RESEARCH ARTICLE

Analysis and forecasting of road traffic mortalities in Azad Jammu and Kashmir

Navid Feroze, Kamran Abbas, Sumaira Rashid, Azhar Saleem

Abstract

Objective: To analyse road traffic accident mortalities in a geographical region.

Method: The retrospective study was conducted in Azad Jammu and Kashmir based on secondary data from 2004 to 2017 collected from the police department. Duncan's multiple range test was used to assess the trends in road traffic accident fatalities with respect to districts and divisions. Different goodness-of-fit criteria were used to compare the performance of different regression models to analyse road traffic accident mortalities with respect to vehicle ownership. The parsimonious time series model was used to forecast the future trends of road traffic accident mortalities. R 3.6.0 software was used for data analysis.

Results: There were 5263 major road traffic accidents during the period studied, causing 2317 deaths and 12963 injuries. The number of mortalities in Mirpur division was 923(39.8%), in Muzaffarabad 794(34.3%), and inss Poonch 600(25.9%). The rates of road traffic accident mortalities per 100,000 population increased up to year 2010 and dropped slowly afterwards (Figure 1C). Some disparities were noted among different districts and divisions with respect to road traffic accident mortalities. Based on different goodness-of-fit criteria, the Smeed's model was found to be the most efficient model to analyse the trends of road traffic accident mortalities with respect to vehicle ownership (Table 1). The forecast for road traffic accident mortalities exhibited some fluctuations in the start and a uniform trend afterwards (Figure 6).

Conclusion: Disparities in road traffic accident fatalities across different districts and divisions of Azad Jammu and Kashmir were observed. Though the rate of road traffic accident mortality was seen to be decreasing since 2010, the situation is for behind compared to the global Sustainable Development Goals.

Key Words: RTA mortalities, Smeed's model, Time series.

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Introduction

Road traffic accidents (RTAs) are the 10th leading cause of death globally, resulting in more than 1.2 million fatalities annually. Moreover, the RTAs are leading cause of deaths for youth aged 15-29 years[1]. Keeping in view the importance of the issue, there are numerous studies regarding investigation of RTA mortalities in different countries, states and cities around the globe, like China[2], Saudi Arabia[3], Nigeria[4], Iran[5], Mexico[6], Brazil[7], Slovak Republic[8], Kenya[9] and Bhutan[10]. Sustainable Development Goal (SDG) 3.6 aimed at restricting the number of RTA mortalities to 50% by 2020 compared to 2015[1]. In order to monitor the progress towards the target, there is a need to have accurate and reliable information on RTAs related injuries and fatalities. Unfortunately, in many developing countries, either reliable data regarding RTAs is unavailable or there has been little attempt to analyse the trends of RTA fatalities[11].

Department of Statistics, The University of Azad Jammu and Kashmir, Muzaffarabad, Pakistan

Correspondence: Navid Feroze. Email: navidferoz@gmail.com

The state of Azad Jammu and Kashmir (AJK) has a total area of 13,297 square kilometres (5,134 sq miles), and a total population of 4,045,366 as per the 2017 census. It is distributed into 10 districts and 3 divisions; Muzaffarabad, Poonch and Mirpur. The state has a road network spread over 17,033km and there are 129,477 vehicles[12,13]. The government of AJK has paid attention to the issue of RTAs and has started several awareness campaigns for different stakeholders. Despite these campaigns, the RTAs are having an upward trend[13]. The current study was planned to analyse RTA mortalities in AJK in terms of trends and forecasts.

Materials and Methods

The retrospective study was conducted in AJK based on secondary data from 2004 to 2017 collected from the police department. The data included RTA fatalities, size of population and number of vehicles from 2004 to 2017. The freely available R 3.6.0 software was used for data analysis[14]. The package pwr[15] was used to estimate the sample size, estimating the standard deviation for RTAs as 61.85, and assuming the margin of error to be 20 units[15]. The data available for the study both in terms of number of RTAs and RTA-related fatalities was much higher compared to the required 2828 and 1764, respectively. The varying trends of RTA mortalities were compared using analysis of variance (ANOVA). The influence of increase in number of motor vehicles on RTA mortalities was investigated using the most suitable statistical model, explored by comparing multiple linear regression model (MLR), Smeed's model[16] and Andreassen model[17]. Smeed's model and Andreassen model was used to approximate the per vehicle fatalities in India[18], while the MLR model was used to analyse the trends of RTA mortalities[19]. The suitability of the model in the current study was decided using different goodness-of-fit criteria, such as log-likelihood (LL), Akaike information criteria (AIC), Bayesian information criteria (BIC) and Kolmogorov Smirnov goodness-of-fit test[20]. The parsimonious model for forecasting of the future RTA mortalities was also explored, and the autoregressive integrated moving average (ARIMA) models were preferred in line with literature.[21] The Ljung Box test[21] was used to check whether the residuals of the proposed model were white noise.

