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Review Article

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Trend and future of infant mortality in Pakistan

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ABSTRACT

In South Asia, Pakistan is contributing to the highest childhood mortality, including infant mortality. Child mortality has been declined globally, but Pakistan is still struggling and far behind the targets of Sustainable Development Goals. There are several reasons behind high childhood mortality, including socioeconomic determinants and a lack of effective implementation of health-related policies, particularly in primary health care settings. In the present study, we use the stochastic univariate models to uncover the trend of infant mortality by using more than half of the century data from 1960-2017.

The secondary data on infant mortality rate from 1960 to 2017 was extracted from World Bank Dataset. Descriptive and time series analysis were applied by using the programming language R.

The median infant mortality rate was 109 per 1,000 live births, whereas a higher mortality rate (189.8/1000) was reported in 1960. A gradual decline in infant mortality rates is experienced every year. The mortality rate went down below 100/1,000 live births from 1993 and remained 61.2/1,000 in 2017. ARIMA (1, 2, 2) is an adequate forecasting model selected by using the Auto ARIMA function with a root mean square error is 0.1006. Five years ahead forecast is obtained and yielded that infant mortality rate is expected to remain in 2018 [59.54, C.I (59.34 - 59.73)], 2019 [57.93, C.I (57.47 - 58.40)], 2020 [56.39, C.I (55.48 - 57.30)], 2021 [54.90, C.I (53.35 - 56.45)] and 2022 [53.47, C.I (51.05 - 55.88)].

The decreasing trend is expected in the infant mortality rate in Pakistan.

KEYWORDS: Forecast, Infant mortality rate in Pakistan, Time series model.

INTRODUCTION

The world has made considerable progress in reducing child mortality, including the infants infant, over the past quarter-century. The infant mortality rate (IMR) has dropped down across the world, in 1990 an estimated death rate remain 65/1,000 and went down below 29/1,000 in 2017[1]. A significant reduction in the annual infant death rate were reported from 8.8 million in 1990 to 4.1 million in 2017[1]. According to the world health organization (WHO), children belongs to WHO African region (51/1,000) had a six times higher risk of dying before celebrating their first birthday compared to the European Region (8/1,000) [1]. The child mortality estimation report in 2018 showed that the estimated death of children and young adolescents was 6.3 million in 2017[2]. The report also revealed that children under age 5 accounted for 5.4 million deaths (with 2.5 million neonatal and 1.6 million infant), a considerable portion of the total deaths of 6.3 million[2]. Developing countries, namely India, Pakistan, Nigeria, the Democratic Republic of the Congo, and Ethiopia accounted for the highest number of newborn deaths, 39% reported in Southern Asia and 38% in sub-Saharan Africa[3].

Pakistan is the 5th most populated developing country in the world and placed 2nd in Islamic countries after Indonesia, with a higher proportion lived in rural areas, lower literacy rate, insufficient health care settings, and poor quality of life. Pakistan is among the countries that contribute to 50% of all newborn deaths[3]. In South Asia, Pakistan placed at the top with the highest IMR (64/1,000 live births) followed by the neighboring border sharing country Afghanistan (53/1,000), India (35/1,000), Bangladesh (28/1,000), Nepal (28/1,000), Iran (13/1,000) and Sri Lanka (8/1,000)[4].

According to Pakistan medical association, one of the main causes of high infant and maternal mortality in Pakistan is unsafe delivery practices. Although the mortality rates declined among children of all age groups over the last couple of decades but , in Pakistan, every year, millions of

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children lost their lives due to most treatable or preventable causes, for instance, lower respiratory tract infections, malnutrition, diarrhea, malaria, pneumonia, and measles. Lack of breastfeeding practices and more trend towards artificial feeding in infants and inadequate weaning practices further worsen the situation.

Socioeconomic variables are yet another important concern in many developing countries where infant mortality claims a considerable portion of total deaths each year. Many authors contributed through scientific studies to underline the major socioeconomic factors that have had substantial effect leading to higher child and infant mortality. A study conducted in Nepal to underline the impact of Socioeconomic variables on infant mortality and concluded that poorer and middle-class family experienced higher infant mortality compared to wealthier families[5]. The study demonstrated that educated mothers and sufficient government expenditure tend to reduce child mortality, but the fertility rate positively correlates to IMR. The findings extracted by using the data collected through 152 countries depicted that mother education, geographical area of residence, place of delivery, low birth weight, working parents, mothers receiving a blood transfusion during last pregnancy, fertility rate with short birth interval, delivery assistant type, breastfeeding status, antenatal care, child immunization, mother age were associated with higher infant deaths[5,6,7-11].

