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# **e-Proceedings of the 5<sup>th</sup> International Conference on Computing, Mathematics and Statistics (iCMS 2021)**

*Driving Research Towards Excellence*

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## TABLE OF CONTENT

### PART 1: MATHEMATICS

	Page
<b>STATISTICAL ANALYSIS ON THE EFFECTIVENESS OF SHORT-TERM PROGRAMS DURING COVID-19 PANDEMIC: IN THE CASE OF PROGRAM BIJAK SIFIR 2020</b> <i>Nazihah Safie, Syerrina Zakaria, Siti Madhahah Abdul Malik, Nur Bains Ismail, Azwani Alias Ruwaidiah Idris</i>	1
<b>RADIATIVE CASSON FLUID OVER A SLIPPERY VERTICAL RIGA PLATE WITH VISCOUS DISSIPATION AND BUOYANCY EFFECTS</b> <i>Siti Khuzaimah Soid, Khadijah Abdul Hamid, Ma Nuramalina Nasero, NurNajah Nabila Abdul Aziz</i>	10
<b>GAUSSIAN INTEGER SOLUTIONS OF THE DIOPHANTINE EQUATION <math>x^4 + y^4 = z^3</math> FOR <math>x \neq y</math></b> <i>Shahrina Ismail, Kamel Ariffin Mohd Atan and Diego Sejas Viscarra</i>	19
<b>A SEMI ANALYTICAL ITERATIVE METHOD FOR SOLVING THE EMDEN-FOWLER EQUATIONS</b> <i>Mat Salim Selamat, Mohd Najir Tokachil, Noor Aqila Burhanddin, Ika Suzieana Murad and Nur Farhana Razali</i>	28
<b>ROTATING FLOW OF A NANOFUID PAST A NONLINEARLY SHRINKING SURFACE WITH FLUID SUCTION</b> <i>Siti Nur Alwani Salleh, Norfifah Bachok and Nor Athirah Mohd Zin</i>	36
<b>MODELING THE EFFECTIVENESS OF TEACHING BASIC NUMBERS THROUGH MINI TENNIS TRAINING USING MARKOV CHAIN</b> <i>Rahela Abdul Rahim, Rahizam Abdul Rahim and Syahrul Ridhwan Morazuk</i>	46
<b>PERFORMANCE OF MORTALITY RATES USING DEEP LEARNING APPROACH</b> <i>Mohamad Hasif Azim and Saiful Izzuan Hussain</i>	53
<b>UNSTEADY MHD CASSON FLUID FLOW IN A VERTICAL CYLINDER WITH POROSITY AND SLIP VELOCITY EFFECTS</b> <i>Wan Faezah Wan Azmi, Ahmad Qushairi Mohamad, Lim Yeou Jiann and Sharidan Shafie</i>	60
<b>DISJUNCTIVE PROGRAMMING - TABU SEARCH FOR JOB SHOP SCHEDULING PROBLEM</b> <i>S. Z. Nordin, K.L. Wong, H.S. Pheng, H. F. S. Saipol and N.A.A. Husain</i>	68
<b>FUZZY AHP AND ITS APPLICATION TO SUSTAINABLE ENERGY PLANNING DECISION PROBLEM</b> <i>Liana Najib and Lazim Abdullah</i>	78
<b>A CONSISTENCY TEST OF FUZZY ANALYTIC HIERARCHY PROCESS</b> <i>Liana Najib and Lazim Abdullah</i>	89
<b>FREE CONVECTION FLOW OF BRINKMAN TYPE FLUID THROUGH AN COSINE OSCILLATING PLATE</b> <i>Siti Noramirah Ibrahim, Ahmad Qushairi Mohamad, Lim Yeou Jiann, Sharidan Shafie and Muhammad Najib Zakaria</i>	98

<b>RADIATION EFFECT ON MHD FERROFLUID FLOW WITH RAMPED WALL TEMPERATURE AND ARBITRARY WALL SHEAR STRESS</b>	<b>106</b>
<i>Nor Athirah Mohd Zin, Aaiza Gul, Siti Nur Alwani Salleh, Imran Ullah, Sharena Mohamad Isa, Lim Yeou Jiann and Sharidan Shafie</i>	