Data normality was checked using Shapiro-Wilk normality test. Duncan's multiple range (DMR) test[22] was used to identify which districts/divisions were different with respect to RTA mortalities. For time series analysis, stationary property was assessed using the Augmented Dickey-Fuller (ADF) test[21]. $P<0.05$ was considered significant.

Results

There were 5263 major RTAs during the period studied, causing 2317 deaths and 12963 injuries. The number of mortalities in Mirpur division was 923(39.8%), in Muzaffarabad 794(34.3%), and in Poonch 600(25.9%). Mean RTA fatality per year was the highest in Mirpur 66±8.960, followed by Muzaffarabad 57±12.54 and Poonch 42±11.23. However, RAT mortalities per 100,000 population was the highest in Muzaffarabad 51, followed by Mirpur 39 and Poonch 31. RTA mortalities generally showed increasing trends with respect to number of vehicles per year (Figure 1A) and time (Figure 1B). RTA mortalities per 100,000 population had an increasing trend up to year 2010 and it dropped slowly afterwards (Figure 1C).

RTA mortalities per 100,000 vehicles had a decreasing trend with little fluctuation (Figure 1D). RTA fatalities per 1000 RTAs had a mixed trend over time (Figure 1E). RTA fatalities per 1000km of road had a decreasing trend since 2010 (Figure 1F).

The dataset was found to be normal as all the observed values were reasonably close to the diagonal line and no observation was outside the 95% limit (Figure 2). DMR test indicated that majority of the districts (Figure 3A) and all the divisions (Figure 3B) were significantly different with respect to RTA mortalities.

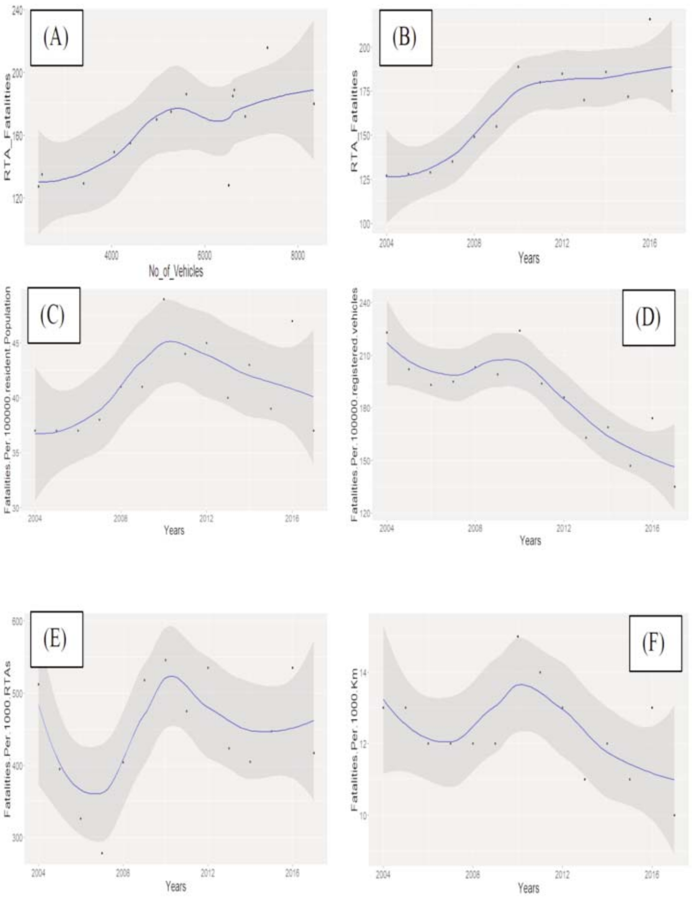

Figure-1: Rates of road traffic accident (RTA) fatalities with respect to population, number of vehicles, RTAs and road (Kms)

Smeed's model was found to the best (Table 1). and was a good fit to assess RTA mortalities (Table 2).