This study is designed to explore the trajectory and pattern of infant mortality in Pakistan from 1960 to 2017 by using stochastic time series models. Globally developing countries contribute a considerable proportion of infant mortality so that effective implementation of models enables us to better understand the pattern of vital events so that adequate policies and timely tends in order to decline IMR.

METHODOLOGY

The officially reported infant mortality event is treated as a study patient. The data include the officially reported infant mortality cases from 1960-2017 of IMR in Pakistan and it is freely available and obtained from (https:/data.worldbank.org/indicator/SP.DYN.IMRT.IN), time-series data with no missing value from 1960-2017. R programming language is used in order to complete descriptive and time series analysis[12]. The R codes for time series data analysis are provided in the appendix. The best model is elected on the basis of accuracy measure, namely, root mean square error (RMSE). The R code in the appendix can automatically select the optimum model among all models.

Modelling the mortality curve is a less conventional approach, although it has been introduced in literature quite long ago with the pioneer work of Gompertz identified an exponential increase in death rates with age[13, 14]. After that many other researchers made their contribution in these models under different formulations[13]. Box-Jenkins's methodology is used to uncover the pattern of IMR per 1,000 live births from 1960 to 2017. The adequate model is achieved on a systematic, iterative process, the readers are referred to Imran M et al [15] for a detailed discussion of Box-Jenkins methodology.

RESULTS

The descriptive analysis of annually IMR (per 1,000 live births) from 1960 to 2017 is illustrated by box plot in Figure-I. The median IMR was109 per 1,000 live births, whereas a higher (189.8) IMR was reported in 1960. The constant gradual declined in IMR from 1990 to 2017, and rate remained 61.2 per 1,000 live births in 2017. The temporal analysis (Figure 2) from 1960 to 2017 yielded that a gradually reduction in IMR was observed every year. Figure-II showed that IMR was over 100 from 1960 to 1993 and remained below 100 from 1994 to onward.

Time Series Analysis: In the present study, we used R Programming Language to uncover the trend of infant mortality series from 1960 to 2017. ARIMA (1, 2, 2) is an adequate forecasting model using the Auto ARIMA function with root mean square error (0.1006). ARIMA (1, 2, 2) indicates that the actual series turned to be stationary after the second differencing order with AR (1) and MA (2). The estimated parameters, along with the standard error, are illustrated in Table-I. A five-year forecast is obtained and yielded that an average 5.6% decline per year in IMR is expected. The detailed forecast description, 80% and 95% confidence interval (C.I) are shown in Table-II. Under the ARIMA (1,2,2) model, the time plot of actual and predicted showing well agreement between actual and predicted values of IMR in Figure-V. While Figure-VI is showing the plot of forecasted along with 80% and 95% lower and upper C.I. The autocorrelation function (ACF), partial autocorrelation function (PACF), and residual plot are presented in Appendix-A.

Table-I: Detail of estimated parameters along with standard error (S.E) of ARIMA (1, 2, 2).

Feature	AR(1)	MA(1)	MA(2)
Parameters	0.9589	-0.8035	0.5029
S.E	0.0402	0.1231	0.1202

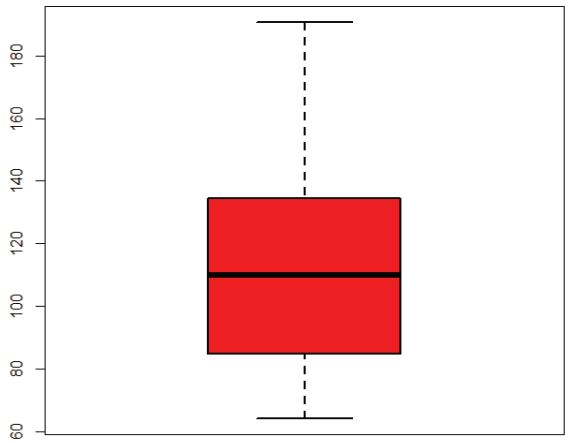

Figure-I: Box plot of IMR.