## **PART 2: STATISTICS**

<b>A REVIEW ON INDIVIDUAL RESERVING FOR NON-LIFE INSURANCE</b>	<b>117</b>
<i>Kelly Chuah Khai Shin and Ang Siew Ling</i>	
<b>STATISTICAL LEARNING OF AIR PASSENGER TRAFFIC AT THE MURTALA MUHAMMED INTERNATIONAL AIRPORT, NIGERIA</b>	<b>123</b>
<i>Christopher Godwin Udomboso and Gabriel Olugbenga Ojo</i>	
<b>ANALYSIS ON SMOKING CESSATION RATE AMONG PATIENTS IN HOSPITAL SULTAN ISMAIL, JOHOR</b>	<b>137</b>
<i>Siti Mariam Norrulashikin, Ruzaini Zulhusni Puslan, Nur Arina Bazilah Kamisan and Siti Rohani Mohd Nor</i>	
<b>EFFECT OF PARAMETERS ON THE COST OF MEMORY TYPE CHART</b>	<b>146</b>
<i>Sakthiseswari Ganasan, You Huay Woon and Zainol Mustafa</i>	
<b>EVALUATION OF PREDICTORS FOR THE DEVELOPMENT AND PROGRESSION OF DIABETIC RETINOPATHY AMONG DIABETES MELLITUS TYPE 2 PATIENTS</b>	<b>152</b>
<i>Syafawati Ab Saad, Maz Jamilah Masnan, Karniza Khalid and Safwati Ibrahim</i>	
<b>REGIONAL FREQUENCY ANALYSIS OF EXTREME PRECIPITATION IN PENINSULAR MALAYSIA</b>	<b>160</b>
<i>Iszuanie Syafidza Che Ilias, Wan Zawiah Wan Zin and Abdul Aziz Jemain</i>	
<b>EXPONENTIAL MODEL FOR SIMULATION DATA VIA MULTIPLE IMPUTATION IN THE PRESENT OF PARTLY INTERVAL-CENSORED DATA</b>	<b>173</b>
<i>Salman Umer and Faiz Elfaki</i>	
<b>THE FUTURE OF MALAYSIA'S AGRICULTURE SECTOR BY 2030</b>	<b>181</b>
<i>Thanusha Palmira Thangarajah and Suzilah Ismail</i>	
<b>MODELLING MALAYSIAN GOLD PRICES USING BOX-JENKINS APPROACH</b>	<b>186</b>
<i>Isnewati Ab Malek, Dewi Nur Farhani Radin Nor Azam, Dinie Syazwani Badrul Aidi and Nur Syafiqah Sharim</i>	
<b>WATER DEMAND PREDICTION USING MACHINE LEARNING: A REVIEW</b>	<b>192</b>
<i>Norashikin Nasaruddin, Shahida Farhan Zakaria, Afida Ahmad, Ahmad Zia Ul-Saufie and Norazian Mohamaed Noor</i>	
<b>DETECTION OF DIFFERENTIAL ITEM FUNCTIONING FOR THE NINE-QUESTIONS DEPRESSION RATING SCALE FOR THAI NORTH DIALECT</b>	<b>201</b>
<i>Suttipong Kawilapat, Benchlak Maneeton, Narong Maneeton, Sukon Prasitwattanaseree, Thoranin Kongsuk, Suwanna Arunpongpaisal, Jintana Leejongpermpool, Supattra Sukhawaha and Patrinee Traisathit</i>	

