NOVATEUR PUBLICATIONS
JournalNX- A Multidisciplinary Peer Reviewed Journal
ISSN No: 2581 - 4230
VOLUME 6, ISSUE 7, July -2020

MODELING AND FORECASTING MAJOR DEPRESSION CASES AT KWEKWE GENERAL HOSPITAL, ZIMBABWE: EMPIRICAL EVIDENCE FROM A BOX-JENKINS "CATCH ALL" MODEL

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ABSTRACT:

This study employs monthly time series data on newly diagnosed Major Depression (MD) cases at Kwekwe General Hospital (KGH) from January 2010 to December 2019; to predict MD cases over the period Janaury 2020 to December 2021. Unit root tests basically confirm that the MD series is integrated of order one. The paper applied the Box-Jenkins "catch all" model, that is; the SARIMA $(0, 1, 1)(0, 1, 1)_{12}$ model. Analysis of the residuals of the applied model shows that the model is quite stable and suitable for forecasting MD cases at KGH over the out-of-sample period. The results of this study basically indicate that MD cases at KGH are likely to increase over the out-of-sample period, but at a decreasing rate. The study offers a 6-fold policy recommendation in order to improve MD management at KGH.

INTRODUCTION:

Depression is a silent killer which can harm a human being in a great way if not treated at the right time (Choudhury et al., 2018). Unfortunately, depression continues to be under-diagnosed, with roughly half the cases detected by primary care physicians (Cepoiu et al., 2008) and only 13% – 49% receiving minimally adequate treatment (Wang et al., 2005). Depression is a common mental disorder (Waraich et al., 2004), with a chronic (Mueller et al., 1999) and recurrent course (Keller et al., 1992). Depression can begin at any age, but average age at onset is late 20s. It is generally associated with functional impairment (Wells et al., 1989) and the compromising of physical health (Pennix et al., 1999). Depression patients show limitation in their activity and well-being (Ormel et al., 1993), besides a higher utilization of health services (Mueller et al., 1999).

There are diverse forms of depression. This paper will only focus on Major Depression (MD). MD is characterised by episodes of all-encompassing low mood accompanied by low self-esteem, and loss of interest or pleasure in normally enjoyable activities. People suffering from MD usually focus their attention on unhappy and unflattering information, to interpret ambiguous information negatively and to harbor pervasively pessimistic beliefs (Kessler et al., 2003; Rude et al., 2004). Patients with MD typically show dysphoric mood and anhedonia accompanied by physical changes such as weight loss or gain, increased or decreased appetite, alteration in sleep pattern and sustained fatigue. Disturbances in cognitive and executive functions are also manifested by lack of concentration and coherent thinking as well as morbid preoccupation by thoughts of death and suicide. Most of these symptoms normally present nearly every day and result in significant distress and impaired social life and occupational performance (Fekadu et al., 2017).

MD is the second leading cause of Years Lived with Disability (YLD) with a prevalence of 8.2% (Janaury & Chimbari, 2018). Almost 10% of the total burden of disease in Sub-Saharan Africa is attributed to neuropsychiatric disorders (Tomlinson et al., 2009) such as MD. The largest proportion of the MD cases occurs between the ages of 15 and 64 years with women being the most affected (Ferrari et al., 2010). In Zimbabwe, common mental disorders like depression are prevalent among women (Chibanda et al., 2011; Chibanda et al., 2016). At least 34% of women in Zimbabwe are affected by MD (Chibanda et al., 2010; January et al., 2015; January et al., 2017; January & Chimbari, 2018). In Zimbabwe, common mental disorders such as depression have been studied, for example; Chibanda et al. (2016) and January & Chimbari (2018) but no study has forecasted the incidence of MD in Zimbabwe. This paper will focus on MD cases received and managed at Kwekwe General Hospital (KGH) in the Midlands province of Zimbabwe. The study is envisioned to go a long way in closing the mental health management gap in Zimbabwe.

1 OBJECTIVES OF THE STUDY:

i. To assess the general trend of MD cases recorded and managed at KGH.
ii. To investigate the months during which newly diagnosed MD cases mostly occur at KGH.
iii. To predict MD cases for the out-of-sample period.

2 RELEVANCE OF THE STUDY:

Depression, especially MD; is not only the most frequent health problem (Murray & Lopez, 1996; 1997a; 1997b); it is also a serious illness, responsible for most suicides (Gilbert, 1992). Worldwide, more than 300 million people suffer from depression (WHO, 2017). It is almost unnecessary to highlight the fact that depression causes significant financial burden to national economies (West, 1987; Kind & Sorensen, 1993; Thomas & Morris, 2003), especially in developing countries such as Zimbabwe. By 2030, depression will be the number one leading cause of global burden of disease (Adebe et al., 2019). There is no doubt; MD is now a serious health problem in Zimbabwe. In order to facilitate better mental health service delivery at KGH, this study examines the trends of MD cases using the Box-Jenkins technique. The paper will go a long way in improving KGH's preparedness to handle and manage MD cases.

