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INTERVENTION ANALYSIS OF MATERNAL HEALTHCARE ENROLLMENT AT MAMPONG GOVERNMENT HOSPITAL, GHANA

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Abstract

Providing quality maternal and neonatal healthcare remains a major challenge to many developing countries. It is as part of this backdrop that Ghana and other sister countries endorsed the Millennium Development Goal 5, to help improve maternal healthcare. In a high commitment, the Government of Ghana initiated an exemption from delivery fees in April 2005 and a free maternal care in July 2008 to help address the high maternal mortality issue and to also replace the cash and carry healthcare system. Using intervention analysis of Box and Tiao, this paper quantify the effects of the interventions on maternal enrollment at the Mampong Government Hospital from January 2001 to December 2011. Results from the estimated intervention model showed an insignificant change of approximately 9 pregnant women from the first policy. The free maternal care policy rather showed a significant additional enrollment of 90 women at the hospital.

Keywords: intervention analysis, maternal healthcare, exemption from delivery fees, free maternal care

1.0 Introduction

Healthcare financing in Ghana has since independence gone through several reviews under different government regimes. Immediately after independence, the then Convention People's Party (CPP) Government led by His Excellency Dr. Kwame Nkrumah embarked on a tax funded "free health care for all" policy. Due to the gradual economic decline and hardship, the policy could not be sustained and as at 1969, a small fee was charged for healthcare services in Ghana. According to Agyepong *et al*. (2007), these small out-of-pocket payments were not targeted to recover full cost but mainly to discourage frivolous usage. Early in the 1970's, the small out-of-pocket payments for healthcare services were found to be insufficient to meet the quality of services provided by the health sector. By the mid of 1985, the Government of Ghana initiated a new healthcare system, known as the "cash-and-carry" system, which was backed by a legislative instrument (L.I. 1313). Under this user-fee system, people who accesses health facilities in Ghana were made to pay cash down before given the necessary medical treatment. Those who refused to pay due to lack of funds were either sent home or left to their fate. In a report by Sulzbach *et al*. (2005), the cash-and-carry system was realized to have decreased access to healthcare, particularly, among the poor, resulting in a decline in utilization of basic health services in the country. The system has again being reported by Oppong (2001) to have caused many low-income households in Ghana to regularly postpone medication, resorting to self-treatment or the use of traditional medicine provided by unregulated healers, spiritualist and itinerant drug vendors.

The enormous challenges recorded under the user-fee (cash-and-carry) system, prompted some healthcare facilities, mainly mission hospitals, to introduce insurance scheme, mostly in the early 1990's. The scheme was jointly managed by the facility providers and the communities and was used as a means to lessen the burden on the poor, in their attempt to access healthcare in Ghana (Creese and Benneth, 1997). The Nkoranza Mutual Health Insurance Scheme (NHIS), introduced by the Catholic Diocese of Sunyani in 1989, the Damongo and the Dangme West Mutual Health Insurance Schemes, both established in the early 1990's, became an enviable models for other communities to emulate. As at the end of 2002, there were about 159 Mutual Health Organisations (MHO) in Ghana. This number steadily increased to 168 MHOs by 2003. However, in the same year, Atim *et al.* (2003) reported that, less than a forty (40) percent of MHOs were functional and could only cover just one (1) percent of the Ghanaian population.

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In a quest to continually improve healthcare delivery and increase its utilization in Ghana, the government enacted the National Health Insurance Act (Act 650) and the National Health Insurance Regulations in 2004, Legislative Instrument 1809. Currently, the scheme is operational in all districts and municipalities in the country. Membership of the National Health Insurance Scheme (NHIS) is opened to all persons resident in Ghana, strictly by subscription (paying premiums) before accessing the benefits under the scheme.

