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A Modelling Framework for Assessing Road Network Impact on Subjective Quality of Life

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Abstract
Development of well-connected road network to insure quality living in cities is a paramount concern in the recent years. Efforts have been made to establish the underlying relationship between urban road network and societal well-being. However, the causal impact of road transport system on societal well-being is not yet well predicted. Such predicament is prompted by limited capture of quality of life attributes in analysis and also due to undefined predictive model for the assessment. This investigation has addressed such gap by ascertaining the social indicators essential for developing a conceptual framework of road network impact on quality of life. Appropriate road connectivity components and quality of life indicators were identified through literature review. Then questionnaire was design and used to collect data on respondents' opinion about the road connectivity components and quality of life indicators. Fifteen (37.5%) out of the forty districts within Abuja city were sampled in which 388 questionnaires were distributed to the respondents. At last, 367 questionnaires were found valid, and coded for the study. Then primary analyses including normality test, reliability test and sample suitability test were performed on the dataset using SPSS 15.0 software. After which exploratory factor analysis was performed to determine their validity for modelling and to summarize the variables into groups of similar identity for multivariate analysis. The present study has identified four road network social components – route options, transport efficiency, network reliability and traffic flow known as social predictors. These factors primarily influence transport-related subjective quality of life indicators - economic well-being, personal accessibility, personal mobility, social interaction and travel safety. Furthermore, the study has established measuring variables for the respective QOL indicators: economic well-being has 6 measuring variables, personal accessibility 5, personal mobility 5, social interaction 8, travel comfort 6, while travel safety has 6 measuring variables. This conceptual framework formed the basis for analyzing the extent to which road network influence the lifestyle of people in Abuja city. The model is essential and can be applied by researchers, planners, engineers and decision-makers to evaluate the impact of transportation network on transport-related well-being.

Keywords: Road Network, Quality of Life, Modelling, Social Indicators, Abuja City

Introduction
The term 'Quality' denotes the excellence of produce or outcome (Osman, 2004). Thus quality of life or well-being is an overall welfare of the general public (Diener and Suh, 1997). It involves community satisfaction with tangible and intangible materials such as transportation (Myers, 1988). Quality of life emerged as a concept within the Social Indicators Movement and questions basic assumptions about the relationship between well-being and the complex nature of individual and social material and immaterial well-being (Myers, 1988).

Numerous scientific methods for evaluating quality of life have been introduced (Diener and Suh, 1997) among which objective and subjective measures are foremost. Objective quality of life measures the external or observable conditions of life (Xie and Levinson, 2007). Such approach provides the list of elements which form quality of life and offers no formal theory (Dolan et al., 2006, Francesca et al., 2011).Quality of life is measured with objective social indicators – observable facts or conditions of life (Diener and Suh, 1997, Li and Weng, 2007, Apparicio et al., 2008).

Subjective quality of life (Well-being) is concerned with personal internal perception and judgement of life satisfaction or circumstances (Diener and Suh, 1997, Tesfazghi et al., 2010). Such concept is established on the assumption that people's experiential quality of life is best examined by direct expression of their personal feelings about conditions of life (Diener and Suh, 1997; Das, 2008). Subjective well-being avoids relying on the conviction of decision-makers, scholars, or others. This makes the approach superior, suitable and more preferred means of exploring quality of life (Lee 2008; Ibrahim and Chung 2003).

Transportation system has become imperative. A proficient transport network is indispensable for sustaining and enhancing the quality of life in cities, which in turn ensures viable development (Thales, 2012 and Sreelekha et al., 2016b). Despite its significance for societal well-being, existing literature related to assessing transport impact on quality of life is limited (Delbosc, 2012). It is reiterated that the link between transportation system and community well-being is scarcely explored, thus its causal effect remains unclear (Schneider, 2013).

Among the range of road network – travel behaviour literature, Sarkar (2013) explored the pattern and spatial variations of road system. The result revealed that road density and connectivity influence the efficiency of road network, while spatial imbalance in road network retard mobility within a region. Hajrasouliha and Yin (2014) assessed the effect of street interconnection on pedestrian volume. It was found that physical and visual connection mutually have positive effects on pedestrian volumes. Jenelius (2009) studied the relationship between network arrangement and vulnerability. The outcome indicated that variation in road network vulnerability at district level occurs due to disparities in network structure. Parthasarathi et al (2014) studied the impact of road network topology on domestic travel forms. It was found that network structure influence travel pattern of households. Marshall and Garrick (2010) investigated the effect of street networks on road safety. The study established that road network organization influence fatalities.

