

Prediction and Probabilistic Analysis of Accidents in Elevator Installation -Nigerian Experience

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Abstract
Elevator installation sector is one of the safe methods of vertical and horizontal travel in high rising buildings (skyscrappers), and sadly hundreds of people suffer extreme injury or death due to elevator installation accident. Most elevator accidents occur during installation of the elevator itself. This paper takes a closer look at elevators industry in Nigeria focusing on the occurence of installation of elevators accident. This paper applied input modelling simulation method to analyse elevator installation accidents occurrences in Nigeria elevator installation sector and develops a model that will predict the probability or risk of elevator installation accidents. Accident records for the period of 2009 were analyzed using probability distribution curve. A probability distribution curve which resembled Poisson distribution was developed. A point statistic estimator was used to confirm the distribution. Hence, a predictive probability model was developed in terms of average mean time between elevator installation accidents and number of operation days. The average mean time between accidents during this period was 73.03 with standard deviation of 67.93. The probability of elevator installation accident occurrence during this periods was 0.0143. The results of this research is an eye opener to the occurrence of accidents in the elevator installation sector. If the lipservice to safety which is the order of day in most service industries in Nigeria continues; the occurrence of accidents in the future will be overwhelming.
Keywords: Elevators, Installation, Risk, Shaft, Probability.

INTRODUCTION

Incidents involving elevators kill about 30 people and seriously injure about 1,700 people each year in Nigeria [2]. Elevators cause almost 90% of the deaths and 60% of serious injuries. Injuries to people working on or near elevators (installation of elevator while working) including those installing, repairing, and maintaining elevators, and working in or near elevator shafts – account for 14 (almost half) of the annual deaths. Half of the deaths of workers working in or near elevator shafts were due to falls into the shaft. Incidents where workers were caught in/between moving parts of elevators, are in or on elevators or platforms that collapse, or are struck by elevators or counterweights are also numerous[6].

Elevators are potential sources of serious injuries and deaths to the general public and to workers installing, repairing, and maintaining them. Workers are at risk also, for instance, when cleaning elevator shafts, conducting emergency evacuations of stalled elevators, or doing construction near open shafts. State and local authorities recognize such hazards and require periodic inspections of elevators and escalators[7]. Organizations such as the Nigeria Society of Mechanical Engineers (NSME) have set standards for the construction and maintenance of elevators and escalators and for their safe operation[3].

METHODOLOGY

The approach involves input probability modelling simulation of the occurrence of intallation accident for the year 2009. The elevator installation accidents/incidents analyzed were gotten from a major elevator installation firm in South-Western Nigeria. Data were collected for monthly installation accident occurence for the year 2009 and were used to analyse the frequency of installation accident. The data were grouped into two namely. Data for the period were collected. The time interval between the occurrences of consecutive elevator accidents were determined and grouped into class interval with different class width in the range 10, 15, 25, 35 and 50 respectively; a bar chart was drawn for each of these ranges. The smoothest looking bar chart was picked to determine the probability distribution of the data. According to these bar charts, range 30 appears to give the smoothest shape that resembles a Poisson mass function for periods as shown in Figure 1.

Civil and Environmental Research
ISSN 2224-5790 (Paper) ISSN 2225-0514 (Online)
Vol.7, No.5, 2015