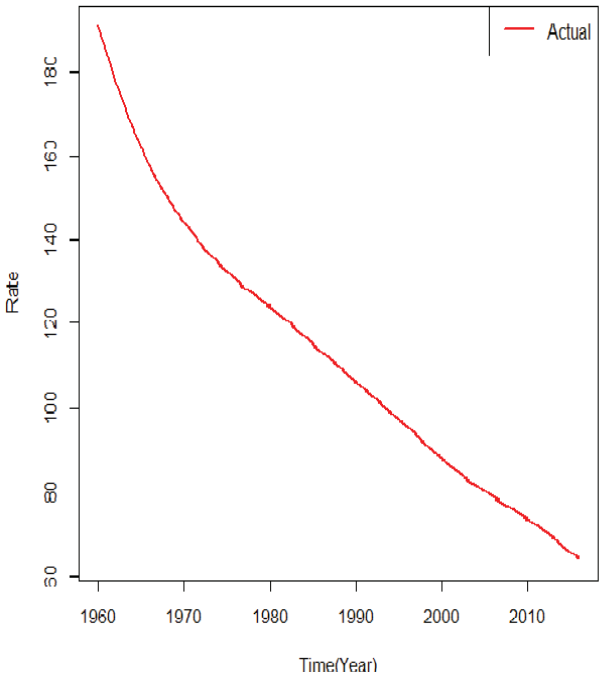

Figure-II: A plot of IMR per 1,000 Live births.

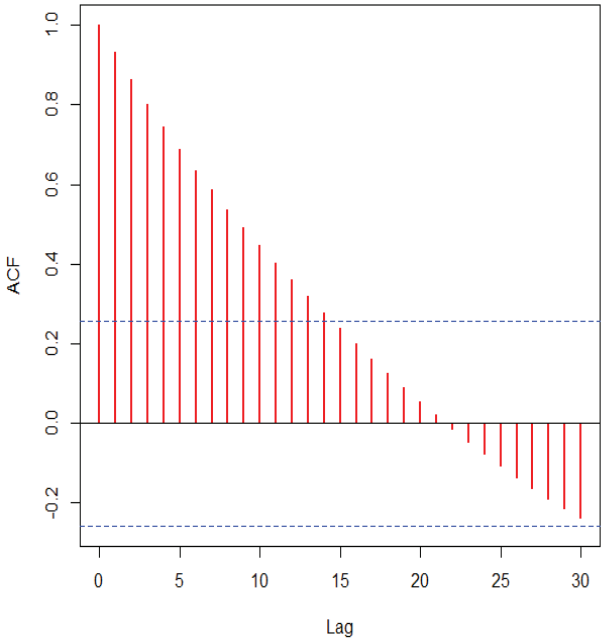

Figure-III: A plot of ACF.

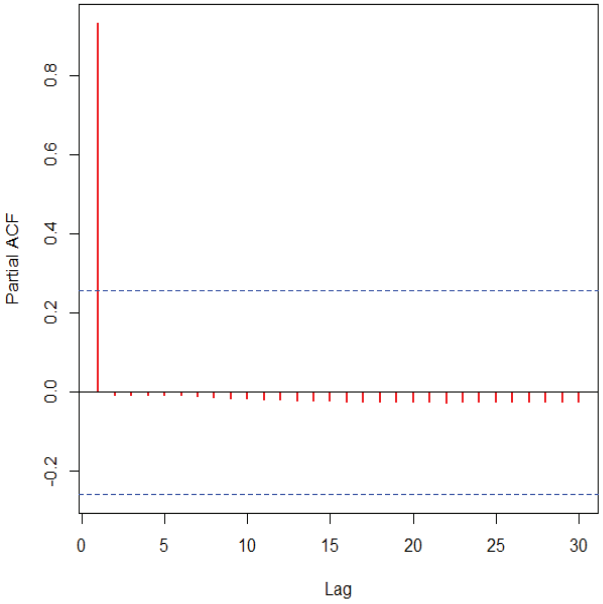

Figure-IV: A Plot of PACF.

