Research Article

Cost -Benefit Analysis of Two Similar Cold Standby System subject to failure due to influenza infections and failure due to a sore throat, rash, body aches, headaches, chills, nausea, vomiting, and diarrhea caused by H1N1 virus due to swine flu

Ashok Kumar Saini

Associate Professor, Department of Mathematics, B. L. J. S. College, Tosham, Bhiwani, Haryana, INDIA.
Email: drashokksaini2009@gmail.com

Abstract

Swine influenza, also called pig influenza, swine flu, hog flu and pig flu, is an infection caused by any one of several types of swine influenza viruses. Swine influenza virus (SIV) or swine-origin influenza virus (S-OIV) is any strain of the influenza family of viruses that is endemic in pigs. As of 2009, the known SIV strains include influenza C and the subtypes of influenza A known as H1N1, H1N2, H2N1, H3N1, H3N2, and H2N3. Swine influenza virus is common throughout pig populations worldwide. Transmission of the virus from pigs to humans is not common and does not always lead to human flu, often resulting only in the production of antibodies in the blood. If transmission does cause human flu, it is called zoonotic swine flu. People with regular exposure to pigs are at increased risk of swine flu infection. Around the mid-20th century, identification of influenza subtypes became possible, allowing accurate diagnosis of transmission to humans. Since then, only 50 such transmissions have been confirmed. These strains of swine flu rarely pass from human to human. Symptoms of zoonotic swine flu in humans are similar to those of influenza and of influenza-like illness in general, namely chills, fever, sore throat, muscle pains, severe headache, coughing, weakness and general discomfort. In August 2010, the World Health Organization declared the swine flu pandemic officially over. In this paper we have taken failure due to influenza infections: fever (100 F or greater), cough, nasal secretions, fatigue, and headache, with fatigue and failure due to a sore throat, rash, body aches, headaches, chills, nausea, vomiting, and diarrhea caused by H1N1 virus due to swine flu. When the main unit fails then cold standby system becomes operative. Failure due to a sore throat, rash, body aches, headaches, chills, nausea, vomiting, and diarrhea caused by H1N1 virus due to swine flu cannot occur simultaneously in both the units and after failure the unit undergoes Type-I or Type-II or Type-III repair facility immediately. Applying the regenerative point technique with renewal process theory the various reliability parameters MTSF, Availability, Busy period, Cost Benefit analysis have been evaluated.

Keywords: Cold Standby, failure due to influenza infections: fever (100 F or greater), cough, nasal secretions, fatigue, and headache, with fatigue and failure due to a sore throat, rash, body aches, headaches, chills, nausea, vomiting, and diarrhea caused by H1N1 virus due to swine flu, first come first serve, MTSF, Availability, Busy period, Cost Benefit Analysis.

***Address for Correspondence:**
Dr. Ashok Kumar Saini, Associate Professor, Department of Mathematics, BLJS College, Tosham, Bhiwani, Haryana, INDIA.
Email: drashokksaini2009@gmail.com

Received Date: 23/02/2014 Accepted Date: 24/10/2014

Access this article online	
Quick Response Code:	Website: www.statperson.com
	DOI: 10 February 2015