To ease the poor and vulnerable pregnant women from paying premiums before accessing healthcare, the government again in April 2005 established a national policy to exempt women from delivery fees. Under this policy, pregnant women were only exempted from charges on deliveries (ie. fees charged at birth process), but were still made to pay fees through the NHIS or out-of-pocket payments. The policy was later replaced by a free maternal care policy, initiated through a Presidential directive in July 2008. The new policy was made to be implemented through the NHIS, so that pregnant mothers who could not attend maternity services due to financial constraints would now have free access to full maternity services such as antenatal, perinatal and postnatal care (NHIA, 2008). In Ghana, most pregnant mothers had to wait until the last 2 or 3 months in pregnancy before enrolling for antenatal care, whiles others completely fails to attend for medical treatment, largely because of lack of funds. The free maternal care policy was targeted to mainly help the poor pregnant mothers in society to desist from self-treatment or the use of concoction which to a large extent contribute to maternal/neonatal mortality, but instead seek free and quality healthcare during and after delivery.

Over the years, the response of pregnant mothers to the free maternal care policy and that of the exemption from delivery fees, have not been scientifically quantified to assess their intended impacts of largely improving access to maternity services. The objective of this study is to apply the intervention analysis of Box and Tiao, to quantify the response of pregnant women at the Mampong Municipality, to the Government's exemption from delivery fees and the free maternal care policies, with respect to enrollment numbers at the Mampong Government Hospital in the Ashanti region of Ghana. The Mampong Government Hospital is the only hospital in the Mampong Municipality. It serves a population of about 75, 367 in the municipality (2000 population census) and around its catchment areas. The municipality also has 7 clinics and 3 midwife homes which together supplement the only hospital. Pregnant women who seek healthcare at the hospital are enrolled under the maternity services through its antenatal healthcare where they are allowed to undergo maternity care until safe delivery. Data on enrollment of pregnant mothers for maternity services before and after the introduction of the free maternal care and the exemption from delivery fees policies was obtained from the Health Information Department at the Mampong Government Hospital. An intervention analysis model was fitted to the data to quantify the impacts of the two policies on maternal enrollment for maternity services at the hospital.

This paper consists of five (5) sections. In the current section, Ghana's healthcare system was reviewed and the objective of the study has been explicitly stated. The section again outlined the structure of the paper. Section 2 presents the ARIMA-Intervention modeling approach and also specifies the intervention model being used for the study. Empirical Results and Discussion of the ARIMA-Intervention models are presented in section 3 of the paper. Lastly, conclusion and acknowledgement are presented in sections 4 and 5 respectively.

2.0 Materials and Method

To quantify the effects of the intervention events being studied in this paper, a monthly enrollment data of pregnant women at the Mampong Government Hospital was obtained from the hospital's Health Information Department. Pregnant women who accessed the hospital's facilities are registered into the maternity services, where, they are adequately given healthcare until safe delivery. The monthly maternal enrollment data which was obtained from the hospital spans from January 2001 to December 2011. The data which was accessed on 24th February 2012 was used to fit an ARIMA-Intervention model. The modeling approach of the ARIMA-Intervention technique is then explained in the next subsection

2.1 Intervention Analysis Approach

Most often, external events sometimes causes several patterns of distortions in observed time series data. Such external events may be seen as a policy change, political or economic events or the enactment of new regulatory laws. Wei (1989) commonly referred these external events as intervention events. In studying these intervention events, Box and Tiao (1975) developed a useful stochastic modeling technique to help in assessing the impacts of the events on various respective time series. In one of their popular papers, Box and Tiao used the intervention technique to assess the impact of air pollution control laws in Los Angeles. The technique has then been tested and applied in many fields of study.