ADF value -2.683 confirmed that the original series was non-stationary (p=0.312). The time plot for the log-

Table-1: Model comparison for analysis of the RTA mortalities.

Models	LL	AIC	BIC
Smeed's Model	50.381	-94.761	-92.844
Andreassen Model	-53.163	114.326	116.882
MLR Model	-51.008	110.016	112.572

RTA: Road traffic accident, LL: Log-likelihood, AIC: Akaike information criteria, BIC: Bayesian information criteria, MLR: Multiple linear regression.

Table-2: Analysis of RTA mortalities using Smeed's model.

Division	n	a	b	R^2	F/V = a(V/P)b	KS Value	P.value
Muzaffarabad	5	368.364	-1.270	0.858	$368.364(V/P)^{-1.270}$	0.200	> 0.999
Poonch	5	72.671	-1.165	0.864	$72.671(V/P)^{-1.165}$	0.200	> 0.999
Mirpur	5	995.748	-1.685	0.879	$995.748(V/P)^{-1.685}$	0.200	> 0.999
Mean		479.000	-1.373				
S.D		417.366	0.275				
C.V		0.870	0.200				
Time (Time Series Smeed's Model)							
2004-08	5	1.556	-0.354	0.649	$1.556(V/P)^{-0.354}$	0.500	0.059
2009-13	5	0.125	-0.134	0.724	$0.125(V/P)^{-0.134}$	0.400	0.873
2014-17	4	17.648	-0.591	0.840	$17.648(V/P)^{-0.591}$	0.250	> 0.999
Mean		6.443	-0.360				
S.D		9.730	0.230				
C.V		1.510	0.640				

F = No. of RTA fatalities, V = No. of vehicles, P = Population in million, 'a' and 'b' are the parameters of the Smeed model. SD: Standard deviation, CV: Coefficient of variants, RTA: Road traffic accident.

Table-3: Comparison of different ARIMA models for RTA mortalities.

Model No.	Model	AIC	BIC	LL
1	ARIMA(0,0,0)	-15.82855	-14.69866	9.91428
2	ARIMA(1,0,0)	-21.13380*	-19.43895*	13.56690
3	ARIMA(2,0,0)	-17.17833	-15.91853	13.08916
4	ARIMA(0,0,1)	-18.18734	-16.49249	12.09367
5	ARIMA(0,0,2)	-16.60881	-14.34901	12.30441
6	ARIMA(1,0,1)	-20.79816	-18.53836	14.39908
7	ARIMA(1,0,2)	-19.59255	-16.76780	14.79627*
8	ARIMA(2,0,1)	-18.86740	-16.04265	14.43370
9	ARIMA(2,0,2)	-18.42152	-16.56332	12.21076

* indicates that the statistics favoured a particular model; ARIMA: Autoregressive integrated moving average, LL: Log-likelihood, AIC: Akaike information criteria, BIC: Bayesian information criteria, RTA: Road traffic accident.

differenced series did not show any trend (Figure 4A). ADF statistic value 5.061 verified that the log-differenced series was stationary (p=0.012). Next, autocorrelation function (ACF) (Figure 4B) and partial autocorrelation function (PACF) plots (Figure 4C) indicated that ARIMA 1,0,1 model was suitable, but ACF and PACF plots can be deceptive at times, so different ARIMA models were considered in order to reach a parsimonious model for forecasting RTA mortalities (Table 3).