Attempts have also been made to understand the relationship between some aspects of transport system and quality of life. Such studies comprise the link between quality of life and accessibility (Lotfi and Koohsari, 2009), physical activity (Adams et al., 2009, Frank et al., 2010, Sarmiento et al., 2010), transport diversity (Feng and Hsieh, 2009), transportation sustainability (Steg and Gifford, 2007), transportation structure performance (Schneider et al 2013). Whereas such studies have assessed the impact of transportation system on various elements of objective quality of life, a comprehensive multi-dimensional approach for assessing transport-related subjective quality of life is scarce in the existing literature. Therefore, this research is aimed at identifying the social factors and developing a modelling framework that is suitable for exploring the influence of road network on quality of life.

Materials and Methods

This research was performed in Abuja city which is centrally located in Nigeria (Figure 1) at Latitude 7° 25' N & 9° 20' N of the Equator and Longitude 5° 45' E & 7 39' E of the Greenwich Meridian. The Federal Capital Territory (FCT) has landmass coverage of 2,824 Square Miles (7,315 Km2) (Dawan, 2000). About six local area councils constitute the FCT, including Abaji, Abuja Municipality, Bwari, Gwagwalada, Kuje, and Kwali (Figure 1). Abuja city is situated in the Metropolitan area council and covers a land area of 250 Km^2. The metropolis has a total road length of 1,738.95 kilometres. The paved roads have a total length of 1,028.8 Kilometres while the unpaved roads cover a distance of 710.15 Kilometres.

The road network existing in Abuja city has hierarchical structure consisting of Expressways (Figure 1) linked by Arteries and Sub- arteries (Ways), Collectors (Secondary) and Local (Street) roads. This research consisted of two phases: a pilot survey and the main survey. Initially, an intensive literature review was carried out to identify road network social components, transport-related quality of life (QOL) indicators and their allied variables. Questionnaire was designed based on the identified list of road network social components, QOL indicators and the related variables. Using a Likert scale, the respondents assessed the performance of road network by rating their view on the identified components of network. The respondents also graded their satisfaction with each quality of life indicator variables. The Likert scale ranged from 1 to 5, where 1 represented strongly agree and 5 represented strongly disagree. Such technique was used to investigate the participants' opinion on how road network social components influence quality of life indicator variables. The respondents' view regarding the influence of social components on QOL indicators were recorded.

During the study, fifteen districts were sampled out of the existing forty districts; in which 388 questionnaires were distributed to the respondents in Abuja city. Thirteen (13) questionnaires were not retrieved from the respondents while eight (8) of those retrieved had about 70% - 80% missing data, so they were not considered valid for analysis. At last, 367 questionnaires were found valid, coded, and analysed using statistical programme for social science (SPSS) software to generate information on road network performance and transport related quality of life indicators.

Series of empirical analysis were carried out on the road network social components and QOL variables. Primarily, normality test was performed to define the distribution of dataset so as to establish normal distribution of the sampled cases. Reliability test was done to determine inter-item correlations and internal consistency of all the indicator variables. Furthermore, the Kurtosis and Skewness statistical values were generated. Sample suitability test was conducted using Kaiser-Meyer-Olkin (KMO) and Bartlett's test to ascertain whether the answers given and the strength of relationship between the variables were satisfactory.

Exploratory factor analysis (EFA) was conducted to examine the relevance and group factor variables into components and as well test their validity and contribution to the perceived model. Factor extraction was computed based on the following specifications: principal component extraction, varimax rotation, threshold for factor extraction of Eigen value >1. Only factors with loading more than 0.75 were retained here as recommended by Jolliffe (2002).

The items tested comprise road network social components including route options (RDCON1), network reliability (RDCON2), transport efficiency (RDCON3), and free traffic flow (RDCON4). Also examined were the reliability of quality of life indicators. These included personal accessibility (ACES), personal mobility (MOBL), emotional travel safety (SAFE), travel comfort (COMF), economic well-being (ECON) and social interaction (SOCL).