The intervention analysis modeling approach mainly consists of two key components: the noise component which represents the pre-intervention period plus an intervention component that incorporates the intervention events in the model. Symbolically, the intervention analysis model may be written as;

$$Y_t = f(I_t) + N_t \quad (1)$$

where, Y_t is the response series, $f(I_t)$ is the intervention component and N_t is the noise component. To fit such a model, the ARIMA or noise component of the model may first be identified. According to Enders (1995), the general modeling approach of the ARIMA model proposed by Box and Jenkins comprises the following stages: model identification, estimation and diagnostic checking. Using the sample autocorrelation function (ACF) and the partial autocorrelation function (PACF), the form and order of tentative ARIMA models are specified under the identification stage. Table 1 presents some characteristics of the theoretical ACF and PACF for selecting simple Autoregressive models (AR) and Moving Average models (MA). Preferably, parameters of selected models are estimated with the maximum likelihood estimation method. The Akaike information criterion (AIC) and the Schwarz Bayesian information criterion (BIC) are often used to select optimal models among competing or candidate ARIMA models. Under the diagnostic stage, the adequacy of the optimal model is checked based on residual analysis and the Ljung-Box test of goodness of fit.

After obtaining an adequate noise model for the pre-intervention data, a dichotomous intervention function is then added to the noise model to fit a full ARIMA-Intervention model. The intervention function can either be a step or pulse function depending on the duration of the event being studied. A one-time event is usually modeled with a pulse function, whereas a reasonably lasting event is modeled with step function. A step intervention function (S_t) is coded as **0** for the absence of the intervention event and as **1** during the onset and the entire presence of the event.

$$I_t = S^{(T)}{}_t = \begin{cases} 1, & t \geq T \\ 0, & t < T \end{cases} \quad (2)$$

The pulse intervention function (P_t) is also coded as **1** for the onset of the intervention events and as **0** otherwise.

$$I_t = P_t^{(T)} = \begin{cases} 1, & t = T \\ 0, & t \neq T \end{cases} \quad (3)$$

The ARIMA-Intervention model would finally be deemed as an adequate fit for the response series if it has well-behaved residuals and do also passes the goodness of fit test.

2.2 Intervention Model Specification

The focus of this study is to quantify the effects of two intervention programmes initiated by the Government of Ghana to improve maternal healthcare in the country. The first intervention programme which started from April 2005 and lasted up to June 2008, instructed all healthcare delivery points to exempt pregnant women from delivery charges. The programme was later replaced by an absolutely free healthcare programme in July 2008. The latter programme makes it a right for every woman in Ghana to enjoy a free healthcare system immediately after being diagnosed as being pregnant, throughout to the time of delivery. In quantifying the effects of these programmes on maternal enrollment for quality and professional healthcare assistance, the Mampong Government Hospital in the Ashanti region of Ghana was chosen as our study target. The intervention model was applied to quantify the impact of two events. These events were modeled with step intervention functions due to their mode of occurrences. The hypothesized intervention model for this study is written as;

$$Y_t = c + w_1 I_{1t} + w_2 I_{2t} + \frac{\theta(B)}{\phi(B)} \varepsilon_t, \quad (4)$$

where,

$$I_{1t} = S_t = \begin{cases} 1, & April\ 2005 \leq t \leq July\ 2008 \\ 0, & otherwise \end{cases}$$

$$I_{2t} = S_t = \begin{cases} 1, & t \geq July\ 2008 \\ 0, & otherwise \end{cases}$$

Y_t is the monthly increase or decrease of maternal enrollment recorded at the hospital; I_{1t} represents a step function for the exemption from delivery fees; I_{2t} shows a step function for the free maternal care; and c is a constant term.

3.0 Empirical Results and Discussion

The analysis of the study was carried out based on the results obtained from the data, using the R version 2.14.1 statistical package (R Development Core Team, 2010). Preferably, the maximum likelihood estimation method was the main estimation approach used in this study to estimate the reported parameters.

