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Inclusive Urban Design: Enhancing Pedestrian and Cyclist Safety in Islamabad's Expanding Road Networks

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Abstract:

The phenomenon of urban growth in recent years especially in Islamabad has promoted enhanced construction and development of the road network that enhances vehicular operation. But these extensions failed to promote safety for pedestrians and cyclists and became ironic that better infrastructure endangers non-motorized users. This study examines the effects of Islamabad's Road extensions on pedestrian and cyclist safety using conceptual theories including Risk Homeostasis Theory, Environmental Stress Theory, and Crime Prevention Through Environmental Design. A detailed on-site study was made on different roads including behavioral patterns of traffic, prevailing conditions and adequacy of available infrastructures. According to the study, large lanes result in traffic movements although they increase risks of accidents for the weaker road users because of elevated speeds and lack of pedestrian infrastructure. Among policy advice developed the inclusion of pedestrian and cyclist facilities, traffic calming and environmental considerations for urban design are highlighted. This is further affirmed by the study pointing that the coordination of technology and the public in the planning of cities is fundamental if safety and mobility are to be met in the plurality of the city.

Keywords: Islamabad, socially sustainable urban development, walking safety, cycling safety, sustainable cities, mobility

INTRODUCTION

Thus, Islamabad, the capital of Pakistan can be viewed as the ultimately typical representation of the new tendencies in developing countries' urbanization. Thus, to respond to increasing car traffic, the development of the road infrastructure has been considered a priority. For instance, the

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projects like Islamabad Expressway and Srinagar Highway intends to provide ease of traffic and minimizing traffic jam. But these changes have significantly left pedestrians and cyclists in insecure conditions much as safety considerations are of paramount importance.

With concern to road expansion the main goal is to increase traffic efficiency and integration but often the gains are overshadowed by costs. From the results presented and references cited there is an indication that while road expansions have been effective in addressing the efficiency of vehicular traffic, it has resulted in a rise in traffic speeds, traffic accidents, and a decrease in the perceived road safety by non-motorized road users. This paper looks at road expansion in Islamabad and examines the effects of these on pedestrians and cyclists. Field data and theoretical frameworks are then used to enhance the understanding of inclusive urban planning and policy changes. And the responsibilities regarding the protection of all the lives on and around the road—the pedestrians, cyclists and other vulnerable groups must be met, continue to be some of the most important concerns of sustainable development of cities.

This study aims to assess how roadway extension changes the safety of travelers in Islamabad with an emphasis on the motorized road system improvement impact with the rates of traffic flow and speed as well as reductions in accessibility of the roads for NMT users. To examine the impacts of some factors such as noise pollution and air quality degradation on the behaviors and safety attitudes of road users in an urban environment. To understand effects of cultural values, weak implementation of traffic laws, and urban design and planning approaches on risky and protective actions among drivers, pedestrians and cyclists. To determine and record missing signals, where there are no or poorly marked crosswalks, bike lanes, or other forms of safety measures for both the pedestrians and cyclists in some busy corridors. To prepare well-coordinated and informed recommendations on inclusive urban planning based on international experience as well as develop recommendations for the specific problems of Islamabad.

LITERATURE REVIEW

Urban road expansions and safety have been explored in both international and regional literature. According to UN-Habitat (2013), despite the rationale for road expansion is to relieve congestion, the generally applied solution increases danger to NMU, if no attention is paid to them in planning. This is important, especially in growing urban contexts such as Islamabad; here, the needs of drivers dominate at the expense of the pedestrian. Likewise, Wilde's (1994) Risk Homeostasis postulates that drivers use perceived risk factors to decide on their behaviors thereby neutralizing positive impacts of widening of roads. Elvik and colleagues (2009) also contribute towards this reasoning, observing that smoother roads equal even more daring behavior behind the wheel – including exceeding the speed limit and taking uncovered overtaking maneuvers.

According to Stokols (1972), psychological consequences of environmental stressors likewise affect users of roads in urban areas including noise and pollution. Such stressors are associated with cognitive function's A decline, as well as the likelihood of engaging in less-safe behaviors. The same assertion is echoed by Ali et al. (2023) who found the anti-environmental deterioration marks a major impact of expansion of road networks in urban areas in Islamabad. Noise pollution was recorded to be above 85dB and particulate matter that was above 120 $\mu g/m^3$ making life on expanded roads very unpleasant to human health both physically and psychologically. Equally,

Peden et al. (2004) note that factors like green buffers, noise barriers are essential in preventing these negative effects thus supported by other metropolitan studies in Karachi Adeel et al., (2018).