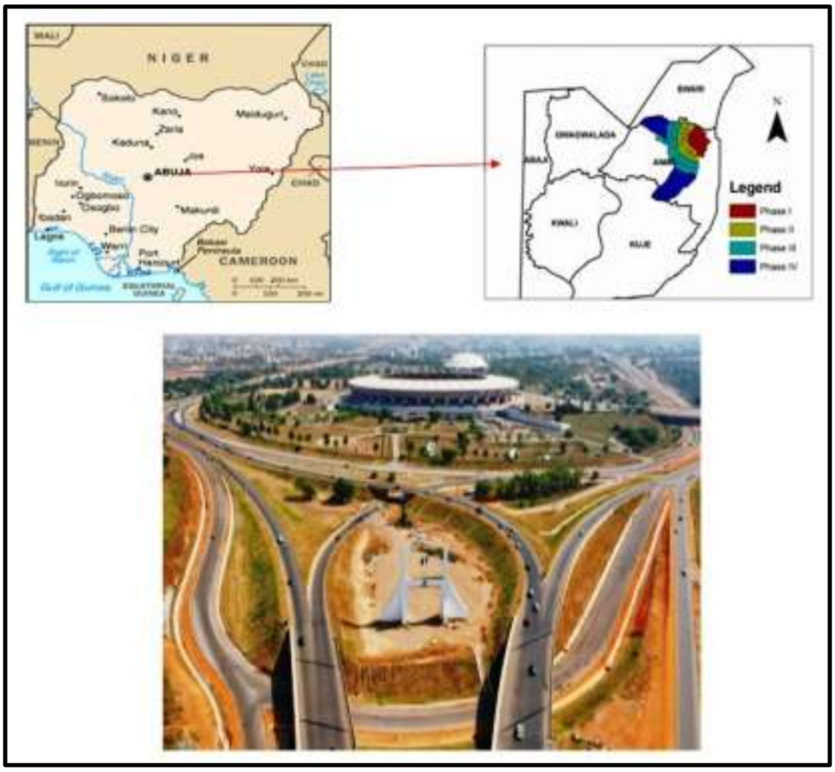

Figure 1: Study Area

Results and Discussion

Road network social components, QOL indicators and the respective variables were initially identified through literature review. Normality test define the normal distribution of dataset or the sampled cases. The result in Figure 2 indicates that the entire dataset were normally distributed. The results of Kurtosis and Skewness statistical values affirm that about 98.56% response cases were found within the tolerable range of ±1.96 for analysis in this investigation.