<b>ACCELERATED FAILURE TIME (AFT) MODEL FOR SIMULATION PARTLY INTERVAL-CENSORED DATA</b>	<b>210</b>
<i>Ibrahim El Feky and Faiz Elfaki</i>	
<b>MODELING OF INFLUENCE FACTORS PERCENTAGE OF GOVERNMENTS' RICE RECIPIENT FAMILIES BASED ON THE BEST FOURIER SERIES ESTIMATOR</b>	<b>217</b>
<i>Chaerobby Fakhri Fauzaan Purwoko, Ayuning Dwis Cahyasari, Netha Aliffia and M. Fariz Fadillah Mardianto</i>	
<b>CLUSTERING OF DISTRICTS AND CITIES IN INDONESIA BASED ON POVERTY INDICATORS USING THE K-MEANS METHOD</b>	<b>225</b>
<i>Khoirun Niswatin, Christopher Andreas, Putri Fardha Asa OktaviaHans and M. Fariz Fadilah Mardianto</i>	
<b>ANALYSIS OF THE EFFECT OF HOAX NEWS DEVELOPMENT IN INDONESIA USING STRUCTURAL EQUATION MODELING-PARTIAL LEAST SQUARE</b>	<b>233</b>
<i>Christopher Andreas, Sakinah Priandi, Antonio Nikolas Manuel Bonar Simamora and M. Fariz Fadillah Mardianto</i>	
<b>A COMPARATIVE STUDY OF MOVING AVERAGE AND ARIMA MODEL IN FORECASTING GOLD PRICE</b>	<b>241</b>
<i>Arif Luqman Bin Khairil Annuar, Hang See Pheng, Siti Rohani Binti Mohd Nor and Thoo Ai Chin</i>	
<b>CONFIDENCE INTERVAL ESTIMATION USING BOOTSTRAPPING METHODS AND MAXIMUM LIKELIHOOD ESTIMATE</b>	<b>249</b>
<i>Siti Fairus Mokhtar, Zahayu Md Yusof and Hasimah Sapiri</i>	
<b>DISTANCE-BASED FEATURE SELECTION FOR LOW-LEVEL DATA FUSION OF SENSOR DATA</b>	<b>256</b>
<i>M. J. Masnan, N. I. Maha3, A. Y. M. Shakaf, A. Zakaria, N. A. Rahim and N. Subari</i>	
<b>BANKRUPTCY MODEL OF UK PUBLIC SALES AND MAINTENANCE MOTOR VEHICLES FIRMS</b>	<b>264</b>
<i>Asmahani Nayan, Amirah Hazwani Abd Rahim, Siti Shuhada Ishak, Mohd Rijal Ilias and Abd Razak Ahmad</i>	
<b>INVESTIGATING THE EFFECT OF DIFFERENT SAMPLING METHODS ON IMBALANCED DATASETS USING BANKRUPTCY PREDICTION MODEL</b>	<b>271</b>
<i>Amirah Hazwani Abdul Rahim, Nurazlina Abdul Rashid, Abd-Razak Ahmad and Norin Rahayu Shamsuddin</i>	
<b>INVESTMENT IN MALAYSIA: FORECASTING STOCK MARKET USING TIME SERIES ANALYSIS</b>	<b>278</b>
<i>Nuzlinda Abdul Rahman, Chen Yi Kit, Kevin Pang, Fauhatuz Zahroh Shaik Abdullah and Nur Sofiah Izani</i>	

## **PART 3: COMPUTER SCIENCE & INFORMATION TECHNOLOGY**

- ANALYSIS OF THE PASSENGERS' LOYALTY AND SATISFACTION OF AIRASIA PASSENGERS USING CLASSIFICATION** 291  
*Ee Jian Pei, Chong Pui Lin and Nabilah Filzah Mohd Radzuan*
- HARMONY SEARCH HYPER-HEURISTIC WITH DIFFERENT PITCH ADJUSTMENT OPERATOR FOR SCHEDULING PROBLEMS** 299  
*Khairul Anwar, Mohammed A.Awadallah and Mohammed Azmi Al-Betar*
- A 1D EYE TISSUE MODEL TO MIMIC RETINAL BLOOD PERFUSION DURING RETINAL IMAGING PHOTOPLETHYSMOGRAPHY (IPPG) ASSESSMENT: A DIFFUSION APPROXIMATION – FINITE ELEMENT METHOD (FEM) APPROACH** 307  
*Harnani Hassan, Sukreen Hana Herman, Zulfakri Mohamad, Sijung Hu and Vincent M. Dwyer*
- INFORMATION SECURITY CULTURE: A QUALITATIVE APPROACH ON MANAGEMENT SUPPORT** 325  
*Qamarul Nazrin Harun, Mohamad Noorman Masrek, Muhamad Ismail Pahmi and Mohamad Mustaqim Junoh*
- APPLY MACHINE LEARNING TO PREDICT CARDIOVASCULAR RISK IN RURAL CLINICS FROM MEXICO** 335  
*Misael Zambrano-de la Torre, Maximiliano Guzmán-Fernández, Claudia Sifuentes-Gallardo, Hamurabi Gamboa-Rosales, Huizilopoztli Luna-García, Ernesto Sandoval-García, Ramiro Esquivel-Felix and Héctor Durán-Muñoz*
- ASSESSING THE RELATIONSHIP BETWEEN STUDENTS' LEARNING STYLES AND MATHEMATICS CRITICAL THINKING ABILITY IN A 'CLUSTER SCHOOL'** 343  
*Salimah Ahmad, Asyura Abd Nassir, Nor Habibah Tarmuji, Khairul Firhan Yusob and Nor Azizah Yacob*
- STUDENTS' LEISURE WEEKEND ACTIVITIES DURING MOVEMENT CONTROL ORDER: UTM PAHANG SHARING EXPERIENCE** 351  
*Syafiza Saila Samsudin, Noor Izyan Mohamad Adnan, Nik Muhammad Farhan Hakim Nik Badrul Alam, Siti Rosiah Mohamed and Nazihah Ismail*
- DYNAMICS SIMULATION APPROACH IN MODEL DEVELOPMENT OF UNSOLD NEW RESIDENTIAL HOUSING IN JOHOR** 363  
*Lok Lee Wen and Hasimah Sapiri*
- WORD PROBLEM SOLVING SKILLS AS DETERMINANT OF MATHEMATICS PERFORMANCE FOR NON-MATH MAJOR STUDENTS** 371  
*Shahida Farhan Zakaria, Norashikin Nasaruddin, Mas Aida Abd Rahim, Fazillah Bosli and Kor Liew Kee*
- ANALYSIS REVIEW ON CHALLENGES AND SOLUTIONS TO COMPUTER PROGRAMMING TEACHING AND LEARNING** 378  
*Noor Hasnita Abdul Talib and Jasmin Ilyani Ahmad*

