = 1000 × 0.9355 = 935.5 ≈ 936

$$L_3 = \frac{l_3 + l_{3+1}}{2} = \frac{l_3 + l_4}{2} = \frac{1000+936}{2} = 968$$

$T_{x=} \sum_3^9 L_j$ For $T_3 = 3701$

$e_3 = \frac{T_3}{l_3}$ = 3.701

Hence, $e_0$ = 3+ 3.701 = 6.701

Now, using equation (3.11) we obtain the variance of the expected time to develop the disease as in the table below.

**Table 4: Variance of Expected Period ($e_x$) of Developing the Disease**

| S/N | $X$ | $l_x$ | $2(p_j q_j)$ | $l_j p_j^2$ | *col4+col5* | *Col6/col3* | $s_{e_x}^2$ | $S_{e_x}$ |
|---|---|---|---|---|---|---|---|---|
| 1 | 3 | 1000 | 0.1207 | 875.1603 | 875.2810 | 0.8753 | .8439 | 0.9186 |
| 2 | 4 | 936 | 0.2742 | 654.1667 | 654.4409 | 0.6992 | 0.6250 | 0.7906 |
| 3 | 5 | 782 | 0.3153 | 505.3716 | 505.6869 | 0.6467 | 0.4502 | 0.6909 |
| 4 | 6 | 629 | 0.3688 | 359.5913 | 359.9601 | 0.5723 | 0.2886 | 0.5347 |
| 5 | 7 | 475 | 0.4983 | 133.0250 | 133.5233 | 0.2811 | 0.1455 | 0.3814 |
| 6 | 8 | 252 | 0.4898 | 46.2919 | 46.7817 | 0.1856 | 0.0752 | 0.2743 |
| 7 | 9 | 108 | 0.4444 | 11.9976 | 12.4420 | 0.1152 | 0.0288 | 0.1698 |

In reference to table 4, it is clear that the variance, $s_{e_o}^2 = s_{e_3}^2 =$ 0.8439 with the corresponding standard deviation, $S_{e_0}$ = 0.9186.

Thus the 95% confidence interval (C.I), using (3.22) could be obtained as:

6.701 ± 1.96 (0.0267) = [6.5985, 6.804]

**Result And Conclusion**

In the previous section, $e_3$, the expected length of time an employee who would have stayed up to 3 years in the job before contracting the disease was 3.701years (**see Table 3**). That is he/she has approximately three years seven months to have worked before the onset of the disease if still exposed to it. Consequently, a newly employed, who is fresh in the job would have the expected period $e_0$, of 6.701years (i.e $e_o$ = 3 +3.701), approximately 6years seven months before the onset of the disease if exposed. Although this of course is dependent on a number of factors, which were not covered in this work. Comparing our estimate for $e_o$ =6.701 with the arithmetic mean length of stay of the employees (X') in **Table1,** which was 6.345years we observe no significant difference. Meanwhile the derivation and estimation of the variance, standard deviation and confidence interval for our estimate forms the central focus of this research as an extension to the previous work (by the first author) in this direction. The estimates of the variance and the 95% C.I. of $e_0$ as obtained in the analysis, are respectively, 0.8436 and [6.5985, 6.804].While comparing the variance of $e_0$ (0.8436) with that of mean length of stay ($X^1$), (2.6163), we are confident our estimator is better with the relative efficiency of approximately 32%. We thus strongly recommend the use of occupational hazards table in obtaining expected length of developing disease/ailment associated with job.

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 the disease and or provide necessary precautionary measures to minimize or to avoid it completely.

It is however to be noted that the name of the industry from which the data used in this work were obtained is kept off record for confidentiality.

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