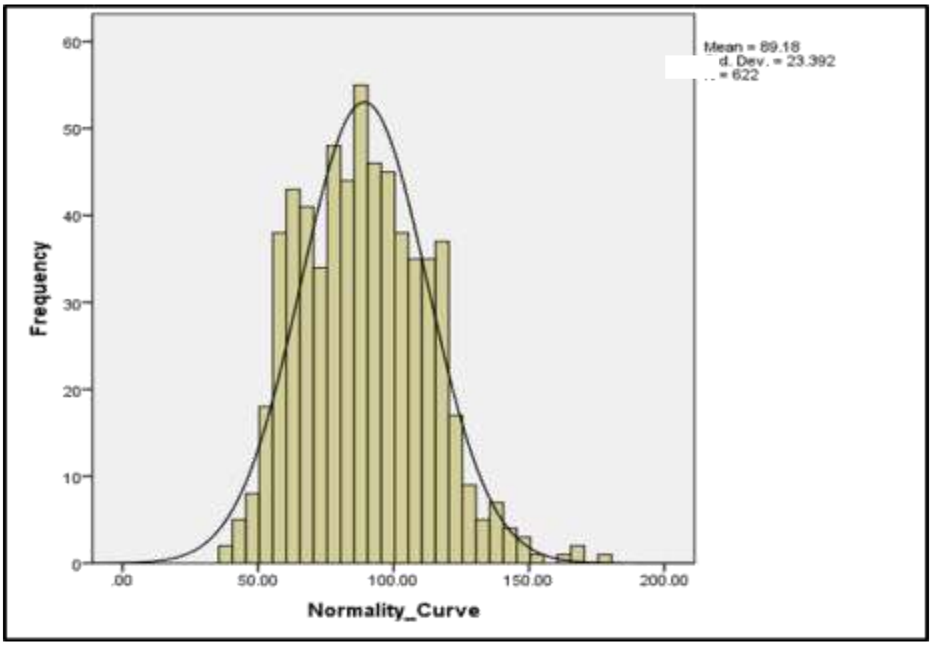

Figure 2: Normal Distribution of Response Cases

Reliability Test

Reliability test determine inter-item correlations and internal consistency of all the indicator variables. The result of reliability test presented in Table 1 reveals that all main indicator variables (represented in bold digits) were above the threshold of 0.75 Cronbach alpha coefficient. The result also shows that the overall inter-item correlations of variables had reliable scale of greater than (0.5) the threshold of reliability. This implies that the variables could be grouped into seven main factors tagged as latent indicators. The individual items represented the measurable sub-factors. Thus both the main factors and sub-factors of road network components and quality of life have the ability to measure the perceived conception or model.

Sample Suitability

The result of sample suitability test presented in Table 2 indicates a sample acceptability of 0.913 which is higher than the threshold of 0.7 Cronbach alpha coefficient. This implies that the responses by the participants and the power of association among the indicator variables were adequate for analysis.

Table 1: Test of Reliability

Item	Label	Inter-Item Correlation	Cronbach's Alpha
RDCON1	Road network enables multiple route options.	.686	**.879**
RDCON2	Roads are reliable for all transport modes.	.720	
RDCON3	Road network fully satisfy transport demands.	.762	
RDCON4	The road network permits swift traffic flow.	.754	
ACES1	Easy to reach shopping precinct.	.702	**.891**
ACES2	Easy to reach job location.	.736	
ACES3	Easy to reach hospital/clinic.	.781	
ACES4	Easy to reach primary/secondary schools.	.703	
ACES5	Easy to travel directly to different destinations.	.672	
COMF1	Public transport operation is satisfactory.	.554	**.826**
COMF2	Feel comfortable walking along roadways.	.815	
COMF3	Feel convenient vehicular trip along roadways.	.720	
COMF4	Road network layout is emotionally appealing.	.667	
COMF5	Bus-stop supply is satisfactory on roadways.	.721	
COMF6	Convenient seating arrangement at bus-stops.	.692	
ECON1	Roadways create retail business opportunity.	.757	**.880**
ECON2	Roadside shops satisfy local consumer needs.	.758	
ECON3	Roadside retail reduces travel cost to market.	.682	
ECON4	Roadside shop renting increases local earning.	.705	
ECON5	Road retails certify local group economy.	.602	
ECON6	Roadside shops ensure lovely environment.	.579	
MOBL1	Physical layout of road network is satisfactory.	.557	**.820**
MOBL2	Satisfactory route options to destination.	.759	
MOBL3	The roads enable different travel mode choices.	.717	
MOBL4	The roads facilitate easy personal movement.	.703	
MOBL5	Public transport cost is bearable.	.485	
SAFE1	Feel emotional safe walking along roadways.	.673	**.791**
SAFE2	Feel safe cycling on the roadways.	.691	
SAFE3	There is less traffic accident on the roadways.	.582	
SAFE4	Less attack of road users during night trip.	.556	
SAFE5	Less road robbery during night trip.	.582	
SAFE6	Less & bearable road traffic noise.	.545	
SOCL1	Access to community meetings.	.808	**.907**
SOCL2	Access to social association gatherings.	.777	
SOCL3	Access to religious activities; worship centres.	.688	
SOCL4	Easy visit to family members and friends.	.662	
SOCL5	Accessibility to out-door sports (games).	.721	
SOCL6	Access to amusement and recreational parks.	.676	
SOCL7	Access to places of leisure and entertainment.	.745	
SOCL8	Access to public transportation system.	.697	

Table 2: KMO and Bartlett's Test

KMO and Bartlett's Test		
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.913
Bartlett's Test of Sphericity	Approx. Chi-Square	15425.684
	df	741
	Sig.	0.000

Exploratory Factor Analysis

Exploratory factor analysis (EFA) examine the relevance and group factor variables into components. It also tests their validity and contribution of factor variables to the perceived model. The result of EFA in Table 3 depicts the seven rotated component matrix extracted from the forty one (41) indicator variables. Each of these components form a cluster of variables; of which road network components (RCON1, RCON2, RCON3, and RCON4) forms a unit. Six latent indicators of quality of life (unobservable-factors) have been established comprising social interaction, personal accessibility, economic well-being, personal mobility, travel comfort and travel safety.