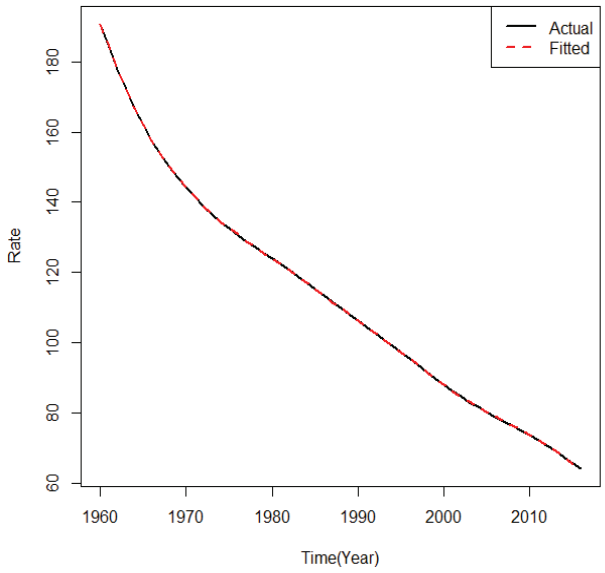

Figure-V: A Plot of actual & predicted ARIMA (1,2,2).

Table-II: Detail of estimated parameters along with S.E, ARIMA (1, 2, 2).

Time	Forecast	80% C.I		95% C.I	
		Low	High	Low	High
2018	59.54	59.41	59.67	59.34	59.73
2019	57.93	57.63	58.24	57.47	58.40
2020	56.39	55.80	56.98	55.48	57.30
2021	54.90	53.89	55.91	53.35	56.45
2022	53.47	51.89	55.04	51.05	55.88

DISCUSSION

For instance, pneumonia and diarrhea are considered as leading infectious causes of mortality among under five-year children across the world. In 2015, 49% of global pneumonia deaths occurred collectively in India, Nigeria, Pakistan, Democratic Republic of the Congo, and Ethiopia [19]. About 26.93% of diarrhoeal deaths were associated in children younger than five years, and 90% of diarrhoeal deaths are attributed to south Asia and sub-saharan Africa[20]. In Pakistan, 31% of a child age 6-11 months is affected with diarrhea and only 71% are seeking advice or treatment for diarrhoea[18].

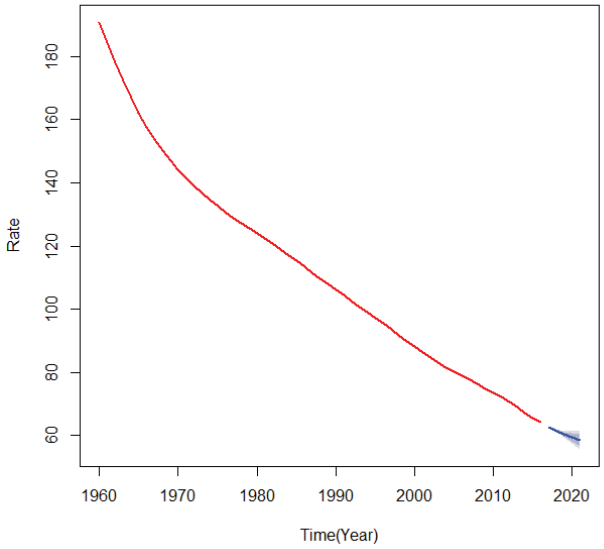

Figure-VI: A plot of forecasted , ARIMA (1,2,2), C.I 80%, 95%

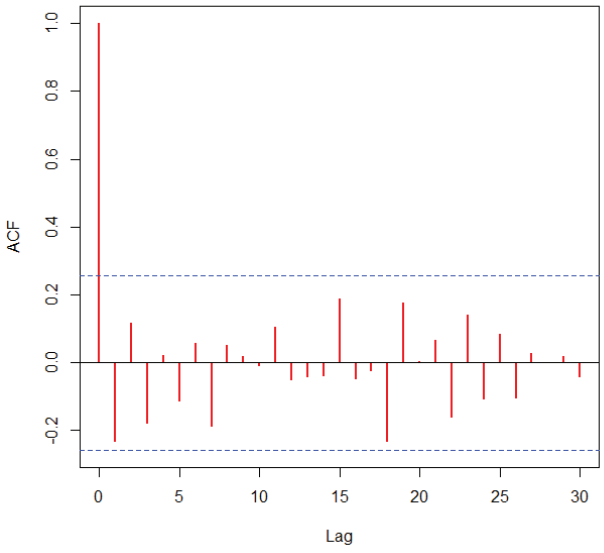

Figure-VII: A plot of ACF.