## **PART 4: OTHERS**

- ANALYSIS OF CLAIM RATIO, RISK-BASED CAPITAL AND VALUE-ADDED INTELLECTUAL CAPITAL: A COMPARISON BETWEEN FAMILY AND GENERAL TAKAFUL OPERATORS IN MALAYSIA** 387  
*Nur Amalina Syafiqa Kamaruddin, Norizarina Ishak, Siti Raihana Hamzah, Nurfadhlina Abdul Halim and Ahmad Fadhly Nurullah Rasade*
- THE IMPACT OF GEOMAGNETIC STORMS ON THE OCCURRENCES OF EARTHQUAKES FROM 1994 TO 2017 USING THE GENERALIZED LINEAR MIXED MODELS** 396  
*N. A. Mohamed, N. H. Ismail, N. S. Majid and N. Ahmad*
- BIBLIOMETRIC ANALYSIS ON BITCOIN 2015-2020** 405  
*Nurazlina Abdul Rashid, Fazillah Bosli, Amirah Hazwani Abdul Rahim, Kartini Kasim and Fathiyah Ahmad@Ahmad Jali*
- GENDER DIFFERENCE IN EATING AND DIETARY HABITS AMONG UNIVERSITY STUDENTS** 413  
*Fazillah Bosli, Siti Fairus Mokhtar, Noor Hafizah Zainal Aznam, Juaini Jamaludin and Wan Siti Esah Che Hussain*
- MATHEMATICS ANXIETY: A BIBLIOMETRIX ANALYSIS** 420  
*Kartini Kasim, Hamidah Muhd Irpan, Noorazilah Ibrahim, Nurazlina Abdul Rashid and Anis Mardiana Ahmad*
- PREDICTION OF BIOCHEMICAL OXYGEN DEMAND IN MEXICAN SURFACE WATERS USING MACHINE LEARNING** 428  
*Maximiliano Guzmán-Fernández, Misael Zambrano-de la Torre, Claudia Sifuentes-Gallardo, Oscar Cruz-Dominguez, Carlos Bautista-Capetillo, Juan Badillo-de Loera, Efrén González Ramírez and Héctor Durán-Muñoz*

## ACCELERATED FAILURE TIME (AFT) MODEL FOR SIMULATION PARTLY INTERVAL-CENSORED DATA

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The performance of maximum likelihood estimators of the parameters of Accelerated Failure Time (AFT) regression model based on Weibull distribution with simple imputations methods under Partly-Interval Censored (PIC) data is studied. The proposed model is tested through the simulation data and the result were compare with semiparametric model. The result indicates that the AFT with Weibull distribution is comparable with Cox model under simulated PIC data via breast cancer data in the present of imputation techniques. In additional to that the result suggested that the parameters of our model are stable, and the treatments are significant for simulated breast cancer patients.