LITERATURE REVIEW:

Moore et al. (2012) forecasted depression using Exponential Smoothing and Gaussian Process Regression and concluded that depression time series from patients with Bipolar Disorder are very heterogeneous and this constrains the accuracy of automated mood forecasting across sets of patients. Choudhury et al (2013) explored the potential to use social media to detect and diagnose major depressive disorder in individuals and basically found out that social media contains useful signals for characterizing the onset of depression in individuals. Tsugawa et al. (2015) forecasted depression from Twitter data in Japanese sample. However, their predictions from data across a longer period were less accurate. Guntuku et al. (2017) reviewed literature on detecting depression and mental illness on social media and concluded that automated detection methods may help in identifying depressed or otherwise at-risk individuals through the large-scale passive monitoring of social media. This study, which is largely inspired by Moore et al (2012); will not employ the social media for analysis (Choudhury et al., 2013; Tsugawa et al., 2015) but rather apply the Box-Jenkins approach to

time series forecasting in order to analyze MD cases at KGH.

METHODOLOGY:

A generalized Box-Jenkins SARIMA model can be expressed as follows:

$$\phi_p(B)\emptyset_p(B^s)MD_t = \theta_q(B)\Theta_q(B^s)\varepsilon_t \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots [1]$$

Where B is the backshift operator, $\phi_p, \emptyset_p, \theta_q$ and Θ_q are polynomials of order p, P, q and Q respectively. ε_t is a white noise process and $MD_t = \nabla_d \Delta_s^D Y_t$ is the differenced R series.

1 DATA:

This study is based on monthly observations of new Major Depression (MD) cases recorded and managed at Kwekwe General Hospital (KGH) in the city of Kwekwe in Zimbabwe, from January 2010 to December 2019. The out-of-sample forecast ranges over the period January 2020 to December 2021. All the data employed in this study was gathered from KGH at the Health Information department.

2 DIAGNOSTIC TESTS AND MODEL EVALUATION:

Unit Root Tests: Graphical Analysis

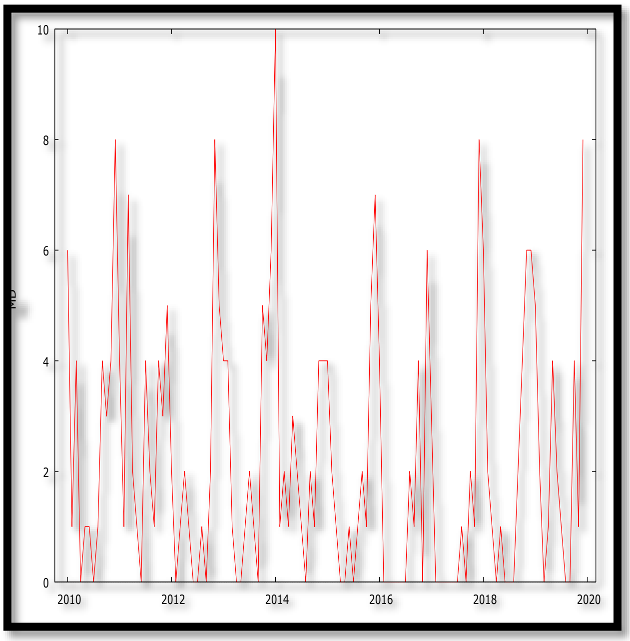


Figure 1: Graphical Analysis

Figure 1 above shows that MD does not follow any particular trend. Hence, the series seems to be stationary in levels. However, a formal unit root test will be carried out using the Augmented-Dickey-Fuller (ADF) test in order to confirm the level of stationarity of the series under consideration. It is imperative to note that most MD cases have been recorded in either December or Janauray of each year.

