SOCIAL DISTANCE MODEL OF INNOVATIVE URBAN DESIGN: IMPLICATIONS OF POST-PANDEMIC STRATEGIC PLANNING FOR URBAN FORMS

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ABSTRACT

Undoubtedly, the theories and models of city planning need to provide mapping of resilience in urban areas in current situation and in case of any other pandemic in future. So, the authors consider the shift of the strategic planning paradigms of urban design for post-pandemic era around the world. This paper aims to provide a practical mathematical model that correlates Social Distancing (SD) to personal and communal hygiene, Room Density (RD), Open Spaces (OS), desire for need to interact and alternate for need to interact. These parameters are given numerical attributes formulated with the help of primary as well as secondary data. The results are ranked to depict level of SD. For conceptualization of this theory and formulation of mathematical model, classical concept of density was revisited and used to assess soundness of urban design. This paper covers an innovative theory and suggests the approach to investigate the strategic planning aspects on the basis of the post-pandemic urban design model. The developed model enables making decisions whether an urban area is suitable for effective social distancing or not. It will also identify the weaknesses of existing urban designs and will provide opportunity to improve the strategic planning of both the business entities and city development.

Keywords: Strategic Planning, Urban Design, Social Distancing, Economic and Mathematical Model, Covid -19

INTRODUCTION

World's economy is facing an ongoing pandemic situation of coronavirus disease known as COVID-19. This disease is characterized by the acute respiratory syndrome caused by the SARS-CoV-2 (WHO, 2020). World Health organization has declared it as public health emergency of international concern and a pandemic. Reportedly more than 188 countries have been affected by the disease with a 4.34 million reported cases (Dong, Du & Gardner, 2020). The virus is highly contagious and spread through air and surfaces (Huang et al., 2020). According to expert's opinion, one can do very little to prevent the spread. A lock down might delay the outbreak of the disease for a while (Giesecke, 2020). However, the cases will reappear when restrictions are softened or

expunged. But a complete lock down for unlimited span of time is not possible for any country in the world. Experience has shown that lock downs have proven futile in one way or other. The only preventive measure found so far for the disease is social distancing. Social distancing is a non-pharmaceutical measures intended to prevent the sprawl of a contagious disease by maintaining physical distance between the people (Hensley, 2020; Pueyo, 2020). Social distancing is an arising challenge for city planners and managers in post COVID-19 era. High population density and poor sanitation conditions appear biggest problem to control proliferation of pandemic in busy urban centers (Neiderud, 2015). In such situation, Letchworth and Welwyne's garden cities seems only safe metropolises on the earth where social distancing can be maintained with personal and social hygiene (Hall, CLUB & II, 1977; Miller, 2015). Though Ebenezer Howard has remained target of criticism for centuries due to generous utilization of space (Fishman, 1982), but COVID-19 has proved him right if social distancing has to be ensured. The advocates of high density have carved their way in history of urban planning in vertical expansion with spear head role of Le Corbusier (Gans & Corbusier, 2006). He ensured high density downtowns with higher level of sanitation and hygiene. How can Zaha Hadid be ignored while going vertical. Her building design, space utilization, sunlight provision and shapes have remained unique (Woods, 2008).

COVID-19 is spreading like an uncontrolled wildfire. It seems that everyone will be exposed to severe acute respiratory syndrome until effective social distancing ensured. With the beginning of 2020, health emergency worldwide was declared by "World Health Organization".Covid-19 was officially declared as pandemic and upmost health emergency on 11th of March (Chappell, 2020). Since then, this pandemic has converted into international public health concern as well as economic crisis that has affected global economy of 90 trillion US dollars, which is beyond anything that previous century has witnessed. Thus, governments are trying to adopt policies to avoid complete lockdowns along with minimizing the spread of this contagious virus. It is estimated that more than 142 million peoples have suffered from disease with death rate of over 3.0 million. Consequently, governments have no option rather than attempting to develop a balance between health care and economic policies (Hynes et al., 2020). A keen insight into urban planning research has revealed that its major focus was inequalities in marginalized and poor groups of society, making them more susceptible to pandemics (Wade, 2020). Though, mankind is not facing the first pandemic, but very limited amount of literature is available addressing the correlation between cities and pandemics (Sharifi & Garmsir, 2020).