The Ljung Box test at lags 4 (p=0.817), 6 (p=0.842) and 10 (p=0.744) indicated that the residuals from the proposed model were white noise. To assess the efficiency of the forecasts from the proposed model, observed and forecast values were compared (Figure 5). The future

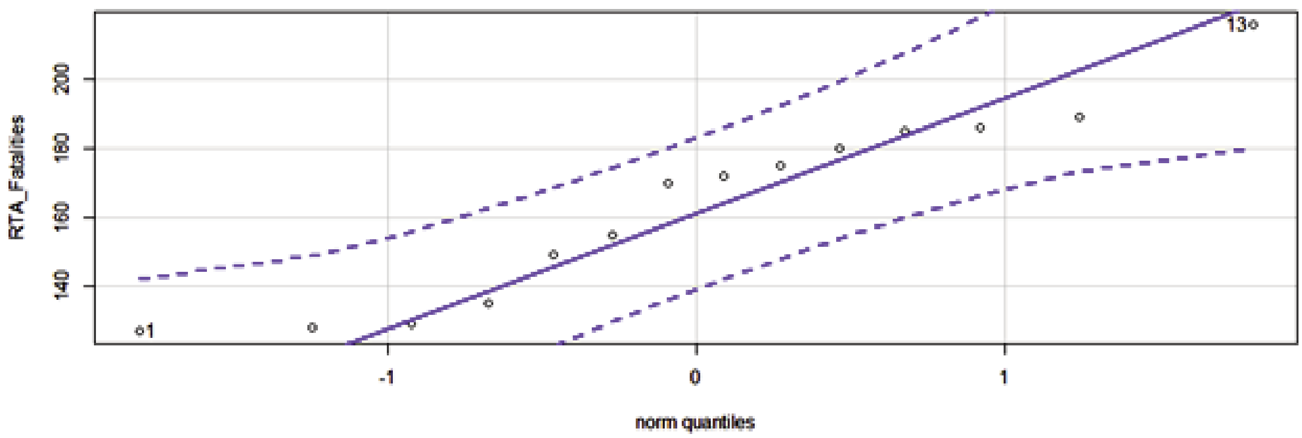

Figure-2: QQ plot for road traffic accident (RTA) fatalities..

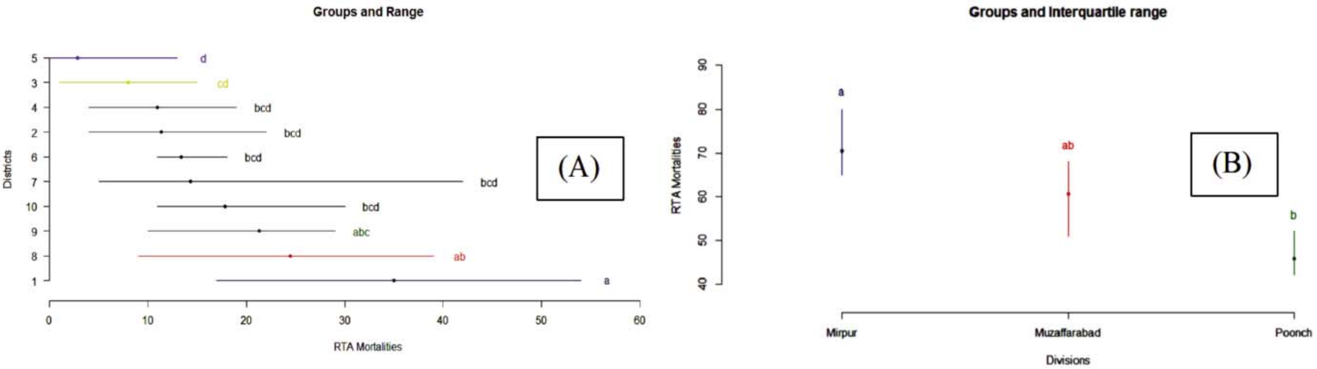

Figure-3: ADuncan's multiple range (DMR) test for different districts and divisions of Azad Jammu and Kashmir (AJK).