Nearly half of all deaths in children under 5 are attributable to undernutrition. Globally, an estimated children age below 5 are affected as being stunted (149 million), wasting (49 million), and overweight (40 million) respectively in 2018 [21]. Higher proportion of children are belonging to Asia, and Africa affected with evidence of being stunted (55% in Asia versus 39% in Africa), wasted (68% in Asia versus 28% in Africa), and overweight (47% in Asia versus 24% in Africa) respectively[21]. According to the 2017-18 PDHS, the prevalence of malnutrition among children in Pakistan has been reported as being stunted 38%, wasted 7% and overweight 3%[18].

Huffman[22] conducted a review study to underline the association between neonatal mortality and breast- feeding practices in the first month of life and found that breast-feeding helped to prevent the initial deaths by hypothermia

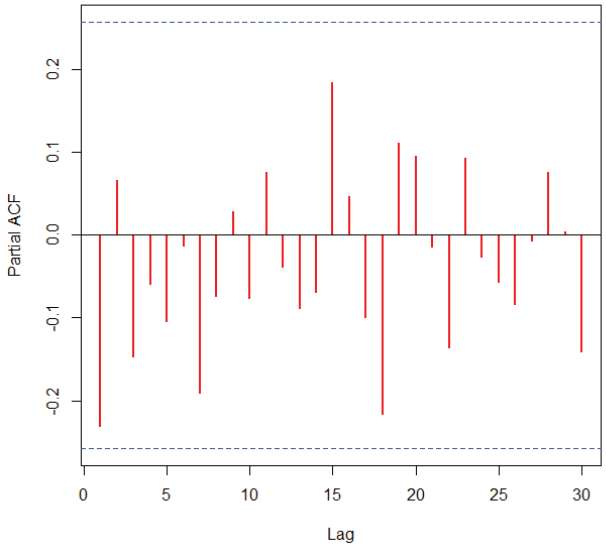

Figure-VIII: A plot of PACF.

and hypoglycemia, particularly among low birth weight and premature babies. Further, the study revealed that most mortalities could be reduced by breast-feeding, especially in developing countries, caused by sepsis, acute respiratory tract infection, meningitis, omphalitis, and diarrhea during the late neonatal period. The risk of death due to diarrhea and pneumonia increased seven-fold and five-fold, respectively, for the infants aged 0-5 months who were not breastfed[23]. Birth weight is an important determinant of maternal and fetal health. Approximately 80% of newborns who die every year are low birthweight, under 2.5 kilogram, because they were either born preterm or small for gestational age or both[24, 25].

In Pakistan as well, low birth weight is also a major contributory factor and data shows about 34% of live births to mother's age less than 20 year had a low birth weight compared with one fifth (21%) of births to mothers age 20-34. Most of the low birth cases (24%) were reported from Punjab as less than 2.5 kilograms, which is closely followed by Sindh about 23% [18]. Lower respiratory infections is the 6th leading cause of mortality of all ages, including children under 5 year, in 2016, the estimated deaths due to lower respiratory infections accounted for about 2.38 million deaths [20]. Acute respiratory infections are the leading cause of death and morbidity among children and kill more children under five years than any other infectious disease[18].

CONCLUSION

Although the mortality rate of all age groups among children is continuing to fall but not enough to achieve the targets of the Sustainable Development Goals (SDG) agenda, particularly in developing countries. On paper, Pakistan's health system seems to be impressive but placed at top with the highest mortality rate in the South Asian region. Sri Lanka had a

considerable decrease in IMR that is 9/1,000 live births in the region. Pakistan needs smart, effective and proactive strategies to reduce mortality caused by preventable and treatable infections timely to achieve the proposed SDG 2030 target of at least 12/1,000 deaths of neonatal and at least 25/1,000 deaths under five-year children. ARIMA (1, 2, 2) is an adequate forecasting model with a forecasting error 0.1006. The decreasing trend is expected in IMR per 1,000 live births in Pakistan. These statistical results will serve as a guide to understand the trend and pattern of infant child mortality and timely intervention; ultimate, achieve better health outcomes as well as targets of SDG 2030.