INTRODUCTION

H1N1 virus pandemic history: A study conducted in 2008, and published in the journal Nature, has managed to establish the evolutionary origin of the flu strain of swine origin (S-OIV). The phylogenetic origin of the flu virus that caused the 2009 pandemics can be traced before 1918. Around 1918, the ancestral virus, of avian origin, crossed the species boundaries and infected humans as human H1N1. The same phenomenon took place soon after in America, where the human virus was infecting pigs; it led to the emergence of the H1N1 swine strain, which later became the classic swine flu. New events of reassortment were not reported until 1968, when the avian strain H1N1 infected humans again; this time the virus met the strain H2N2, and the reassortment originated the strain H3N2. This strain has remained as a stable flu strain until now. The mid-1970s were important for the evolution of flu strains. First, the re-emergence of the human H1N1 strain became a seasonal strain. Then, a small outbreak of swine H1N1 occurred in humans, and finally, the human H2N2 strain apparently became extinct. Around 1979, the avian H1N1 strain infected pigs and gave rise to Euroasiatic swine flu and H1N1 Euroasiatic swine virus, which is still being transmitted in swine populations. The critical moment for the 2009 outbreak was between 1990 and 1993. A triple reassortment event in a pig host of North American H1N1 swine virus, the human H3N2 virus and avian H1N1 virus generated the swine H1N2 strain. Finally, the last step in S-OIV history was in 2009, when the virus H1N2 co-infected a human host at the same time as the Euroasiatic H1N1 swine strain. This led to the emergence of a new human H1N1 strain, which caused the 2009 pandemic. On June 11, 2009, the World Health Organization raised the worldwide pandemic alert level to Phase 6 for swine flu, which is the highest alert level. This alert level means that the swine flu had spread worldwide and there were cases of people with the virus in most countries. The pandemic level identifies the spread of the disease or virus and not necessarily the severity of the disease. Swine flu spread very rapidly worldwide due to its high human-to-human transmission rate and due to the frequency of air travel. In 2015 the instances of swine flu substantially increased to five year highs with over 10000 cases reported and 660 deaths in India. What are the symptoms of swine flu? Symptoms of swine flu are similar to most influenza infections: fever (100 F or greater), cough, nasal secretions, fatigue, and headache, with fatigue being reported in most infected individuals. Some patients may also get a sore throat, rash, body aches, headaches, chills, nausea, vomiting, and diarrhea. In Mexico, many of the initial patients infected with H1N1 influenza were young adults, which made some investigators speculate that a strong immune response, as seen in young people, may cause some collateral tissue damage. The incubation period from exposure to first symptoms is about one to four days, with an average of two days. The symptoms last about one to two weeks and can last longer if the person has a severe infection. Some patients develop severe respiratory symptoms and need respiratory support (such as a ventilator to breathe for the patient). Patients can get pneumonia (bacterial secondary infection) if the viral infection persists, and some can develop seizures. Death often occurs from secondary bacterial infection of the lungs; appropriate antibiotics need to be used in these patients. The usual mortality (death) rate for typical influenza A is about 0.1%, while the 1918 "Spanish flu" epidemic had an estimated mortality rate ranging from 2%-20%. Swine (H1N1) flu in Mexico had about 160 deaths and about 2,500 confirmed cases, which would correspond to a mortality rate of about 6%, but these initial data were revised and the mortality rate worldwide was estimated to be much lower. Fortunately, the mortality rate of H1N1 remained low and similar to that of the conventional flu (average conventional flu mortality rate is about 36,000 per year; projected H1N1 flu mortality rate was 90,000 per year in the U.S. as determined by the president's advisory committee, but it never approached that high number). Fortunately, although H1N1 developed into a pandemic (worldwide) flu strain, the mortality rate in the U.S. and many other countries only approximated the usual numbers of flu deaths worldwide. Speculation about why the mortality rate remained much lower than predicted includes increased public awareness and action that produced an increase in hygiene (especially hand washing), a fairly rapid development of a new vaccine, and patient self-isolation if symptoms developed. Stochastic behavior of systems operating under changing environments has widely been studied. Dhillon, B.S. and Natesan, J. (1983) studied an outdoor power systems in fluctuating environment. Kan Cheng (1985) has studied reliability analysis of a system in a randomly changing environment. Jinhua Cao (1989) has studied a man machine system operating under changing environment subject to a Markov process with two states. The change in operating conditions viz. fluctuations of voltage, corrosive atmosphere, very low gravity etc. may make a system completely inoperative. Severe environmental conditions can make the actual mission duration longer than the ideal mission duration. In this paper we have taken failure due to influenza infections: fever (100 F or greater), cough, nasal secretions, fatigue, and failure due to headache, a sore throat, rash, body aches, headaches, chills, nausea, vomiting, and diarrhea caused by H1N1 virus due to swine flu. When the main unit fails then cold standby system becomes operative. Failure due to a sore throat, rash, body aches, headaches, chills, nausea, vomiting, and diarrhea caused by H1N1 virus due to swine flu cannot occur simultaneously in both the units and after failure the unit undergoes repair facility of Type-I or Type- II by doctor called here ordinary repairman or Type III by multispecialty doctor called here multispecialty repairman in case of failure due to a sore throat, rash, body aches, headaches, chills, nausea, vomiting, and diarrhea caused by H1N1 virus due to swine flu immediately. The repair is done on the basis of first fail first repaired.