Table 2 shows the descriptive statistics of the maternal enrollment at the Mampong Government Hospital, before and after the intervention events took-off. The pre-intervention period spans from January 2001 to March 2005, whereas the post-intervention marks the period from April 2005 to December 2011. From the table, the range of monthly enrollment for the pre-intervention period is recorded to be between 0–89 and that of the post-intervention is from 7–440. Also, the average monthly maternal enrollment recorded under the pre-intervention period was found to be approximately 49 pregnant women. Again, we realized that there was averagely an approximate of 100 enrollments after the two intervention events at the hospital. With respect to the individual intervention events, there was a monthly average of 54.97 (approximately 55) enrollments after the introduction of the exemption from delivery fees policy. We also found that the average monthly enrollment under the free maternal care policy was recorded to have been approximately 142 pregnant women at the hospital.

3.1 Pre-intervention model results

The data in this study consisted of the monthly maternal enrollment at the Mampong Government Hospital from January 2001 to December 2011. The plot of the data is shown in Figure 1. From the figure, the plot on the left panel shows the entire maternal enrollment from January 2001 to December 2011, whiles the time plot at the right panel exhibits enrollment period from January 2001 to March 2005, during which Government had not initiated its intervention programmes. The latter enrollment period would be called the pre-intervention period. This pre-intervention data was used to fit an ARIMA or a noise model. The pre-intervention plot at the right panel of Figure 1 reveals irregular variations but do not show any clear pattern with respect to trend.

Using sample correlograms and the KPSS test proposed by Kwiatkowski-Phillips-Schmidt-Shin (1992), the pre-intervention data was checked for stationarity and possible identification of tentative ARIMA models. From Figure 2, the autocorrelation function (ACF) tends to cut-off at a quicker rate, whiles the partial autocorrelation function (PACF) shows a significant spike at lag 1, and thereafter decays exponentially to almost zero. This attribute of the pre-intervention series signifies a mean stationary series. This is re-affirmed from the KPSS test results in Table 3. With p-values greater than 0.05 (5% significant level), results from the table indicate a level (p-value=0.0819) and trend (p-value=0.1000) stationary for the pre-intervention series. Based on the correlograms in Figure 2, the following non-seasonal candid models were selected for investigations: ARIMA (2, 0, 0); ARIMA (1, 0, 0); ARIMA (0, 0, 2); ARIMA (0, 0, 1); and ARIMA (1, 0, 2)

The Akaike information criterion (Akaike, 1974) and the Schwartz Bayesian information criterion (Schwartz, 1978) were used to select the most appropriate model among the several competing models reported in Table 4. According to Mills (1993) and Robert and McGee (2000), the AIC produces more over-parameterized models, whereas the BIC is much consistent in terms of imposing a stronger penalty for the number of terms in the model than the AIC. This means the ranking order of candid models using the BIC would not be the same as under the AIC. In such a situation, Gómez and Maravall (1998) openly favoured the candid model selected with the BIC over that of the AIC. This is supported by Robert and McGee (2000), who in such circumstances advised that the optimal model should be the one with smallest BIC. In line with this, the optimal candidate model for the pre-intervention data was chosen based on the model with the smallest BIC. From Table 4, ARIMA (1, 0, 0) model with a BIC value of 462.44 was comparably chosen to be our optimal noise model for the pre-intervention data.

The results of the estimated parameters from the chosen noise model are presented in Table 5. From the table, the coefficient of the noise model (ϕ_1) is statistically different from zero and strictly conforms to the bounds of parameter stationarity (ie., $\phi_1 < 1$). In symbols, the fitted noise model could then be written as;

$$Y_t = 48.6145 + 0.3485\, y_{t-1} + \varepsilon_t \qquad (5)$$

The adequacy of the chosen noise model was checked based on the Ljung-Box test and residual analysis. With a p-value (0.6304) greater than 0.05 (5% significant level), results of the Ljung-Box test in Table 5 does not reject randomness of the error terms based on the first 24 autocorrelations of the residuals. This implies that the chosen noise model fits the pre-intervention data quite well. From the table, Shapiro-Wilk normality test results of a p-value (0.8614) greater than the pre-chosen significance level of 0.05, suggest that the model's residuals are normally distributed. This is confirmed from the residual normality plots shown in Figure 3. Clearly, there are no significant spikes from the ACF and PACF residual plots of the noise model as shown in Figure 4. This indicates that the residuals of the fitted noise model follow a white noise process.