**Keywords:** Accelerated Failure Time model, partly interval-censored, imputation techniques.

### 1. Introduction

One of the important methods in statistics that used for analyzing time to event is survival analysis. There is common parametric model in survival analysis underline the exponential, Weibull, Gompers, Lognormal and Log logistic distributions. The AFT and Proportional Hazards Regression Model (PHRM) are derived from a Log logistic (Wei, 1992). There are important nonparametric methods in analysis of survival such as: Kaplan Meier estimator, PHRM and log-rank test. The purpose of this study is to study one of the important models in industrial fields and clinical trials which AFT model that provides an alternative to the commonly used PHRM (Wei, 1992; Saikia and Barman, 2017). In additional to that the data for survival analysis must involve censoring observation that is; right, left and interval-censoring. When the subject involved exact and interval censored data is called a PIC. Several authors used PIC in their research such as; Kim (2003), Alharpy and Ibrahim (2013), Zyoud et al. (2016), Gao et al. (2017) and Saeed and Elfaki (2020). However, in this study PIC will be use based on the simulation data sets via median and random imputations methods. These simple imputations techniques are used to handle the missing data as well to create the exact observations in PIC data.

### 2. Accelerated Failure Time model

It's a huge challenge when estimating the regression parameters of the AFT model in the presence of PIC since the actual failure times are not observed directly and their exact values are unknown. This literature suggested that the parameter estimating methods are mainly the basis of the estimated distribution function of censored observations through the censored intervals and assumed the examination times that to be laid between censored failure time. However, if the actual failure times are not available, parametric method for estimating the parameters is very appealing to researchers since it does not involve complicated statistical assumptions about the distribution of the variables in the model and the error terms of the model. Several researches used AFT model in their studies such as; Pike (1966) studied the AFT model based on the carcinogenesis data. Nelson and Hann (1972) determine the relationship between temperature and failure time data using AFT. Kalbfleisch and Prentice (2002) introduced of survival semi-parametric model, that is a class of log-linear models for time. The explanatory variable act multiplicatively on survival time in AFT.

Brown and Wang (2007) proposed weighted rank estimators that involves smoothing method based on semi-parametric AFT models. Johnson and Strawderman (2009) extended the method of Brown and Wang



(2007) for semiparametric AFT model based on Newton Raphson algorithm and other common numerical methods. However, in this research we will use AFT model based on Weibull distribution for cancer PIC data. Liu and Lim (2018) introduced that the Weibull AFT model for a subject ( $i = 1, 2, \dots, n$ ) which takes the form;

$$\log T_i = \theta' z_i + \sigma \varepsilon_i \tag{1}$$

where random variables  $T_1, T_2, \dots, T_n$  denote the failure times of  $n$  independent subjects,  $z_1, z_2, \dots, z_n$  denote their associated  $p \times 1$  vector of covariates,  $\theta$  is a  $p \times 1$  vector of unknown regression parameters,  $\sigma$  is a scale parameter and  $\varepsilon_i$ 's are the error terms of the model, which are independent and identically distributed according to a Gumbel.

Presently the work of survival for the  $i^{\text{th}}$  individual (during that point) related  $p \times 1$  vector of covariates which is equivalent to the work of the survival for the outrageous worth distribution  $\varepsilon_i$ .

$$S_z(z_i) = S_{\varepsilon_i}(z_i) \tag{2}$$

where

$$z_i = \frac{\log T - \mu - \beta_1 z_1 - \dots - \beta_p z_p}{\sigma} \tag{3}$$

Also,  $S_z$  is a survival for the  $i^{\text{th}}$  individual,  $S_{\varepsilon_i}$  is a survival for the outrageous worth distribution and  $\beta_1, \dots, \beta_p$  are the regression coefficients of interest,  $z_i$  is called the  $i^{\text{th}}$  individual at the time  $t_i$  (which is associated vector of covariates ).

### 3. Simulation Study

Simulation studies are computational tests including results creation through pseudo-random sampling from built up likelihood appropriations. This studies are an irreplaceable statistical analysis asset, particularly in the evaluation of current tactics and the assessment of other methodologies.