ASSUMPTIONS

1. λ_1, λ_2 are constant failure rates when failure due to influenza infections: fever (100 F or greater), cough, nasal secretions, fatigue, and headache, with fatigue and failure due to a sore throat, rash, body aches, headaches, chills, nausea, vomiting, and diarrhea caused by H1N1 virus due to swine flu respectively. The CDF of repair time distribution of Type I, Type II and multispecialty repairmen Type-III are $G_1(t)$, $G_2(t)$ and $G_3(t)$.
2. The failure due to failure due to a sore throat, rash, body aches, headaches, chills, nausea, vomiting, and diarrhea caused by H1N1 virus due to swine flu is non-instantaneous and it cannot come simultaneously in both the units.
3. The repair starts immediately after failure due to influenza infections: fever (100 F or greater), cough, nasal secretions, fatigue, and headache, with fatigue and failure due to a sore throat, rash, body aches, headaches, chills, nausea, vomiting, and diarrhea caused by H1N1 virus due to swine flu and works on the principle of first fail first repaired basis.
4. The repair facility does no damage to the units and after repair units are as good as new.
5. The switches are perfect and instantaneous.
6. All random variables are mutually independent.
7. When both the units fail, we give priority to operative unit for repair.
8. Repairs are perfect and failure of a unit is detected immediately and perfectly.
9. The system is down when both the units are non-operative.

Notations

λ_1, λ_2 - failure rates for failure due to influenza infections: fever (100 F or greater), cough, nasal secretions, fatigue, and headache, with fatigue and failure due to a sore throat, rash, body aches, headaches, chills, nausea, vomiting, and diarrhea caused by H1N1 virus due to swine flu respectively. $G_1(t)$, $G_2(t)$, $G_3(t)$ – repair time distribution Type –I, Type-II, Type III due to influenza infections: fever (100 F or greater), cough, nasal secretions, fatigue, and headache, with fatigue; due to a sore throat, rash, body aches, headaches, chills, nausea, vomiting, and diarrhea caused by H1N1 virus due to swine flu; repair by the multispecialty repairman respectively. p, q - probability of failure due to influenza infections: fever (100 F or greater), cough, nasal secretions, fatigue, and headache, with fatigue and failure due to a sore throat, rash, body aches, headaches, chills, nausea, vomiting, and diarrhea caused by H1N1 virus due to swine flu respectively such that p+ q=1

$M_i(t)$ System having started from state i is up at time t without visiting any other regenerative state

$A_i(t)$ state is up state at instant t

$R_i(t)$ System having started from state i is busy for repair at time t without visiting any other regenerative state.

$B_i(t)$ the server is busy for repair at time t.

$H_i(t)$ Expected number of visits by the server for repairing given that the system initially starts from regenerative state i

SYMBOLS FOR STATES OF THE SYSTEM

Superscripts: O, CS, IIF1, HVDF2

Operative, Cold Standby, failure due to influenza infections: fever (100 F or greater), cough, nasal secretions, fatigue, and headache, with fatigue and failure due to a sore throat, rash, body aches, headaches, chills, nausea, vomiting, and diarrhea caused by H1N1 virus due to swine flu respectively.

Subscripts: niif1, iif1, hvdf2, ur, wr, uR

No failure due to influenza infections: fever (100 F or greater), cough, nasal secretions, fatigue, and headache, with fatigue ;failure due to influenza infections: fever (100 F or greater), cough, nasal secretions, fatigue, and headache, with fatigue ; failure due to a sore throat, rash, body aches, headaches, chills, nausea, vomiting, and diarrhea caused by H1N1 virus due to swine flu, under repair, waiting for repair, under repair continued from previous state respectively

Up states: 0, 1, 2, 3, 8, 9;

Down states: 4, 5, 6, 7

Regeneration point: 0, 1, 2, 3, 8, 9

States of the System

$0(O_{niif1}, CS_{niif1})$

One unit is operative and the other unit is cold standby and there is no failure due to influenza infections: fever (100 F or greater), cough, nasal secretions, fatigue, and headache, with fatigue in both the units.

1($IIF1_{iif1, urI}$, O_{niif1})

The operating unit fails due to influenza infections: fever (100 F or greater), cough, nasal secretions, fatigue, and headache, with fatigue and is under repair immediately of Type- I and standby unit starts operating with no failure due to influenza infections: fever (100 F or greater), cough, nasal secretions, fatigue, and headache, with fatigue.

2($HVDF2_{hvdf2, urII}$, O_{niif1})

The operative unit fails due to a sore throat, rash, body aches, headaches, chills, nausea, vomiting, and diarrhea caused by H1N1 virus due to swine flu and undergoes repair of type II and the standby unit becomes operative with no failure due to influenza infections: fever (100 F or greater), cough, nasal secretions, fatigue, and headache, with fatigue.