Human safety in developing and developed countries has attracted significant attention especially on how pedestrians are protected in cities. According to Peden et al. (2004), better management of other forms of facilities such as crosswalks, pedestrian over passes, and traffic calming measures also reduce accidents. These are in line with Litman (2020) who supports the implementation of the 'urban plazas' where people walk, cycle and drive. Lack of such designs in contexts like Islamabad is therefore a way of putting up a system that hinders non-motorized road users, something that coincidentally, Rafique and Malik (2020) also capture. These challenges are further compounded by a distinct lack of investment in pedestrians in any extensions done on Islamabad's roads, as has been evident by comparing the visualizations with underdeveloped regions that see significantly high levels of jaywalking (Ali et al., 2023).

Subsequently, examining the cultural and social aspects of traffic behaviors offer light by the Theory of Planned Behavior. In Islamabad, there have been concerns in which social practices that support motor cars end up trumping the Somali rights through ignoring traffic lanes to cross the road, or even by speeding. Adeel et al. (2018) recorded similar facts in South Asian countries where traffic Mean laws are not applied routinely Andrea H introduced that women are not expected to obey them. Campaigns aimed at eradicating such cultures as successfully conducted in Bangalore and Dhaka have shown results in changing road user behavior (UN-Habitat, 2013).

Global benchmarking also supports the notion of traffic safety as influenced by urban planning. Complete streets and prioritized pedestrian areas such as in Amsterdam and Copenhagen have been effective in measures towards decreasing incidents and improving the quality of urban environments (Litman, 2020). For example, in Amsterdam, changes in traffic guidelines governing provision of bike lanes and pedestrian crossings have been associated with 35% decrease in number of cyclist's accidents (Peden et al., 2004). Like Copenhagen's strategies for communicating green pathways with automobile traffic calming measures including roundabouts and raised crossings demonstrated in figure-4, shows that the inclusive urban design provides safety and mobility (Rafique & Malik, 2020).

Perhaps, it is high time that Islamabad borrowed such strategies from the current problems it faces to adopt these practices locally. The new technologies in traffic monitoring with the help of artificial intelligence and GIS mapping provide new tools for data-based city planning. Litman (2020) and Ali et al. (2023) revealed that these tools improve road safety outcomes due to application of intervention measures in areas with higher risk. Also, as observing in Singapore and Tokyo where public transport system is well integrated with pedestrian system, the use of vehicular Presenter can be less while increasing accessibility on a general note as estimated by the UN-Habitat in 2013.

Global concern towards sustainability is also appropriate to the context of Islamabad. Pollution stressors such as noise and air are indications of health essentials such as fresh air, clean water and maximum road usage; majority of vulnerable, low-income and non-motorized road users need to be incorporated into an equitable urban design. The kind of design that has proven to be effective based on research conducted by Stokols (1972) as well as Peden et al (2004) on independence on the environment has major barriers which may include green corridors, low emission zones among others. With these strategies, Islamabad can call for solutions to the problems related to urban safety and environmental sustainability.

Thus, literature also presents the phenomenon of paradox of urban road expansion with a more complex approach of intervention. The linking of culture, environment, and technology in relation to the organization of the city can greatly improve safety for those on foot and on bike. From experience of other cities and facilitating availability of advanced technologies, for example, mobility in Islamabad does not have to be a deathtrap or reinforce segregation and inequality while assuming large scale.

METHODOLOGY

Due to this, a cross-sectional study design with a mixed method approach was used to assess the safety consequences of road expansion in Islamabad. This approach used a mixed method approach of data collection and analysis to capture the myriad effects of road expansion on traffic conduct, environment and the level of infrastructure provision.