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Authors Contribution:

Zartashia Shabbir: Substantial contributions to the conception and design of the work.
Anila Riaz: Analysis, and interpretation of data for the work
Fiaz Ahmad: Statistical analysis, interpretation of data for the work.
Muhammad Imran: Data analysis and R-coding.

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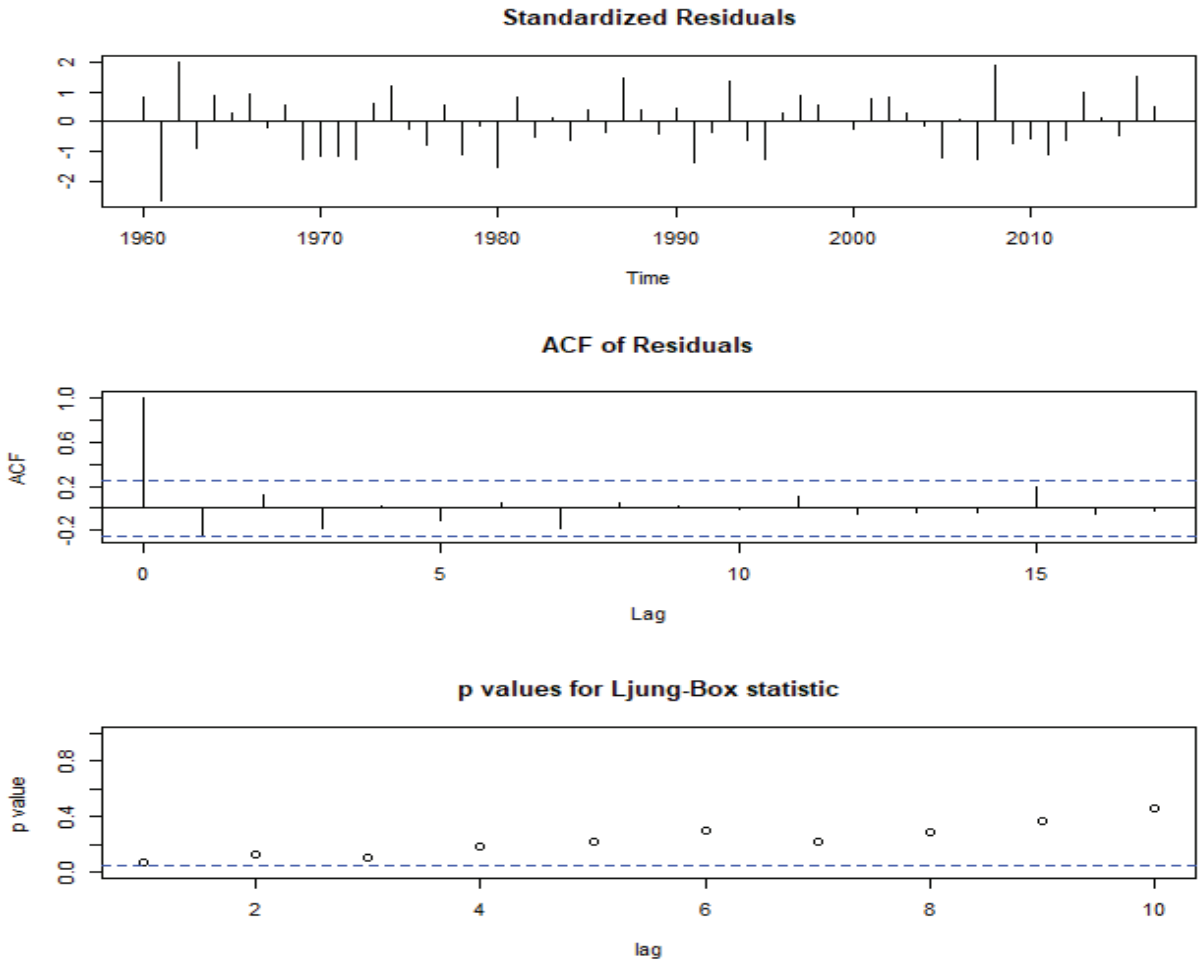

Figure-IX: Plot of ACF residual, Standardized residual and p-value for Ljung- Box statistic.