3($HVDF2_{hvdf2, urIII}$, O_{niif1})

The first unit fails due to a sore throat, rash, body aches, headaches, chills, nausea, vomiting, and diarrhea caused by H1N1 virus due to swine flu and under Type-III multispecialty repairman and the other unit is operative with no failure due to influenza infections: fever (100 F or greater), cough, nasal secretions, fatigue, and headache, with fatigue.

4($IIF1_{iif1,uR1}$, $IIF1_{iif1,wrI}$)

The unit failed due to IIF1 resulting from failure due to influenza infections: fever (100 F or greater), cough, nasal secretions, fatigue, and headache, with fatigue is under repair of Type- I continued from state 1and the other unit failed due to IIF1 resulting from failure due to influenza infections: fever (100 F or greater), cough, nasal secretions, fatigue, and headache, with fatigue is waiting for repair of Type-I.

5($IIF1_{iif1,uR1}$, $HVDF2_{hvdf2, wrII}$)

The unit failed due to IIF1 resulting from failure due to influenza infections: fever (100 F or greater), cough, nasal secretions, fatigue, and headache, with fatigue is under repair of Type- I continued from state 1and the other unit fails also due to a sore throat, rash, body aches, headaches, chills, nausea, vomiting, and diarrhea caused by H1N1 virus due to swine flu is waiting for repair of Type- II.

6($HVDF2_{hvdf2, uRII}$, $IIF1_{iif1, wrI}$)

The operative unit fails due to a sore throat, rash, body aches, headaches, chills, nausea, vomiting, and diarrhea caused by H1N1 virus due to swine flu and under repair continues from state 2 of Type –II and the other unit is failed due to IIF1 resulting from failure due to influenza infections: fever (100 F or greater), cough, nasal secretions, fatigue, and headache, with fatigue and waiting for repair of Type-I.

7($HVDF2_{hvdf2, uRII,}$ $IIF1_{iif1,wrII}$)

The one unit fails due to a sore throat, rash, body aches, headaches, chills, nausea, vomiting, and diarrhea caused by H1N1 virus due to swine flu is continued to be under repair of Type II and the other unit failed due to IIF1 resulting from Failure due to influenza infections: fever (100 F or greater), cough, nasal secretions, fatigue, and headache, with fatigue is waiting for repair of Type-II

8($IIF1_{iif1,urIII,}$ $HVDF2_{hvdf2, wrII}$)

The one unit fails due to influenza infections: fever (100 F or greater), cough, nasal secretions, fatigue, and headache, with fatigue is under multispecialty repair of Type-III and the other unit is failed due to a sore throat, rash, body aches, headaches, chills, nausea, vomiting, and diarrhea caused by H1N1 virus due to swine flu is waiting for repair of Type-II.

9($IIF1_{iif1,urIII}$, $HVDF2_{hvdf2, wrI}$)

The one unit fails due to influenza infections: fever (100 F or greater), cough, nasal secretions, fatigue, and headache, with fatigue is under multispecialty repair of Type-III and the other unit is failed due to a sore throat, rash, body aches, headaches, chills, nausea, vomiting, and diarrhea caused by H1N1 virus due to swine flu is waiting for repair of Type-I

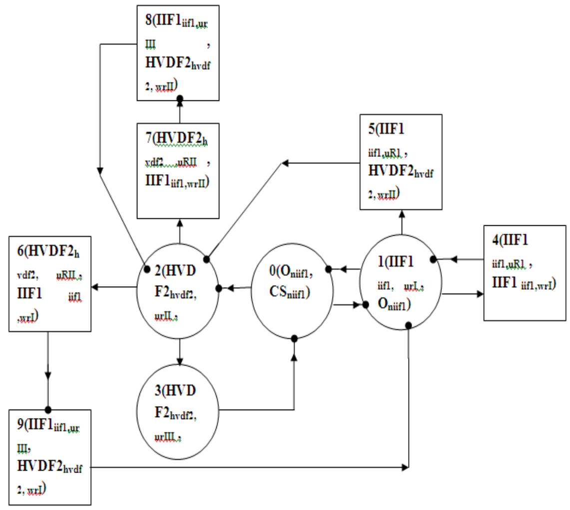

Figure 1: The State Transition Diagram

● Rregeneration point ○ Up State □ Down State

TRANSITION PROBABILITIES

Simple probabilistic considerations yield the following expressions:

$p_{01} = \lambda_1 / \lambda_1 + \lambda_2,\ p_{02} = \lambda_2 / \lambda_1 + \lambda_2,\ p_{10} = pG_1^*(\lambda_1) + q\,G_2^*(\lambda_2),$

$p_{14} = p - pG_1^*(\lambda_1) = p_{11}^{(4)},$

$p_{15} = q - q\,G_1^*(\lambda_2) = p_{12}^{(5)},$

$p_{23} = pG_2^*(\lambda_1) + q\,G_2^*(\lambda_2),\ p_{26} = p - pG_2^*(\lambda_1) = p_{29}^{(6)},$

$p_{27} = q - qG_2^*(\lambda_2) = p_{28}^{(7)},\ p_{30} = p_{82} = p_{91} = 1$ (1)

We can easily verify that

$p_{01} + p_{02} = 1,\ p_{10} + p_{14}\ (=p_{11}^{(4)}) + p_{15}\ (=p_{12}^{(5)}) = 1,$

$p_{23} + p_{26}\ (=p_{29}^{(6)}) + p_{27}\ (=p_{28}^{(7)}) = 1$ (2)

And mean sojourn time is

$\mu_0 = E(T) = \int_0^{\infty} P[T > t]\,dt$

Mean Time to System Failure

$Ø_0(t) = Q_{01}(t)[s]\ Ø_1(t) + Q_{02}(t)[s]\ Ø_2(t)$

$Ø_1(t) = Q_{10}(t)[s]\ Ø_0(t) + Q_{14}(t) + Q_{15}(t)$

$Ø_2(t) = Q_{23}(t)[s]\ Ø_3(t) + Q_{26}(t) + Q_{27}(t)$

$Ø_3(t) = Q_{30}(t)[s]\ Ø_0(t)$ (3-6)

We can regard the failed state as absorbing

Taking Laplace-Stiljes transform of eq. (3-6) and solving for

$ø_0^*(s) = N_1(s) / D_1(s)$ (6)

where

$N_1(s) = Q_{01}^*[\,Q_{14}^*(s) + Q_{15}^*(s)\,] + Q_{02}^*[\,Q_{26}^*(s) + Q_{27}^*(s)\,]$

$D_1(s) = 1 - Q_{01}^*\,Q_{10}^* - Q_{02}^*\,Q_{23}^*\,Q_{30}^*$

Making use of relations (1) and (2) it can be shown that $ø_0^*(0) = 1$, which implies that $ø_0(t)$ is a proper distribution.

$$MTSF = E[T] = \left.\frac{d}{ds}\,ø_0^*(s)\right|_{s=0} = (D_1'(0) - N_1'(0)) / D_1(0)$$

$= (\mu_0 + p_{01}\,\mu_1 + p_{02}\,\mu_2) / (1 - p_{01}\,p_{10} - p_{02}\,p_{23})$

where

$\mu_0 = \mu_{01} + \mu_{02},$

$\mu_1 = \mu_{10} + \mu_{11}^{(4)} + \mu_{12}^{(5)},$

$\mu_2 = \mu_{23} + \mu_{28}^{(7)} + \mu_{29}^{(6)}$

AVAILABILITY ANALYSIS

Let $M_i(t)$ be the probability of the system having started from state i is up at time t without making any other regenerative state. By probabilistic arguments, we have

$M_0(t) = e^{-\lambda_1 t} e^{-\lambda_2 t}$, $M_1(t) = p\, \bar{G}_1(t)\, e^{-\lambda_1 t}$

$M_2(t) = q\, \bar{G}_2(t)$, $M_3(t) = \bar{G}_3(t)$

The point wise availability $A_i(t)$ have the following recursive relations

$A_0(t) = M_0(t) + q_{01}(t)[c]A_1(t) + q_{02}(t)[c]A_2(t)$

$A_1(t) = M_1(t) + q_{10}(t)[c]A_0(t) + q_{12}^{(5)}(t)[c]A_2(t) + q_{11}^{(4)}(t)[c]A_1(t),$

$A_2(t) = M_2(t) + q_{23}(t)[c]A_3(t) + q_{28}^{(7)}(t)[c]\, A_8(t) + q_{29}^{(6)}(t)]\, [c]A_9(t)$