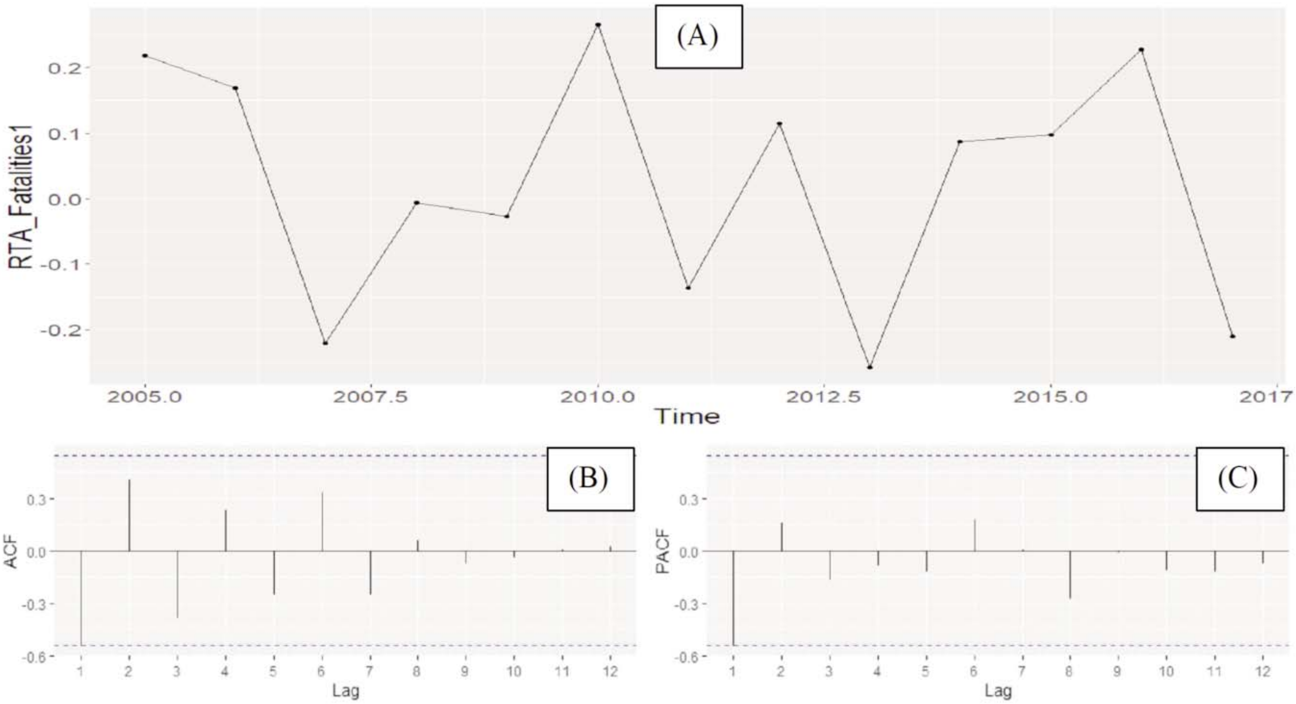

Figure-4: Time, autocorrelation function (ACF) and partial autocorrelation function (PACF) plots for log-differenced road traffic accident (RTA) fatalities.

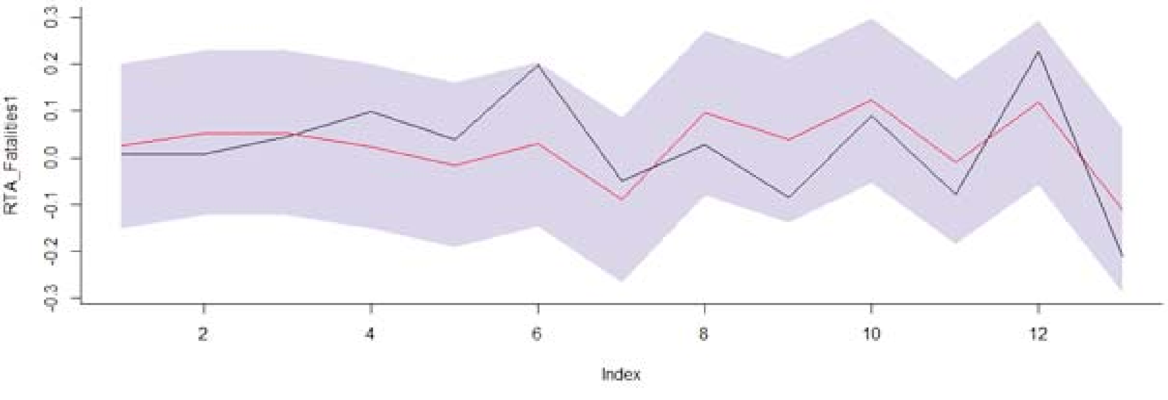

Figure-5: Comparison of observed and forecasted log-differenced road traffic accident (RTA) fatalities.