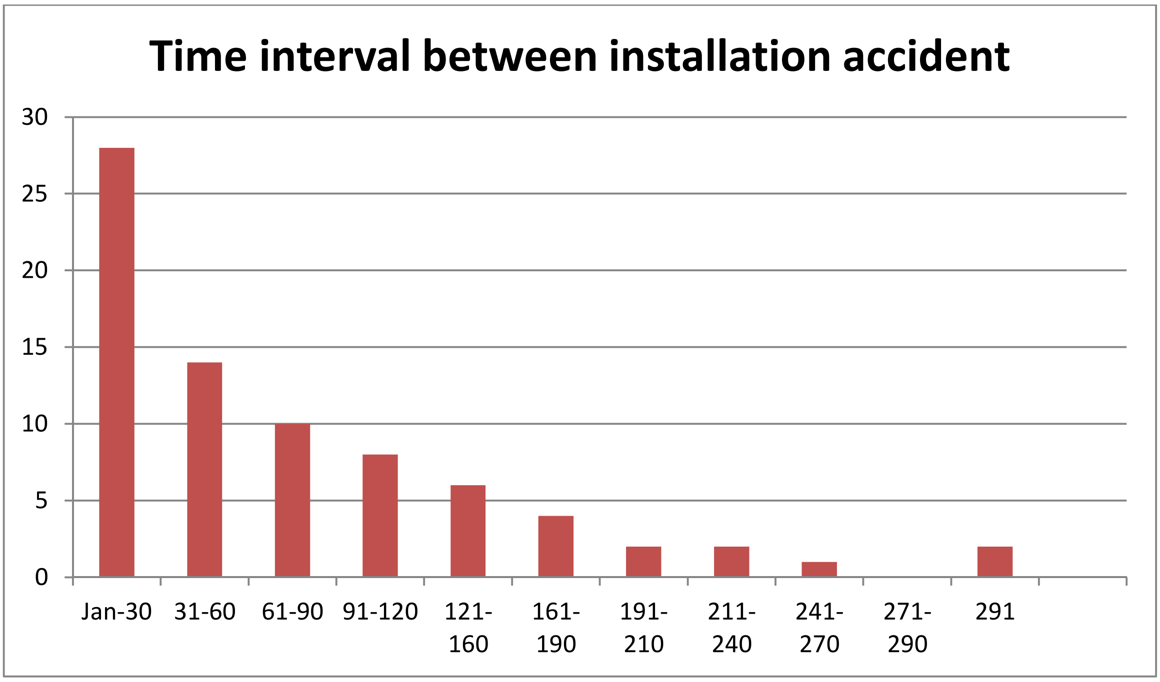

Figure.2: Bar Chart showing Distribution of time intervals between consecutive installation Accidents.

This graph is a discrete distribution graph where $\sigma = \frac{\sqrt{vari(x)}}{\bar{x}}$ is a point statistic estimator to affirm the likely probability distribution of data collected. The point statistics is calculated using this formula

$$\sigma = \frac{\sqrt{vari(x)}}{\bar{x}} \quad \text{..} \ (5)$$

The result $\frac{\sqrt{vari(x)}}{\bar{x}} < 1$ might suggest a binomial distribution; near 1 suggest a Poisson distribution while $\frac{\sqrt{vari(x)}}{\bar{x}} > 1$ would be characteristic of negative binomial or geometric. From the data obtained, the probability distribution is calculated using the formula above.

Table 1: Elevator installation accidents records during period of under review.

Range	X	*No of installation Accident occurrence (f)*	Fx	$(x - \bar{x})$	$(x - \bar{x})^2$	$f(x - \bar{x})^2$
1 – 30	15.5	28	434	-45.03	2027.70	56775.6
31 – 60	45.5	14	637	-27.53	730.62	10228.68
61 – 90	75.5	10	755	-2.47	6.10	61.0
91 – 120	105.5	8	844	32.47	1025.92	3207.36
121 - 160	140.5	6	843	67.47	4552.20	27313.2
161– 190	175.5	4	702	102.47	10500.10	42000.4
191 – 210	200.5	2	401	127.47	16248.60	32497.2
211 – 240	225.5	2	451	152.47	23247.10	46494.2
241 – 270	255.5	1	255.5	182.47	33295.30	33295.30
271 – 290	280.5	0	0	207.47	43043.80	0
291 – 310	300.5	2	301	227.47	51742.60	103485.2
		$\sum = 77$	$\sum = 5623.4$			$\sum = 355358.14$

MEAN $= \frac{\sum f(x)}{\sum f}$

$= \frac{5623.4}{77}$

$= 73.03$

Standard deviation $= \sqrt{\frac{\sum f(x-\bar{x})^2}{\sum f}}$

$= \frac{355358.14}{77}$

$= 67.93$

Therefore, point statistic estimator for this probability distribution

$= \frac{\sqrt{vari(x)}}{\bar{x}}$

= 67.93/77

= 0.88

This value is near 1 which suggests that the probability distribution for installation accidents occurrences is a Poisson distribution.

RESULTS

So it was established that the occurrence of runway accidents in Nigeria aviation sector is Poisson distribution. This work agrees quantitatively with work done by [10]. Therefore, the probability of occurrence of runway accident is given by the Poisson mass function as follows:

$P(T \leq t) = 1 - e^{-\lambda t}$..............................1

Where λ = runway accident causation factor. It is estimated as the mean time between the occurrences of runway accidents.

From equation 1 above, it is shown that

$\lambda = \frac{1}{T_a}$ 2

where T_a is the average time interval between runway accidents. Consider safety period,

$T_a = 70.03$, therefore $\lambda = \frac{1}{70.03} = 0.0143$

Using equation 1, it is possible to predict the probability of occurrence of runway accidents.

$P(T \leq t) = 1 - e^{-0.0143t}$ $t \geq 0$..............................3

Table 2: Assessment of probability of runway accidents in day's interval

Time interval between runway accident in days (t)	λt	$1 - e^{-0.0143t}$
1	0.0143	0.0142
26	0.3718	0.3105
51	0.7293	0.5178
76	1.0868	0.6627
101	1.4430	0.7639
126	1.8918	0.8491
151	2.1593	0.8846
176	2.5158	0.9192
201	2.8743	0.9435
226	3.2318	0.9605
251	3.5883	0.9724
276	3.9468	0.9807
301	4.3043	0.9881
326	4.6618	0.9906
351	5.0193	0.9934

Using the equation 1 above, we can predict the probability of occurrence of elevator installation accident in the elevator installation sector. Table 2 above shows the prediction of probability of elevator installation accident over operating days while Figure 2 shows the exponential distribution of elevator installation accidents..