$A_3(t) = M_3(t) + q_{30}(t)[c]A_0(t)$

$A_8(t) = q_{82}(t)[c]A_2(t)$

$A_9(t) = q_{91}(t)[c]A_1(t)$ (7-11)

Taking Laplace Transform of eq. (7-11) and solving for $\hat{A}_0(s)$

$$\hat{A}_0(s) = N_2(s) / D_2(s) \quad (12)$$

where

$$N_2(s) = \hat{M}_0 [\{1 - \hat{q}_{11}^{(4)}\}\{1- \hat{q}_{28}^{(7} \hat{q}_{82}\}- \hat{q}_{12}^{(5)} \hat{q}_{29}^{(6)} \hat{q}_{91}] + \hat{q}_{01}[\hat{M}_1\{1 - \hat{q}_{28}^{(7)} \hat{q}_{82}\} + \hat{q}_{12}^{(5)} \hat{q}_{23} \hat{M}_3] + \hat{q}_{02}[\{\hat{q}_{23} \hat{M}_3 + \hat{M}_2\}\{1 - \hat{q}_{11}^{(4)}\} + \hat{q}_{29}^{(6)}) \hat{q}_{91} \hat{M}_1]$$

$$D_2(s) = \{1 - \hat{q}_{11}^{(4)}\}\{1- \hat{q}_{28}^{(7} \hat{q}_{82}\}- \hat{q}_{12}^{(5)} \hat{q}_{29}^{(6)} \hat{q}_{91} - \hat{q}_{01}[\hat{q}_{10}\{1 - \hat{q}_{28}^{(7)} \hat{q}_{82}\} + \hat{q}_{12}^{(5)} \hat{q}_{23}] - \hat{q}_{02}[\{\hat{q}_{23} \hat{q}_{30}\{1 - \hat{q}_{11}^{(4)}\} + \hat{q}_{29}^{(6)} \hat{q}_{91} \hat{q}_{10}]$$

(Omitting the arguments s for brevity)

The steady state availability

$$A_0 = \lim_{t\to\infty}[A_0(t)] = \lim_{s\to 0}[s\,\hat{A}_0(s)] = \lim_{s\to 0}\frac{s\,N_2(s)}{D_2(s)}$$

Using L' Hospitals rule, we get

$$A_0 = \lim_{s\to 0}\frac{N_2(s)+s\,N_2'(s)}{D_2'(s)} = \frac{N_2(0)}{D_2'(0)} \quad (13)$$

The expected up time of the system in (0,t] is

$$\lambda_u(t) = \int_0^{\infty} A_0(z)\,dz \text{ So that } \bar{\lambda}_u(s) = \frac{\hat{A}_0(s)}{s} = \frac{N_2(S)}{sD_2(S)} \quad (14)$$

The expected down time of the system in (0, t] is

$$\lambda_d(t) = t- \lambda_u(t) \text{ So that } \bar{\lambda}_d(s) = \frac{1}{s^2} - \bar{\lambda}_u(s) \quad (15)$$

The expected busy period of the server when there is failure due to Failure due to a sore throat, rash, body aches, headaches, chills, nausea, vomiting, and diarrhea caused by H1N1 virus due to swine flu and Failure due to influenza infections: fever (100 F or greater), cough, nasal secretions, fatigue, and headache, with fatigue in (0,t] - R_0

$R_0(t) = q_{01}(t)[c]R_1(t) + q_{02}(t)[c]R_2(t)$

$R_1(t) = S_1(t) + q_{10}(t)[c]R_0(t) + q_{12}^{(5)}(t)[c]\, R_2(t) + q_{11}^{(4)}(t)[c]R_1(t)$

$R_2(t) = S_2(t) + q_{23}(t)[c]R_3(t) + q_{28}^{(7)}(t)\, R_8(t) + q_{29}^{(6)}(t)][c]R_9(t)$

$R_3(t) = S_3(t) + q_{30}(t)[c]R_0(t)$

$R_8(t) = S_8(t) + q_{82}(t)[c]R_2(t)$

$R_9(t) = S_9(t) + q_{91}(t)[c]R_1(t)$ (16-21)

where

$S_1(t) = p\, G_1\overline{(t)}\, e^{-\lambda_1 t}$, $S_1(t) = q\, G_2(t)\, e^{-\lambda_2 t}\, \overline{S_3(t)} = S_8(t) = S_9(t) = G_3(t)$ (22)