THE ADF TEST:

Table 1: Levels-intercept

Variable	ADF Statistic	Probability	Critical Values		Conclusion
MD_t	-7.155722	0.0000	-3.486064	@1%	Stationary
			-2.885863	@5%	Stationary
			-2.579818	@10%	Stationary

Table 2: Levels-trend & intercept

Variable	ADF Statistic	Probability	Critical Values		Conclusion
MD_t	-7.090039	0.0000	-4.036983	@1%	Stationary
			-3.448021	@5%	Stationary
			-3.149135	@10%	Stationary

Table 3: without intercept and trend & intercept

Variable	ADF Statistic	Probability	Critical Values		Conclusion
MD_t	-0.711435	0.4064	-2.586550	@1%	Not stationary
			-1.943824	@5%	Not stationary
			-1.614767	@10%	Not stationary

Table 4: 1st Difference-intercept

Variable	ADF Statistic	Probability	Critical Values		Conclusion
D(MD$_t$)	-10.047331	0.0000	-3.491928	@1%	Stationary
			-2.888411	@5%	Stationary
			-2.581176	@10%	Stationary

Table 5: 1st Difference-trend & intercept

Variable	ADF Statistic	Probability	Critical Values		Conclusion
D(MD$_t$)	-10.00391	0.0000	-4.045236	@1%	Stationary
			-3.451959	@5%	Stationary
			-3.151440	@10%	Stationary

Table 6: 1st Difference-without intercept and trend & intercept

Variable	ADF Statistic	Probability	Critical Values		Conclusion
D(MD$_t$)	-10.095776	0.0000	-2.586550	@1%	Stationary
			-1.943824	@5%	Stationary
			-1.614767	@10%	Stationary

Tables 1 – 6 basically indicate that MD is an I(1) variable, hence; it is reasonable to go ahead and estimate the Box-Jenkins "catch all" model.

Analysis of the Residuals of the SARIMA (0, 1, 1)(0, 1, 1)$_{12}$ Model

Residual Correlogram of the SARIMA (0, 1, 1)(0, 1, 1)$_{12}$ Model

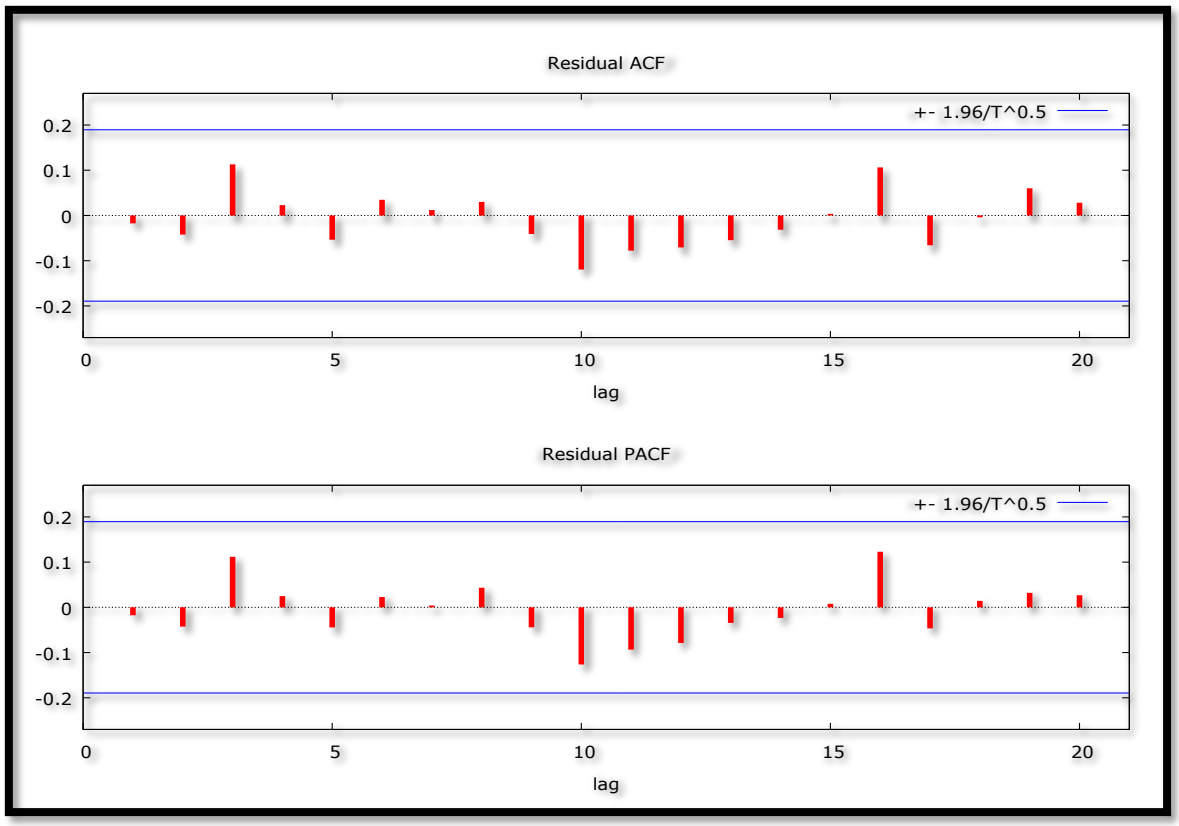


Figure 2: Residual Correlogram

Figure 2 apparently shows that the residuals of the Box-Jenkins "catch all" model are stable and this is clear evidence that the estimated predictive model is adequate.