3.2 ARIMA-Intervention model results

After choosing an appropriate noise model to represent the pre-intervention data, such model is fitted together with a dichotomous intervention function. Here, the dichotomous intervention function consisted of the presence, coded as 1 and absence, as 0, of the Government's intervention events. The estimated parameters of the full intervention model are presented in Table 6. From the table, all the estimated coefficients, with the exception of the exemption from delivery fees' coefficient (Exemption) are statistically different from zero. The fitted intervention model looks reasonably stationary. Mathematically, the full ARIMA-Intervention model could be put in the form;

$$Y_t = 48.6346 + 8.7813 I_{1t} + 89.7126 I_{2t} + (1 - 0.3991B)\varepsilon_t \quad (6)$$

Results from the ARIMA-Intervention model in Table 6 revealed that the Government's exemption from delivery fees showed a non-significant change on the maternal enrollment series. It was again realized that the free maternal care intervention event showed a significant additional change of approximately 90 pregnant women on the maternal enrollment series. Moreover, the residuals of the ARIMA-Intervention model were further investigated based on residual correlograms and the Ljung-Box test of goodness of fit. Results from Table 7 indicate that the ARIMA-Intervention model fits the data reasonably well. The spikes of the residual correlograms in Figure 5 do not show much deviation from a white noise residual.

4. Conclusion

This study aims at quantifying the effects of the exemption from delivery fees and the free maternal intervention events initiated by the Government of Ghana on maternal enrollment at the Mampong Government Hospital. The Box and Tiao intervention modeling approach was used to fit an intervention model to the data obtained. Results from the data indicate that the average monthly enrollment for the pre-intervention period was approximately taken to be 49 pregnant women and that of the post-intervention period was 100. Moreover, the average monthly enrollment under the exemption from delivery fees was approximately 55, whereas that of the free maternal care was also found to be 142.

It was found that results from the fitted intervention model showed a non-significant additional increase of 9 pregnant women enrolled under the exemption from delivery fees programme at the Mampong Government Hospital. Again, it was realized that, the free maternal care programme significantly shot-up maternal enrollment at the hospital by approximately 90 pregnant women. These findings clearly shows that the free maternal care programme had significantly increased the monthly number of pregnant women who otherwise could not have afford healthcare cost to eventually enjoy a free but quality healthcare system during pregnancy, until safe delivery. It can also be inferred that the exemption from delivery fees could not significantly pull enough pregnant women to seek professional medical assistance at the hospital. Perhaps, this might be due the cash and carry healthcare system which made it a must for pregnant women who in most cases could not afford hospital services, to pay for maternity services provided them by health professionals, with the exception of delivery fees.

5. Acknowledgement

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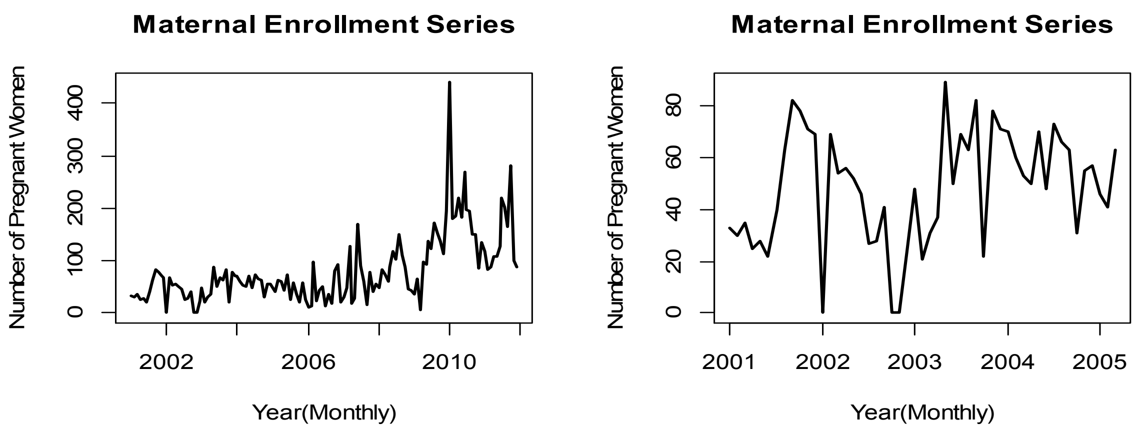