Taking Laplace Transform of eq. (16-21) and solving for $\bar{R}_0(s)$

$$\bar{R}_0(s) = N_3(s) / D_2(s) \quad (23)$$

where

$N_3(s) = \hat{q}_{01}[\hat{S}_1(1 - \hat{q}_{28}^{(7)} \hat{q}_{82}) + \hat{q}_{12}^{(5)}[\hat{S}_2 + \hat{q}_{23}\hat{S}3 + \hat{q}_{28}^{(7)}(\hat{S}8+$

$\ddot{\hat{q}}_{29}^{(6)}\hat{S}9)]+\ddot{\hat{q}}_{02}[\,(\hat{S}_2+\ddot{\hat{q}}_{23}\hat{S}_3+\ddot{\hat{q}}_{28}^{(7)}\hat{S}_8+\hat{S}_9\ddot{\hat{q}}_{29}^{(6)})(1-\ddot{\hat{q}}_{11}^{(4)})+\hat{S}_1\ddot{\hat{q}}_{29}^{(6)}\ddot{\hat{q}}_{91}]$
and $D_2(s)$ is already defined. (Omitting the arguments s for brevity)

In the long run, $R_0 = \dfrac{N_3(0)}{D_2'(0)}$ (24)

The expected busy period of the server when there is failure due to Failure due to a sore throat, rash, body aches, headaches, chills, nausea, vomiting, and diarrhea caused by H1N1 virus due to swine flu and Failure due to influenza infections: fever (100 F or greater), cough, nasal secretions, fatigue, and headache, with fatigue in (0,t] is

$\lambda_{rv}(t) = \int_0^\infty R_0(z)dz$ So that $\bar{\lambda}_{rv}(s) = \dfrac{\hat{R}_0(s)}{s}$

The expected number of visits by the repairman Type-I or Type-II for repairing the identical units in (0,t]- H_0

$H_0(t) = Q_{01}(t)[s][1+ H_1(t)] + Q_{02}(t)[s][1+ H_2(t)]$
$H_1(t) = Q_{10}(t)[s]H_0(t)] + Q_{12}^{(5)}(t)[s]\ H_8(t) + Q_{11}^{(4)}(t)]\ [s]H_1(t),$
$H_2(t) = Q_{23}(t)[s]H_3(t) + Q_{28}^{(7)}(t)\ [s]\ H_8(t) +Q_{29}^{(6)}(t)]\ [c]H_9(t)$
$H_3(t) = Q_{30}(t)[s]H_0(t)$
$H_8(t) = Q_{82}(t)[s]H_2(t)$
$H_9(t) = Q_{91}(t)[s]H_1(t)$ (25-30)

Taking Laplace Transform of eq. (25-30) and solving for $H_0^*(s)$

$H_0^*(s) = N_4(s) / D_3(s)$ (31)

$N_4(s) = \{Q_{01}^* + Q_{02}^*\}[\ \{\ 1 – Q_{28}^{(7)*}\ Q_{82}^*\ \} – Q_{12}^{(5)*}\ Q_{29}^{(6)*}\ Q_{91}^*\ ]$
And
$D_3(s) = \{1 – Q_{11}^{(4)*}\}\ \{\ 1- Q_{28}^{(7)*}\ Q_{82}^*\} – Q_{12}^{(5)*}\ Q_{29}^{(6)*}\ Q_{91}^* - Q_{01}^*[\ Q_{10}^*\{\ 1 – Q_{28}^{(7)*}\ Q_{82}^*\ \}+ Q_{12}^{(5)*}\ Q_{23}^*\ Q_{30}^*] - Q_{02}^*\ Q_{30}^*$
$\{1 – Q_{11}^{(4)*}\}+ Q_{29}^{(6)*}\ Q_{91}^*\ Q_{10}^*]$
(Omitting the arguments s for brevity)
In the long run,
$H_0 = N_4(0) / D_3'(0)$ (32)
where
$N_4(0) = \{1 – p_{11}^{(4)}\}\ \{\ 1- p_{28}^{(7)}\ \} – p_{12}^{(5)}\ p_{29}^{(6)}$

The expected number of visits by the multispecialty repairman Type-III for repairing the identical units in (0, t]- W_0