Thirty-seven (37) observable (sub-factors) indicators were initially identified from the literature review. However, based on the factor loading cut off point of 0.75 adopted in this study, eleven (11) items were found to have low factor loading. These eleven (11) observable (sub-factors) failed to meet the required standard for consideration in this research. Such items represented in bold digit in Table 3 are normally recommended for deletion.

Thus Items COMF1, COMF5, COMF6, ECON6, MOBL1, MOBL3, MOBL5, SAFE4, SAFE5, SAFE6, and SOCL6 in Table 3 were deleted from the present model as earlier explained. After removing these 11 low factor loading items, the observable factors were reduced to twenty-six (26) variables for modelling as presented in Table 4.

Table 4 illustrates that four (4) road network social components and twenty six (26) quality of life indicators were above the admissible value (0.75) factor loading. This implies that the variables were suitable for development of a conceptual model. Overall, seven latent (unobservable) constructs or factors including road network components, personal accessibility, personal mobility, economic well-being, emotional travel safety, travel comfort and social interaction have been ascertained. These plus the thirty (30) observable (sub-factors) formed the constituents of the intended conceptual modelling as represented in Figure 3.

Table 3: Exploratory Factor Analysis

Rotated Component Matrix[a]							
	Component						
	1	2	3	4	5	6	7
RCON3	.896						
RCON4	.867						
RCON2	.833						
RCON1	.832						
ACES3		.899					
ACES4		.857					
ACES2		.854					
ACES1		.784					
ACES5		.776					
COMF2			.905				
COMF3			.841				
COMF4			.840				
COMF5			**.727**				
COMF6			**.722**				
COMF1			**.654**				
ECON2				.880			
ECON1				.868			
ECON3				.825			
ECON4				.807			
ECON5				.766			
ECON6				**.686**			
MOBL4					.904		
MOBL3					.898		
MOBL2					.889		
MOBL1					**.615**		
MOBL6					**.591**		
MOBL5					**.590**		
SAFE1						.818	
SAFE2						.791	
SAFE3						.757	
SAFE5						**.697**	
SAFE4						**.654**	
SAFE6						**.617**	
SOCL1							.836
SOCL7							.815
SOCL3							.814
SOCL4							.808
SOCL5							.787
SOCL2							.775
SOCL8							.764
SOCL6							**.681**
Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalization.							
a. Rotation converged in 7 iterations.							

Table 4: Summary Road Network Social Components & QOL Indicators

Item Code	Factor Survey Statement	Factor Loading
RCON3	Road network satisfies transport demand	.896
RCON4	Road network permits swift traffic flow	.867
RCON2	Road network is reliable for all travel modes	.833
RCON1	Road network enables multiple route options	.832
ACES3	Easy to reach hospital and clinic	.899
ACES4	Easy to reach primary & secondary schools	.857
ACES2	Easy to reach job locations	.854
ACES1	Easy to reach shopping precincts	.784
ACES5	Ease direct travel to different destinations	.776
COMF2	Feel comfortable walking along the roadways	.905
COMF3	Convenient vehicular trip on the roadways	.841
COMF4	Road layout is emotionally appealing	.840
ECON2	Roadside shops satisfy consumer needs	.880
ECON1	Roadway retails create business opportunity	.868
ECON3	Roadside retail reduces travel cost to market	.825
ECON4	Roadside shop renting rises local earning	.807
ECON5	Road retailing ensure local group economy	.766
MOBL4	The roads ease personal movement	.904
MOBL3	The roads ease travel by different modes	.898
MOBL2	Satisfactory route options to destination.	.889
SAFE1	Feel emotionally safe walking on roadways	.818
SAFE2	Psychologically safe to cycle on roadways	.791
SAFE3	There is less traffic accident on the roadways	.757
SOCL1	Ease access to community meetings	.836
SOCL7	Ease access to places of leisure	.815
SOCL3	Ease access to religious worship centres	.814
SOCL4	Ease visit to family members and friends	.808
SOCL5	Ease access to out-door sports (games)	.787
SOCL2	Ease access to association gatherings	.775
SOCL8	Ease access to public transportation system	.764