Figure 1: Monthly Maternal Enrollment Series at the Mampong Government Hospital

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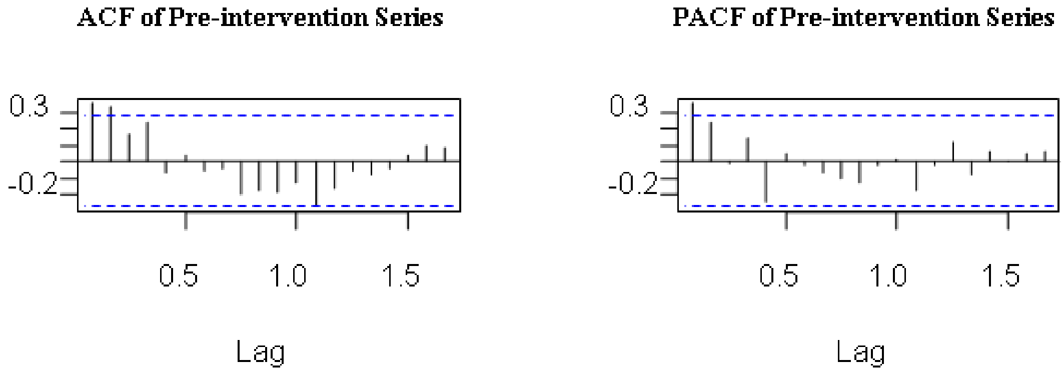