Quantitative Data Collection

Quantitative tools included:

- **Traffic Counters**: Several looped counters were placed at most of the major road intersections to measure traffic volume and concentration. The information concerned hour-of-day congestion and traffic flow rates.
- **Speed Monitoring Devices**: The average vehicular speeds were measured using radar guns and other automated speed monitors on the expanded and under construction roads mainly.
- **Noise and Air Quality Sensors**: Noise measurements in dB and airborne particles in $\mu g/m^3$ were recorded with portable devices at several sites, providing useful environmental information needed in assessing the overall effects of the road extensions.

Qualitative Data Collection

Qualitative methods complemented quantitative analysis by capturing perceptions and behaviors of road users:

- **Observational Checklists**: Surveys contained questions on how much of a delay additional pedestrians and cyclists took at certain hotspots, crossings, their patterns and the number of times interventions were nearly missed.
- **Structured Questionnaires**: A questionnaire was administered to the different road users through the cross-sectional survey which involved pedestrians, cyclists and drivers based on safety awareness and encounter.
- **Thematic Interviews**: In-depth semi structured interviews carried out among urban planners, traffic authorities, and residents enabled us to grasp more on infrastructural deficiencies and cultural dimensions of road safety.

Sample Framework and Locations

To increase the generalizability of findings, a stratified and random approach was adopted where roads under construction, expanded, schools' compounds, etc., were included in the sample.

Table 1: Survey locations chosen to reflect the diversity of urban contexts in Islamabad

Road Type	Sample Size	Key Characteristics

Expanded Roads	300	High-speed vehicular flow
Under-Construction Roads	200	Disruptions due to roadworks
Established Roads	150	Moderate traffic and mixed road usage
School Zones	100	High pedestrian activity
Industrial Areas	50	Presence of heavy vehicles and pollution

Advanced Analytical Tools

Spatial and temporal trends were determined with GIFF and real time traffic data assignments. R software was utilized to enhance the idea of accident hotspots, pedestrian and cyclist facilities, and traffic flow. Furthermore, real time data gave enhanced information on congestion and speed difference.

Limitations

While the methodology ensured robust data collection, certain limitations were acknowledged:

- **Time Constraints**: Data was only collected within specific hours of the day and may have missed off-peak activities.
- **Participant Bias**: This issue arises because the survey often provides the respondents with an opportunity to censor their socially accepted response as opposed to their actual nature of operation.
- **Environmental Variability**: Environmental factors including the presence of rain during certain analysis affected noise and pollution readings.

This study was marked by the use of an ambitious and well-coordinated mixed methods approach which enriched the investigation of the changing behaviors of road users and provided evidence for the making of sound policymaking recommendations.

Table 2: Survey Sample Distribution

Road Type	Sample Size	Key Characteristics
Expanded Roads	300	High-speed vehicular flow
Under-Construction Roads	200	Disruptions due to roadworks
Established Roads	150	Moderate traffic and mixed road usage
School Zones	100	High pedestrian activity
Industrial Areas	50	Presence of heavy vehicles and pollution

The survey also included direct observations of pedestrian and cyclist behavior at high-traffic zones and intersections, providing nuanced insights into the challenges faced by non-motorized road users. Environmental metrics, such as noise and air pollution levels, were measured using portable sensors to evaluate the broader impacts of road expansions on urban quality of life.

FINDINGS AND ANALYSIS

Traffic Flow and Speed Dynamics

The study also identified that as the roads are extended, for example the Islamabad Expressway, this results in increased volumes of traffic use but also increased likelihood of speeding. The speed recorded was 72 km/h on the arteries and 60% of the observed drivers we found were over the

legal speed limit. This is in paradigm with Risk Homeostasis Theory, whereby the enhancement on the road condition makes people to be riskier when they are on the road.

Table 3: Traffic Volume and Speed Analysis

Road Type	Average Speed (km/h)	Speeding Incidents (%)	Traffic Volume (vehicles/hour)
Expanded Roads	72	60	4,500
Under-Construction Roads	50	35	2,800
School Zones	20	10	1,200

Pedestrian Safety

Two specific areas of investigation included pedestrian crossings and sidewalks; these were perceived to be poorly provided for on expanded roads, which saw hesitation times average 8 seconds, and occasions of jaywalking. Blue Area, which is marked commercial was the most dangerous area for pedestrians followed very closely by near-miss incidents. These findings bring out the fact that there is a lack of good sidewalks that can accommodate pedestrians and safe zebra crossings and a lack of bicycle lanes.