RESULTS OF THE STUDY:

4.1 DESCRIPTIVE STATISTICS:

Table 7: Summary Statistics, using the observations 2010:01 - 2019:12, for the variable MD (120 valid observations)

Mean	Median	Minimum	Maximum
2.1667	1.0000	0.0000	10.000
Std. Dev.	C.V.	Skewness	Ex. kurtosis
2.3130	1.0676	1.1300	0.58956

Table 7 shows that the average number of major depression cases over the period under study is 2 cases per month. The minimum number of major depression cases is 0 while the maximum is 10 and was recorded for January 2014. It is imperative to note that most MD cases peak in either December or January of each year. This is quite reasonable in Zimbabwe, precisely because, during the festive December holidays people usually spend a lot of financial resources with their friends and families. In the New Year, particular; in January, most people realize they now seriously lack financial resources and they are in great financial trouble. This could be an explanation as to why stress levels balloon in January or December and hence higher cases of MD. Similarly, people may feel isolated during festive seasons, feeling that they do not "fit in" with the "festive cheer" and consequently feel very lonely and depressed. This is very true especially in Zimbabwe where the economy is perennially paralyzed. Many people will be depressed during festive holidays such as December, largely because they will be financially strained. The same also applies in January of each year.

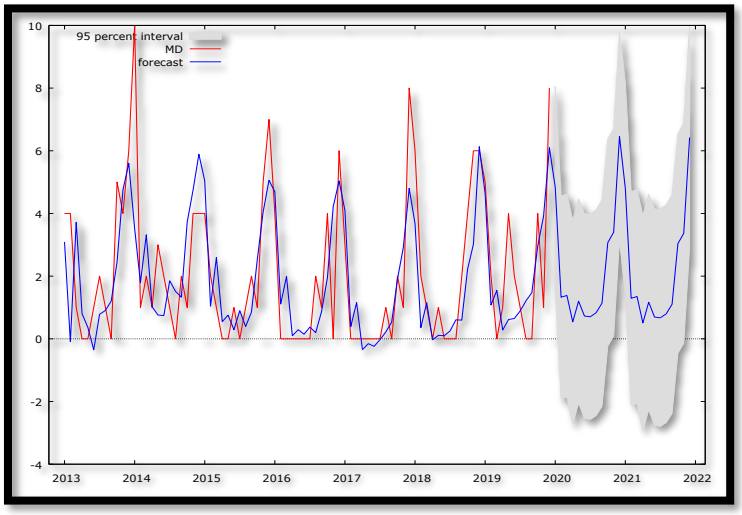
2 RESULTS PRESENTATION:

Table 8: Main Results of the SARIMA (0, 1, 1)(0, 1, 1)$_{12}$ Model

The SARIMA (0, 1, 1)(0, 1, 1)$_{12}$ model can be presented as follows:

$$(1 - B)(1 - B^{12})MD_t = (1 - 0.923298B)(1 - 0.858809B^{12})\varepsilon_t \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots [2]$$

Variable	Coefficient	Standard Error	z	p-value
θ_q	-0.923298	0.0488982	-18.88	0.0000***
Θ_q	-0.858809	0.180362	-4.762	0.0000***