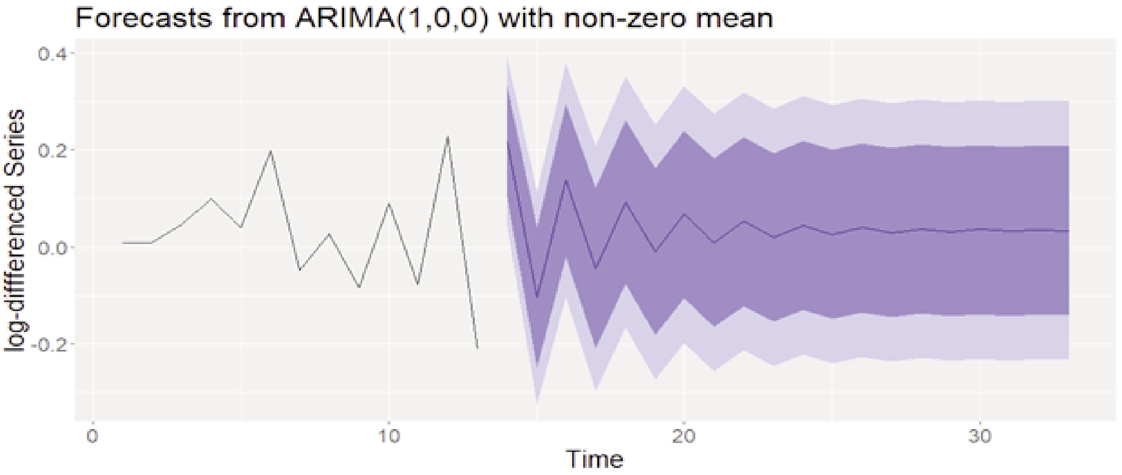

Figure-6: Forecasts for log-differenced road traffic accident (RTA) fatalities.

trend of the forecasts indicated that the current strategies to minimise RTA mortalities in AJK may not create a significant impact (Figure 6).

Discussion

To the best of our knowledge, the current study is the first to analyse and forecast the RTA mortality trends in AJK. The recorded decline in RTA mortality in AJK since 2010 is encouraging, particularly considering a 53.3% increase in registered vehicles and 22.5% increase in the resident population during the same period[10]. The mortality decrease probably reflects substantial improvements in transportation infrastructure and healthcare system during the rehabilitation process after the devastating earthquake in AJK on October 8, 2005. It is also an encouragement for the awareness campaigns started by AJK traffic police department during last few years. However, the average RTA mortalities per 100,000 persons in AJK between 2004 and 2017 was 41, which is still much higher than 17.2 globally[1].

DMR test indicated that majority of the districts and all the divisions were significantly different with respect to RTA mortalities. These disparities might reflect varying degrees of urbanisation, different patterns of population mobility, different road infrastructure, different traffic control efforts, different capacities to handle emergencies and long-term trauma care in different districts and divisions of AJK.

Smeed's space-variant model was a good fit for RTA mortalities compared to the other competing models used in the study. The proposed model was almost equally representative in all AJK divisions. Smeed's time variant model was also quite suitable for modelling RTA mortalities with respect to vehicle ownership in different time periods. Based on results from Smeed's model, it was concluded that RTA fatalities were more consistent across different divisions of AJK. On the other hand, RTA fatalities were little inconsistent over time. The reason might be the improved road network which got completed around 2010. The other reason may be the road safety campaigns of the traffic police department over the last few years.

The forecasts for RTA mortalities in AJK had some fluctuations in the start and a uniform trend afterwards. This indicates that current strategies to minimise RTA mortalities in AJK may not create significant impacts in the future. Hence, systematic and sustainable efforts are needed to accelerate progress in road traffic safety in AJK.

The current study has some limitation. Firstly, the data regarding different subgroups, such as RTA by type of vehicle, type of road users, gender, place (urban, rural) and age group were not available. Secondly, the study used data reported to police which is often incomplete due to under-reporting of RTAs. Efforts should be made to continue to improve the validity and timeliness of RTA-related data in AJK.

Conclusion

Though decrease in the rates of RTA mortalities has been observed since 2010, AJK is still far behind in terms of achieving global targets. In addition, some disparities in RTA fatalities across different districts and divisions were observed. Further, current strategies to minimise RTA mortalities in AJK may not create significant impacts. Hence, systematic and sustainable efforts are needed to accelerate progress in achieving the global targets.

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