Under certain circumstances, simulation tests are utilized to deliver logical information on the statistical strategies productivity, instead of algebraic tests which is a more common analytical that can incorporate different circumstances. It is not easy to achieve empirical tests for a lot of people. This problem however is solved by our simulation experiments.

They are independent where messy systems settle on inaccurate choices or results so they could decide the sturdiness of strategies under these conditions. It is not true for observational discoveries, as the outcomes may be duplicated where the aspects are removed from a specific model.

A simulation study was done dependent on the true information of breast malignant featured in this hypothesis to look at the impact of the AFT via Weibull model and to assess the covariates in the informational indexes.

Adding up to that sample, we used 20000 times for each treatment (Chemotherapy, Hormone, Radiotherapy (RT) and Surgery). Using mean and standard deviation of 0.0759168 & 0.0227825 for chemotherapy treatment, in light of (0%, 25%, half, and 75%) as levels of accurate perception for the PIC data based on the real data set which is not addressed here in this paper (reader may refer to El Feky, 2021). We acquired the measurements of endurance in every simulation data for the two gatherings of every treatment that depends on the precise observation contrasted with the one evaluated by imputation strategies that is; median and random point through our model. In each simulation data we obtained the function of survival for the two groups (with treatment and without treatment) of each treatment that based on the exact observation compared to the one estimated by mentioned imputations methods.

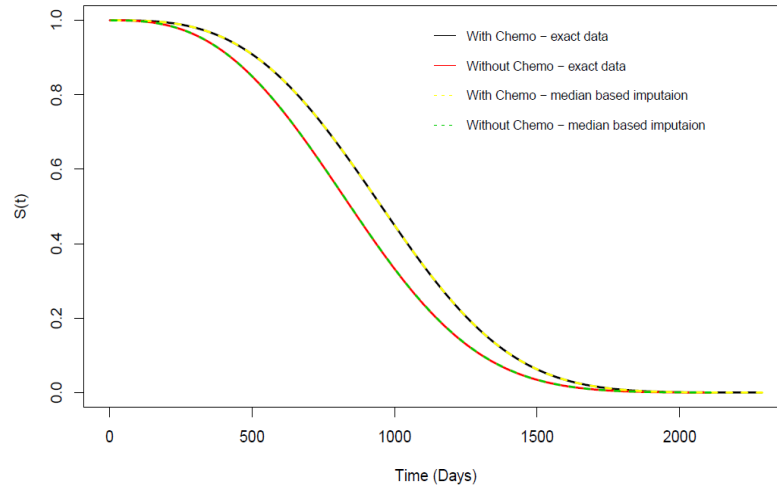
**Table 1:** Results from chemotherapy and hormone obtained by AFT model with median imputation based on simulation data

Type of Parameter	Percentage of observation	Exact	Estimate	SE of Estimation	P-value
<b>Chemotherapy</b>					
Coefficient	0		0.094042	0.004943	2e-10
Shape			2.903226	0.081959	
Scale			972.7186	3.479775	
Coefficient	25		0.094244	0.004944	2e-16
Shape			2.904272	0.016458	
Scale			972.2322	3.478308	
Coefficient	75		0.094223	0.004945	2e-16
Shape			2.902097	0.016454	
Scale			972.3008	3.479340	
<b>Hormone</b>					
Coefficient	0		0.167267	0.005038	2e-10
Shape			2.880782	0.016654	
Scale			920.6089	3.389513	
Coefficient	25		0.167590	0.005046	2e-16
Shape			2.876051	0.016633	
Scale			920.1505	3.392943	
Coefficient	75		0.167824	0.005063	2e-16
Shape			2.866203	0.016587	
Scale			919.7937	3.401836	