Table 4: Pedestrian Safety Indicators

Road Type	Pedestrian Accidents (per month)	Jaywalking Incidents (%)	Average Hesitation Time (seconds)
Expanded Roads	8	30	8
School Zones	2	3	5
Commercial Zones	10	20	7

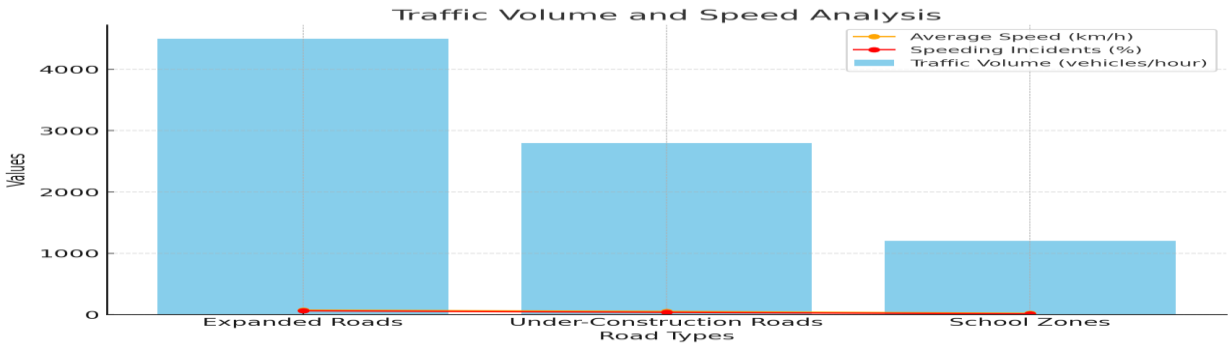
Environmental and Psychological Impacts

Exploratory and industrial roads were quickest in conveying high noise and pollution levels that have negative impacts on safety perception and cognition of the road's users. Ambient sound pressure on expanded roads stood at about 85 dB (> 65 dB recommended limit). It was noted that exposure to such environmental stressors over long periods may lead to increase driver and pedestrian frustration level as well as reduce their situational awareness.

Table 5: Environmental Impact Analysis

Road Type	Noise Levels (dB)	Pollution Levels (PM2.5, $\mu g/m^3$)	Safety Perception (1-5)
Expanded Roads	85	130	3
Industrial Roads	80	110	3
School Zones	65	70	4

Figure 1: Traffic Volume and Speed Analysis

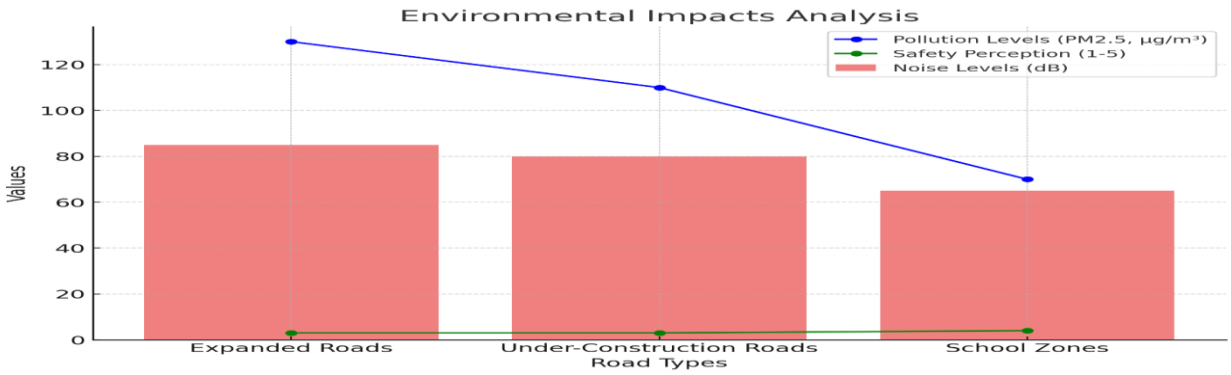


The graph compares traffic volume, average speed, and speeding incidents across three road types: including expanded roads, under construction roads, and school zones. The highest traffic volume (4,500 vehicles/hour) and average speed (72 km/h) is found on expanded roads where 60% exceed driving speed limits. Following the under construction roads, with moderate traffic volume (2,800 vehicles/hour) with speed (50 km/h) and 35% speeding incidents occurs. Only 10% of drivers speed in school zones (lowest traffic volume of 1,200 vehicles per hour, 20 km per hour average speed). The data show that road shape influences traffic behaviour with expanded roads favouring vehicular mobility, often at the expense of safety and that school zones adopt measures to minimize speeding and safety for pedestrians.