Figure 2: Sample ACF and PACF of the monthly Maternal Enrollment Series

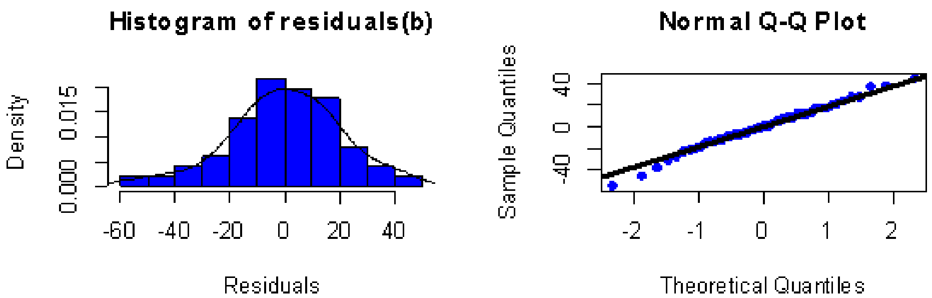

Figure 3: Residual Normality Plot of the selected noise model

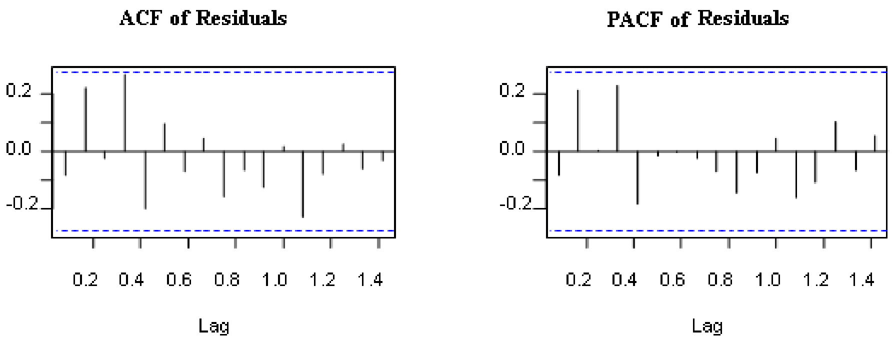

Figure 4: ACF and PACF of the selected noise model's residuals

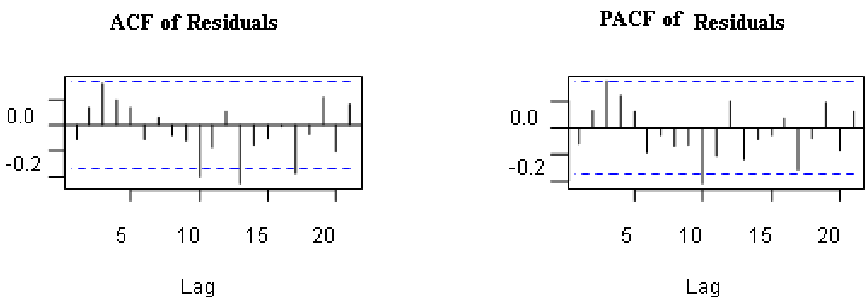

Figure 5: Residual ACF and PACF of the Intervention model

Table 1: Characteristics of Theoretical ACF and PACF for simple AR and MA models

Process	**ACF**	**PACF**
AR(p)	Tails off as exponential decay/damped sine wave	Cuts off after lag *p*
MA(q)	Cuts off after lag *q*	Tails off as exponential decay/damped sine wave
AR(1)	Tails off as exponential decay/damped sine wave	Spike at lag 1, then cuts off to zero
MA(1)	Spike at lag 1, then cuts off to zero	Tails off as exponential decay

Table 2: Descriptive Statistics of Maternal enrollment at Mampong Government Hospital

Before the Interventions		After the Interventions	
(Jan 2001 - Mar 2005)		(Apr 2005 - Dec 2011)	
Monthly Average =	48.63	Monthly Average =	99.93
Range =	0-89	Range =	7-440

Table 3: Stationarity Test

	KPSS Test for Level/Trend Stationarity	
	Test statistic	P-value
Level	0.3891	0.0819
Trend	0.1056	0.1000

Table 4: Penalty function statistics of candidate models

	Candidate Models				
	ARIMA(2,0,0)	ARIMA(1,0,0)	ARIMA(0,0,2)	ARIMA(0,0,1)	ARIMA(1,0,2)
AIC	455.61	456.64	457.45	459.06	457.74
BIC	463.34	462.44	465.18	464.86	467.4

Table 5: Parameter Estimates for ARIMA(1, 0, 0) model

	Model Fit Statistics		
	AIC	BIC	
	456.64	462.44	
Coefficients	Estimate	Std Error	t - statistic
ar1	0.3485	0.1306	2.6685
Intercept	48.6145	4.3475	11.1822

Shapiro-Wilk Test Statistic		Ljung-Box Test Statistic		
W	p-value	Chi-Square	df	p-value
0.9874	0.8614	21.141	24	0.6304

Table 6: Parameter Estimates of the full ARIMA-Intervention model

	Model Fit Statistics		
	AIC		BIC
	1384.9		1399.31
Coefficients	Estimates	Std Error	t-statistic
ar1	0.3991	0.0806	4.9516
Exemption	8.7813	15.2605	0.5754
Freecare	89.7126	15.2146	5.8965
Intercept	48.6346	10.2027	4.7668

Table 7: Ljung-Box test for the ARIMA-Intervention model

	Summary of Test Statistic		
Test Type	Chi-square	df	p-value
Ljung-Box	35.3193	24	0.0638