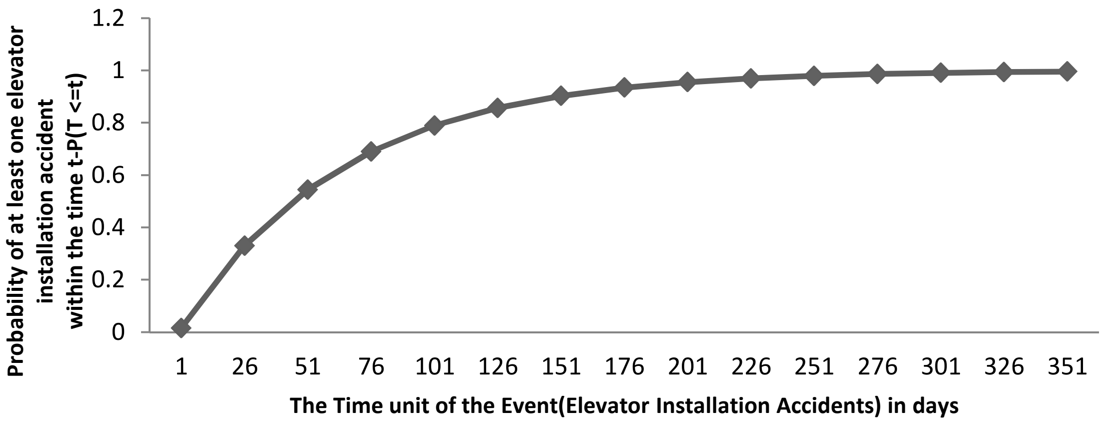

Fig 2: Dependence of the probability of the occurrence of at least one elevator installation accident within time interval t (in day, probability of at least one elevator installation accident within the time t – P (T ≤ t)

DISCUSSION

This study uses sample of 77 accidents in the year under investigation. The distribution of time interval between occurrences of accidents is shown in Figure 1. Data analysis provides an estimate of the accident causation factor for the period: $\lambda = 0.0143$ accidents per day. A further analysis of time interval between accidents indicates they have been independently and exponentially distributed (a point statistic estimator confirms the distribution matching the empirical and theoretical data) [9], [10]. This offers confirmation that the observed pattern of accident during this period can be treated as Poisson process. This present study has revealed that the probability of elevator installation accidents in the sector. So, if there is unlikely to be any improvement on safety activities then the exponential distribution that describe the occurrence of elevator installation accidents can be used for predicting the probability of future events. Figure 2 illustrate the probability of occurrence of at least one elevator installation accident per period t.

CONCLUSION

The study has presented an input modelling methodology for probabilistic modelling of elevator installation accidents occurrence. The behaviour of elevator installation accidents is Poisson-event and the probability distribution is exponential. This can be use to predict the probability of elevator installation accidents occurrence in Nigeria. The chance of elevator installation accidents occurrence increase in days, for instance the probability of at least one elevator installation accidents occurring from now is 0.0143 and from 26 days is 0.3105. It is pertinent to state that this methodology can be useful in evaluating the performance of elevator installation safety activities.

REFERENCES

[1] Jonathan C and Andrew W. (1995).Shepherd Inventory Credit – An approach to developing agricultural markets, FAO, Rome.
[2] Hax, A.C. and Candea, D. (1984). Production and Operations Management. Prentice-Hall, Englewood Cliffs, NJ, pp. 135, http://catalogue.nla.gov.au/Record/772207.
[3] Blazewicz, J., Ecker, K.H., Pesch, E., Schmidt, G. und Weglarz J. (2001). Scheduling Computer and Manufacturing Processes. Berlin (Springer). ISBN 3-540-41931-4.
[4] Fleischmann, M., (2001). Quantitative Models for Reverse Logistic, Lecture Notes in Economics and Mathematical Systems 501. Springer-Verlag, Berlin.
[5] Schrady, D., (1967). A deterministic inventory model for repairable items. Naval Research Logistics 14, 391–398.
[6] Silver, E.A., D.F. Pyke and R. Peterson,(1998) Inventory Management and Production Planning and Scheduling, Third Edition, John Wiley & Sons, New York.
[7] Tersine, R.J (1994), Principles of Inventory and Materials Management, Fourth Edition, Prentce Hall, Prentice Hall, Englewood Cliffs, NJ
[8] Miles John. (1994). Elevator Industry Employees Working In and Around Pits and Equipment. 9/19/94. OSHA Standards Interpretations and Compliance Letters. OSHA .
[9] A.M. Law and W.D. Kelton, Simulation, Modelling and Analysis. Second Edition, Mc Graw-Hill., (1991).
[10] O.O. Akinyemi and O.T. Koyejo, Priority Dispatch Scheduling in an Automobile Repair and Maintenance Workshop. *Journal of Engineering Science and Technology.* (2011), Vol.6, (606 – 618).