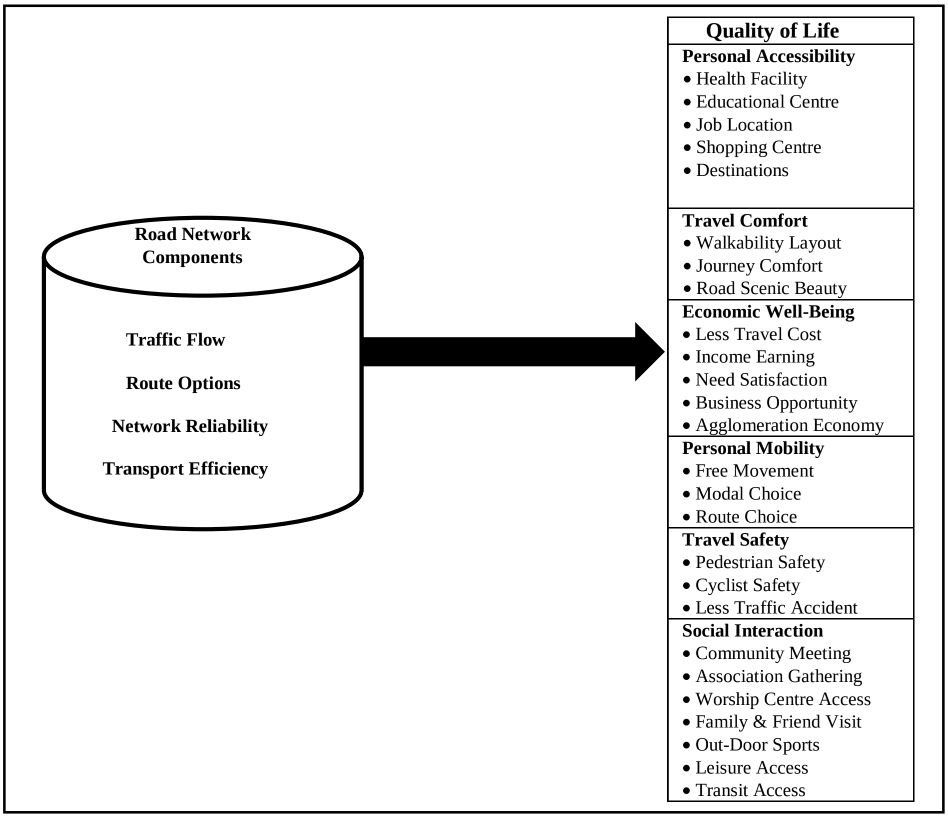

Figure. 3: Road Network – Subjective Quality of Life Model

This newly introduced multi-faceted model (Figure 3) implies that the performance of road network can be determined by rating four (4) components namely route options, network efficiency, transportation reliability and traffic flow as outlined in Figure 3. These four components serve as exogenous (independent) factors in the model. The influence of road network on quality of life is detected by the six latent (unobservable) components specifically personal accessibility, travel comfort, economic well-being, personal mobility, travel safety, and social interaction. Each of these six latent components are measured by their respective sub-component (observable) indices as defined in the diagram (Figure 3). The six latent components and their respective sub-factors function as endogenous (dependent) factors in the model.

Conclusion

A suitable conceptual framework is required for better and authentic assessment of road network impact on personal quality of life. This research has identified suitable road network social components and quality of life indicators that could be used in determining multiple influence of the variables within and across the factors. Such newly developed conceptual model pools road network social elements and subjective quality of life variables into a single multi-faceted analysis. This is a general scheme, which is highly significant and serves as a productive framework for appraising, modelling and forecasting the empirical effect of road transport network on societal well-being. The set of indicators reflects the causal links between phenomena and can monitor the performance of transport network on societal well-being. Hence, the model is essential and can be applied by researchers, planners, engineers and decision-makers to evaluate the impact of transportation network on transport-related well-being in cities and elsewhere.

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