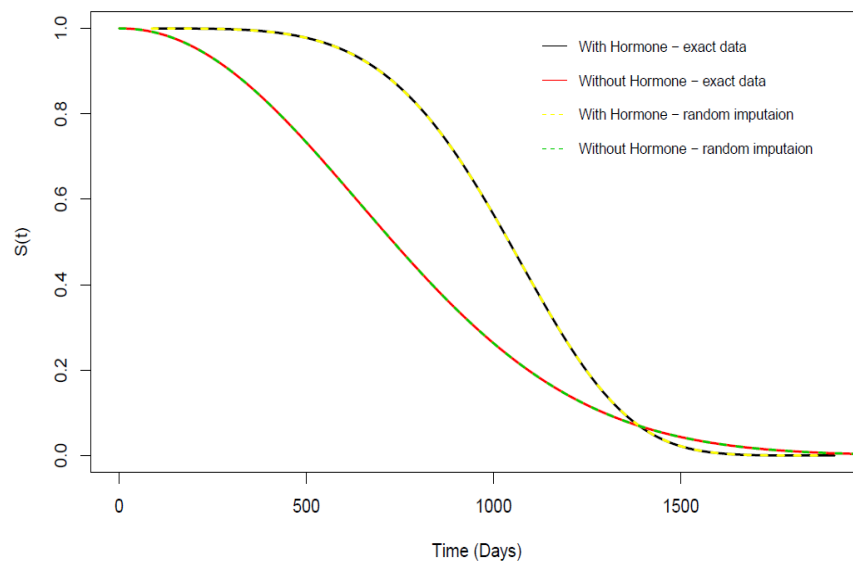
Table 1 display the outcomes from AFT model based on median point for chemotherapy and hormone treatment with different percentages of exact and interval censored data. It showed significant results with respect Standard Deviation (SD) of the estimators and their p-value. These results indicate that for more exact observation in the data the result is better (as value of AIC=282573.8 when 75% exact compared to AIC= 282597.3 for 0% exact). Moreover, the chance of survival increases significantly when patient used both treatments compared with a patient who have not gone through either treatment while fighting with breast cancer (Figures 1 & 2).

Table 2 display the results for the Radiotherapy (RT) and surgery treatments based on random imputation with and without both treatments through different exact observations of PIC with 0%, 25% and 75%. The patient treated with both treatments have a long survival compared to those without treatment while fighting with breast cancer.

These results indicate that when we have more exact observation the result is more reasonable for PIC data. Moreover, the chances of survival increase significantly when patient use the above-mentioned treatments compared with a patient who haven't gone through any of treatment while fighting with breast cancer as showed in Table 1 & 2 and Figure 1, 2, 3 and 4. In additional to that, Figure 5 showed that the AFT with Weibull distribution via PIC breast cancer data under median imputation is comparable with Cox model based on Chemo treatment.



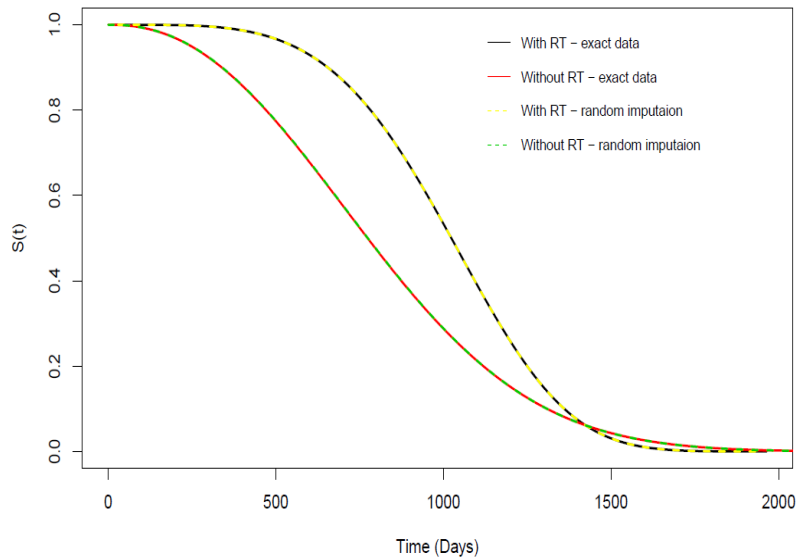
**Figure 1:** The function of survival based on chemotherapy with 0% exact observation from median imputation via AFT model.