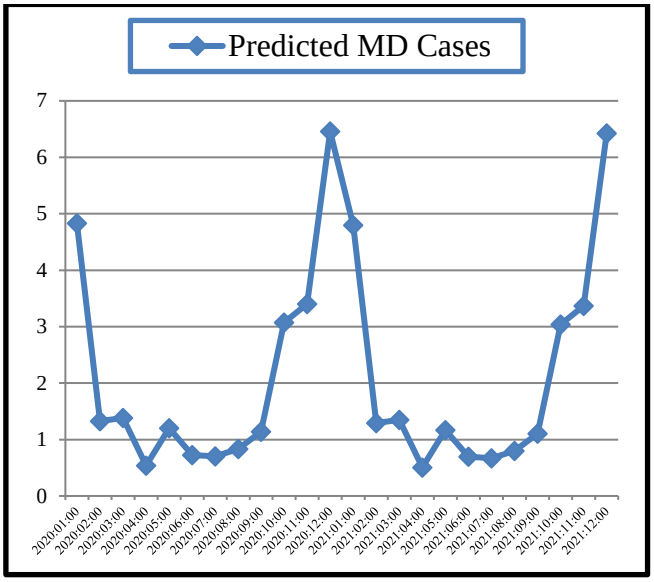
Forecast Graph Figure 3: Forecast Graph

Out of Sample Forecasts

Table 9: Out-of-sample forecasts

Year: Month	Predicted MD Cases	Standard Error	95% Confidence Interval
2020:01	4.82995	1.64201	(1.61166, 8.04823)
2020:02	1.32761	1.64683	(-1.90013, 4.55534)
2020:03	1.38263	1.65164	(-1.85454, 4.61979)
2020:04	0.540303	1.65644	(-2.70626, 3.78686)
2020:05	1.20338	1.66122	(-2.05255, 4.45932)
2020:06	0.727738	1.66599	(-2.53754, 3.99301)
2020:07	0.704228	1.67074	(-2.57036, 3.97882)
2020:08	0.832810	1.67548	(-2.45107, 4.11669)
2020:09	1.13657	1.68021	(-2.15658, 4.42972)
2020:10	3.07218	1.68492	(-0.230205, 6.37457)
2020:11	3.40012	1.68962	(0.0885256, 6.71172)
2020:12	6.45861	1.69431	(3.13782, 9.77939)
2021:01	4.79628	1.73167	(1.40226, 8.19030)
2021:02	1.29394	1.73763	(-2.11175, 4.69963)
2021:03	1.34896	1.74356	(-2.06836, 4.76628)

2021:04	0.506637	1.74948	(-2.92227, 3.93555)
2021:05	1.16972	1.75537	(-2.27074, 4.61018)
2021:06	0.694072	1.76124	(-2.75790, 4.14605)
2021:07	0.670561	1.76710	(-2.79289, 4.13401)
2021:08	0.799143	1.77293	(-2.67574, 4.27403)
2021:09	1.10290	1.77875	(-2.38338, 4.58919)
2021:10	3.03851	1.78455	(-0.459135, 6.53616)
2021:11	3.36646	1.79033	(-0.142517, 6.87543)
2021:12	6.42494	1.79609	(2.90468, 9.94521)



Graphical Presentation of the Predicted Monthly MD Cases at KGH (Out-of-Sample)

Figure 4: Graphical presentation of out-of-sample forecasts

Main results of the estimated model are show in table 8 above. Within the same table, a mathematical expression of the estimated model is presented as equation [2]. All the parameters of the estimated Box-Jenkins "catch all" model are statistically significant at 1% level of significance. Table 9 and figure 3 & 4 are out-of-sample forecasts of the estimated model. The model predicts that most MD cases will be received in December 2020 and December 2021. Hence, our model shows that the seasonal pattern of MD cases at KGH repeats in December of every year. It is also worthy to note that there is a general increase in MD cases at KGH over the out-of-sample period, although at a relatively decreasing rate. This is a just a wake-up call for mental health policy makers not only in the Midlands province but also the entire country at large. These results are consistent with Adebe et al (2019) who predicted that MD will be the number one global health threat by 2030. The results are also consistent with Murray & Lopez (1996) who argued that by 2020, MD will be second only to ischemic heart disease in terms of disability experienced by sufferers.

3 RECOMMENDATIONS:

i. The government of Zimbabwe should strengthen referral systems for patients suffering from MD.
ii. The government of Zimbabwe should make sure that there are adequate medications for MD patients not only at KGH but also in the whole country.
iii. The government of Zimbabwe should train more qualified mental health practitioners in order to improve mental health service delivery not only at KGH but also in the whole country at large.
iv. Zimbabwe's Friendship Bench, as a "talk therapy" is highly recommended in the fight against MD.
v. There is need for KGH to come up with rehabilitation programmes for MD patients who unemployed and or have been disengaged from social activities over a long term.
vi. There is need for KGH to provide psychoeducation to all patients as well as involved family members in order to improve attitude towards MD and adherence to medication.

CONCLUSION:

It is almost unnecessary to reiterate the fact that MD, just like any other mental illness, has a destructive impact on the individual, family and society. In Zimbabwe, just like any other developing country, MD is now a threat to public health. Hence the need for prediction of MD cases in order to unveil the likely trend

of the disease in the future. This study focused on KGH in Kwekwe, in the Midlands province of Zimbabwe. The paper employed the Box-Jenkins SARIMA model, particulary, the SARIMA $(0, 1, 1)(0, 1, 1)_{12}$ model. The model predicts that there will be a general increase in MD cases at KGH over the out-of-sample period. The paper is envisaged to go a long way in reducing the burden of MD not only at KGH but in the whole country at large.

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