$W_0(t) = Q_{01}(t)[s][1+ W_1(t)] + Q_{02}(t)[s][1+ W_2(t)]$
$W_1(t) = Q_{10}(t)[s]W_0(t)] + Q_{12}^{(5)}(t)[s]\ W_8(t) + Q_{11}^{(4)}(t)]\ [s]W_1(t),$
$W_2(t) = Q_{23}(t)[s]W_3(t) + Q_{28}^{(7)}(t)\ [s]\ W_8(t) +Q_{29}^{(6)}(t)]\ [c]W_9(t)$
$W_3(t) = Q_{30}(t)[s]W_0(t)$
$W_8(t) = Q_{82}(t)[s]W_2(t)$
$W_9(t) = Q_{91}(t)[s]W_1(t)$ (33-38)

Taking Laplace Transform of eq. (33-38) and solving for $H_0^*(s)$

$H_0^*(s) = N_5(s) / D_3(s)$ (39)

$N_5(s) = Q_{01}^*\ Q_{12}^{(5)*}\ [\ Q_{23}^*\ Q_{30}^* + Q_{28}^{(5)*}\ Q_{82}^* + Q_{29}^{(6)*}\ Q_{91}^*\ ] + Q_{02}^*\ [\ Q_{23}^*\ Q_{30}^* + Q_{28}^{(5)*}\ Q_{82}^* + Q_{29}^{(6)*}\ Q_{91}^*\ ]\{1 – Q_{11}^{(4)*}\}]$
(Omitting the arguments s for brevity)
In the long run,
$W_0 = N_5(0) / D_3'(0)$ (40)
where $N_5(0) = p_{01}\, p_{12}^{(5)} + p_{02}\{1 – p_{11}^{(4)}\}$

COST-BENEFIT ANALYSIS

The Benefit-Function analysis of the system considering mean up-time, expected busy period of the system under failure a sore throat, rash, body aches, headaches, chills, nausea, vomiting, and diarrhea caused by H1N1 virus due to swine flu and failure due to influenza infections: fever (100 F or greater), cough, nasal secretions, fatigue, and headache, with fatigue, expected number of visits by the repairman for unit failure. The expected total Benefit-Function incurred in (0, t] is C (t) = Expected total revenue in (0, t]

- expected busy period of the server when there is failure due to Failure due to a sore throat, rash, body aches, headaches, chills, nausea, vomiting, and diarrhea caused by H1N1 virus due to swine flu and Failure due to influenza infections: fever (100 F or greater), cough, nasal secretions, fatigue, and headache, with fatigue in (0,t]
- expected number of visits by the repairman Type- I or Type- II for repairing of identical the units in (0,t]
- expected number of visits by the multispecialty repairman Type- III for repairing of identical the units in (0,t]

The expected total cost per unit time in steady state is

$C = \lim_{t\to\infty}(C(t)/t) = \lim_{s\to 0}(s^2 C(s))$

$= K_1A_0 - K_2R_0 - K_3H_0 - K_4W_0$

where

K_1: Revenue per unit up-time,

K_2: Cost per unit time for which the system is busy under repairing,

K_3: Cost per visit by the repairman type- I or type- II for units repair,

K_4: Cost per visit by the multispecialty repairman Type- III for units repair

CONCLUSION

After studying the system, we have analyzed graphically that when the failure rate due to a sore throat, rash, body aches, headaches, chills, nausea, vomiting, and diarrhea caused by H1N1 virus due to swine flu and failure due to influenza infections: fever (100 F or greater), cough, nasal secretions, fatigue, and headache, with fatigue increases, the MTSF, steady state availability decreases and the Cost-function decreased as the failure increases.

REFERENCES

1. Dhillon, B.S. and Natesen, J, Stochastic Anaysis of outdoor Failure due to influenza infections: fever (100 F or greater), cough, nasal secretions, fatigue, and headache, with fatigueSystems in fluctuating environment, Microelectron. Reliab., 1983; 23, 867-881.
2. Kan, Cheng, Reliability analysis of a system in a randomly changing environment, Acta Math. Appl. Sin. 1985, 2, pp.219-228.
3. Cao, Jinhua, Stochatic Behaviour of a Man Machine System operating under changing environment subject to a Markov Process with two states, Microelectron. Reliab., 1989; 28, pp. 373-378.
4. Barlow, R.E. and Proschan, F., Mathematical theory of Reliability, 1965; John Wiley, New York.
5. Gnedanke, B.V., Belyayar, Yu.K. and Soloyer, A.D., Mathematical Methods of Relability Theory, 1969 ; Academic Press, New York.

Source of Support: None Declared
Conflict of Interest: None Declared