Figure 2: Pedestrian Safety Analysis

The graph compares jaywalking incidents, hesitation times, and pedestrian accidents across three road types: including expanded roads, under construction roads, and school zones. The greatest percentage of jaywalking incidents (30%) and greatest hesitation time (8 seconds) occur on roads that log more pedestrian accidents (8 incidents per month) than any other type and report the highest percentage of jaywalking incidents. On 25 percent of under construction roads, there are moderate safety risks: 15 percent jaywalking, 7 seconds of hesitation time, 6 average monthly accidents for pedestrians, and 2 injury fatalities per year. The school zones show the safest conditions; minimal jaywalking incidents (3%), shortest hesitation time (5 seconds), and 2 per month pedestrian accidents. The outputs of this analysis highlight the importance of improved pedestrian infrastructure during and reporting of road expansions and under construction roads, to reduce risk and enhance safety.

Figure 3: Environmental Impacts Analysis



The "Environmental Impacts Analysis" graph illustrates the relationship between pollution levels, noise levels, and safety perceptions across three road types: School Zones, expanded roads, and under construction roads. The traffic that moves through the expanded roads has the highest pollution levels, at 130 µg/m^3 PM2.5, the highest noise levels, at 85 dB, and the lowest safety perception score, at 3 out of 5. High noise (80 dB) and pollution (110 µg/m^3 PM2.5) levels are also reported for under construction roads, as are similarly low levels of safety perception, 3. In comparison, school zone pollution levels (70 µg/m^3 PM2.5) and noise (65 dB) levels are significantly lower; safety perception score is improved (4). In particular, this analysis focuses on the environmental hardships faced by pedestrians and cyclists on these expanded and under construction roads and the subsequent necessity of green buffer and noise barrier implementation to enhance the urban liability and safety.

Thematic Analysis of Qualitative Data

Hence, the cross-sectional analysis for qualitative data used THMA method and made available rich patterns and findings about urban design and associated perception of safety in Islamabad. The participants agreed with the statement with reference to the lack of crosswalks and bike lanes for pedestrians. For example, respondents were unanimous in pointing out that wider carriageways allow for speeding making it riskier to cross or cycle.

Table 6: Themes and Participant Insights

Theme	Participant Insights
Lack of Pedestrian Infrastructure	"There are no proper sidewalks, so we have to walk on the road, which is dangerous."
Speeding on Expanded Roads	"Drivers think wider roads mean they can go as fast as they want."
Perceived Environmental Stress	"The noise from traffic is unbearable, especially during peak hours."
Safety in School Zones	"Supervised crossings near schools make me feel safer for my children."
Impact of Cultural Norms	"In our society, people don't give way to pedestrians."

The findings of the qualitative analysis are consistent with these quantitative results, emphasizing the importance of considering the ideal architecture for all people in cities. The study found out that enhanced community disparagement and campaign, as well as more infrastructure provision and

construction of facilities, including pedestrian ways and speed management measures could greatly contain the above enumerated difficulties.

DISCUSSION

The study reveals patterns of road design, traffic behavior, and safety perceptions reciprocate in nature. Broad and level pavements allow the car to gain higher speed so the chances of having an event of an accident involving pedestrians and cyclists are high. Such finding is suggestive of Wilde's (1994) Risk Homeostasis Theory, whereby increased perception of risk results to corresponding heightened levels of risk taking. Research in other developing cities also supports these facts, pointing to the fact that where there is expansion of roads, car motorists are favored with little or no regards to other road users such as non-motorized road users (UN- Habitat 2013, Adeel et al., 2018).