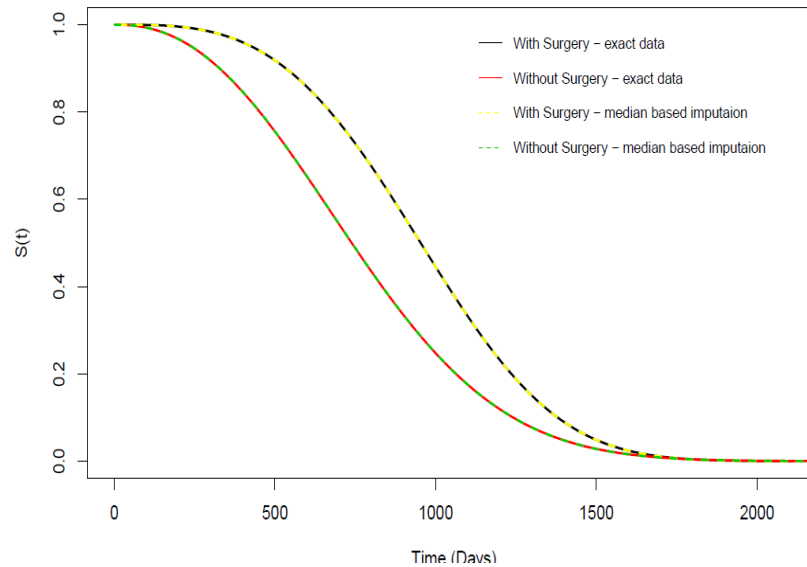
**Figure 2:** The function of survival based on hormone with 25% exact observation from random point imputation via AFT model.

**Table 2:** Results from Radiotherapy (RT) and Surgery obtained by AFT model with median imputaion based on simulation data

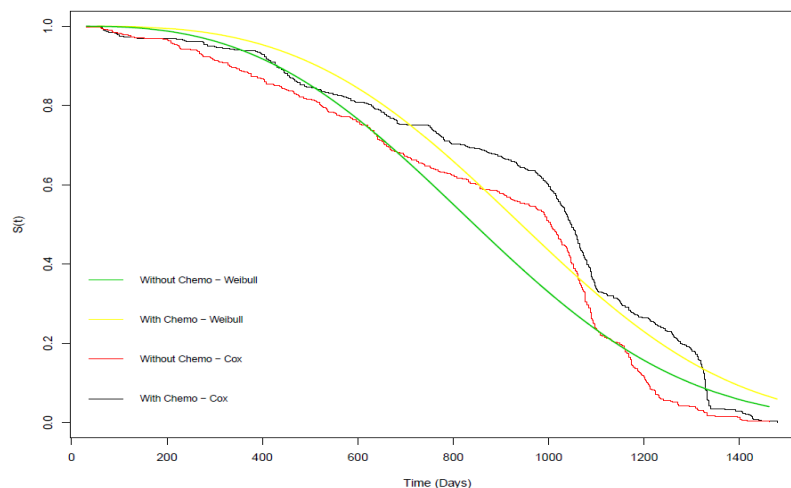
Type of Parameter	% of Exact observation	Estimate	SE of Estimation	P-value
<b>Radiotherapy</b>				
Coefficient	0	0.134629	0.004918	2e-10
Shape		2.941726	0.016868	
Scale		947.5181	3.400072	
Coefficient	25	0.134742	0.004925	2e-16
Shape		2.937418	0.016850	
Scale		947.2983	3.403819	
Coefficient	75	0.135145	0.004928	2e-16
Shape		2.935213	0.016841	
Scale		946.8905	3.404387	
<b>Surgery</b>				
Coefficient	0	0.164277	0.00531	2e-10
Shape		2.704938	0.01545	
Scale		887.0654	3.42914	
Coefficient	25	0.164408	0.00531	2e-16
Shape		2.703855	0.01545	
Scale		886.9470	3.42988	
Coefficient	75	0.164177	0.00532	2e-16
Shape		2.699769	0.01543	
Scale		886.9672	3.43458	



**Figure 3:** The function of survival based on radiotherapy with 25% exact observation from random point imputation via AFT model.



**Figure 4:** The function of survival based on surgery with 75% exact observation from median point imputation via AFT model.



**Figure 5:** The function of survival based on Chemo from median point imputation via AFT model compare with Cox model.

#### 4. Concluding

In this study, AFT model is used based on Weibull distribution via simple imputation technique to simplify the procedure for PIC data which are the median and random imputations. The estimated survival function were computed based on the maximum likelihood estimation. The simulation data was used based on the real breast cancer data (which not addressed here in this paper). The data generated for 2000 times from the every medicines that is hormone, surgery, chemotherapy and RT.

It can be concluded that AFT model with various attributions techniques fits the data well particularly when the data is PIC. In additional, when there is more exact observations in data the result are more

accurate which similarly to the finding by other researchers such as Kim (2003), Alharpy and Ibrahim (2013), Zyoud et al. (2016).

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