These risks are made worse by poor pedestrian facilities, including crosswalks and bike lanes, on the roadway. Litman (2020) explains how such gaps are addressed using complete streets design to include, integrated pedestrian and cyclist infrastructure reduces the occurrence of accidents. Rafique and Malik (2020) also note that, through inclusive design, safety is improved while the rights of everyone to access infrastructure are protected, crucial especially in emerging modern cities of Islamabad, for instance. According to Ajzen's (1991) Theory of Planned Behavior, people's behavior is determined by decisional expectations and covers risky behaviors such as jaywalking and speeding. However, in Islamabad, cultural aspects add to these factors – societal norms in the country put car users above pedestrians (Rafique & Malik, 2020; Adeel et al., 2018).

Even external factors such as noise and pollution decrease safety perceptions amongst employees. According to Stokols (1972), environmental press like noise reduces the ability to think and act appropriately and thereby augur well for risk taking. Exposure to such loud noise or noise more than 85 dB such as that on Islamabad Expressway expanded roads leads to deterioration of psychological health and decrease level of situation awareness (Ali et al., 2023). This makes a situation where the quality of air is also poor, to be even more dangerous to drivers and pedestrians as they become so fatigued and less keen on their focus on the road most of the time (Peden et al., 2004). Similar trends have been observed in other rapidly urbanizing cities with pollution being associated with stress and increased accidents (UN-Habitat, 2013; Litman, 2020).

Half constructed roads are other inversions which also cause stress and confusion due to poor visibility and irregularities occasioned by the construction. These conditions are consistent with the research conducted by Rafique & Malik (2020). From his research, construction zones are some of the most dangerous areas in accident occurrence. Temporary diversions have truncated signages and may not include a proper walkway, posing high risks. On the other hand, the limited access zones produce more desirable and friendly environments for pedestrians, such as supervision crossing and low speeds. Various sources, including Peden et al., 2004 and UN-Habitat, 2013 have revealed that intensive measures are effective to enhance specific MEs to provide safer urban environment. For instance, Erling's Halme, a district in Copenhagen, has found it effective to adopt green pathways with speed-controlled areas to minimize pedestrian accidents by 40% (Litman, 2020).

The implications confirm the need for a holistic approach in the development of spatial structure of cities paying attention to the variety of characteristics of users and environmental concern. Various cities like Amsterdam and Copenhagen have apposite examples of such kind of models regarding the independent mobility and security (Litman, 2020, 2013). While grappling with these issues could impel the formulation of safer and more equitable road systems for Islamabad, the adoption of such global best practices shows this. Also, the smart technologies to support GIS mapping and artificial intelligence for incorporated traffic management systems can enrich the planning initiative to secure precise approaches for problems in urban areas (Ali et al., 2023; Rafique & Malik, 2020).

CONCLUSION

Although the road expansions in Islamabad are intended to improve automobile traffic flow these have adverse effects on pedestrians and cyclist safety in urban design systems. With the consideration of well-designed infrastructure portfolio, traffic calming measures and environmental sustainability, Islamabad has the potential to build sustainably safe urban form. There is still much to be learnt, for example, the long-term effects of these interventions should be investigated as well as the extent to which the interventions can be scaled up in other large cities. However, the key success factors contributing towards the development of the sustainable urban future of the city will be the integration of technologies and encouraging public engagement.

Policy Recommendations

1. **Traffic Calming Measures**: Increased sidewalks, speed humps, high curbed roads or curves or roundabouts in new extended roads to reduce speed. Additional management of heavy inflow intersections is also possible by the provision of roundabouts and other signs at points of high traffic density.
2. **Pedestrian and Cyclist Infrastructure**: Ensure bike lanes, disjointed sidewalks, and pedestrian bridges within areas with high human and bicycle traffic. Implementation of better lighting and additional textures on the pavement for the visually impaired should also be implemented.
3. **Environmental Mitigation**: Build barriers and green screens for noisy and busy roadways; support the use of electric cars on the road. This needs to integrate the public transport structure should also help lower the reliance on private automobiles.
4. **Public Awareness Campaigns**: Teach road users about equal obligations towards ensuring roads safety and other proper conduct when crossing the road. Involving people in the community as key players in intervention development to enhance road safety status.
5. **Enforcement and Monitoring**: Use of speed enzyme cameras and real time traffic systems to enforce compliance with the law on traffic. Eliminate accident-recurring tendencies by using AI and developing analytical models of accidents prone areas.

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