But this specific situation has fetched to forefront the dispute of urban exposure to pandemics and created resuscitated concern in this subject. In this context this paper considers the approach to investigate the strategic planning aspects on the basis of the post-pandemic urban design model providing a solution to gauge whether an effective social distancing is possible in a city or not.

MATERIALS

Post-Pandemic Urban Design Impact on Strategic Planning

Each aspect of strategic planning could be consider taking into account that infectious diseases that spread beyond a country boarder becomes a pandemic and humans have witnessed a number of such outbreaks in their known history. These pandemics have taken millions of lives, caused enormous burden on health care systems and huge economic losses (Fernandes, 2020; LePan, 2020). Emergence of respiratory epidemics calls for precautions such as isolation of patients and closure of public spaces. Also, it shifts the image of metropolises and public places into vacant environments. But at the end of crisis urban planner are required to incorporate the social thinking

and health practices into city design. Historical pandemics have taught us lessons about consequences and effects of changing environment that are effecting city designs, zoning laws and preliminary idea of quarantine (Gouveia & Kanai, 2020). For example; after crisis of Black Death in European societies changed their concept of urban design by incorporating larger public places to diminish the feeling of being quarantined and to increase connectivity with nature. It also helped the urban planners to develop revitalized urban form in order to avoid overcrowding in expanding cities. The Black Death crisis affected the urban design of European societies by calling for o larger public spaces, which provide a greater opportunity to connect with nature and reduce the feeling of isolation. Also, pandemics helped planners to improve the radical urban of renaissance, expanded their cities to prevent overcrowding (Mahoney & Nardo, 2016).

Major reason of the Cholera outbreak in London during 1850 was mixing of drinking water with waste water as illustrated by the WHO data. This disease played a major role in improvement of existing urban design by managing waste materials in streets, integrating well ventilated designs into building and more access to day light *via* open spaces. Infrastructure design also experiences a major shift when it was felt that mixing of drinking water and waste water must be avoided in Thames River. Sir Joseph Bazalgette built the Victoria embankment alongside the river which helped to terminate the Cholera crisis. Main sewage system was constructed downstream the river to prevent future mixing of waste and drinking water (Rosés et al., 2020).

During the 2nd industrial revolution (1870-1914), world had to face the noxious respiratory virus illness in history as the "Spanish Flu pandemic" killed more than 50 million individuals worldwide, and it clearly resulted in limited social life and slowed down municipality growth to decrease the sprawl of disease (Eltarabily & Elghezanwy, 2020). These measures included replacement of pedestrians' through uncrowded streets, social distancing similar to current times (Allam & Jones, 2020; Matthew & McDonald, 2006). During 21st century, COVID-19 has just been an addition to an extensive list of promptly spreading infectious diseases, like (tuberculosis, 2006) in South Africa and (Ebola, 2014) in West Africa, which epitomized a novel challenge for urban planners to design healthy cities.

Finally, as history constantly reminds us of the relationship between features of cities and critical diseases, it could leave marks on our cities, our societies and ourselves, we should know that things will never go to be as it was the past. During the Covid-19 lockdown, there are changes to the determinants of health, the diverse range of environmental, economic and social factors that impact on human wellbeing, compared to the pre-Covid period (Rice, 2020). Covid-19 has not only overburdened the health care system throughout world but also has resulted in huge economic losses (Pak et al., 2020). Both pandemic and economic losses became international due to globalization, environmental changes and urbanization (Yamey et al., 2017). Reduced productivity, abstained work places and premature deaths have resulted in direct economic consequences. For example, production index of China was decreased by 54% than the preceding month (Rocco, Béland & Waddan, 2020). The International Air Transport Association has shown damage in airline revenue merely from passenger demeanor of up to $314 billion (Dey & Loewenstein, 2020). WHO has asked all countries 'health in all policies' to guarantee that wellbeing is encompassed in every decision-making process and policy across an extensive range of industries and disciplines, health in all policies' is gradually starting to be executed as a 'health in all design's approach (sometimes denoted to as 'design for health'). There are strong repercussions for the town design profession, with concomitant variations required to the principles and guiding values with an emphasis onto health. In a post-Covid-19 situation, if urban plan is to implant health at its fundamental concern, it will require to amend the DNA of its principles and beliefs (Rice, 2019).

Post-Pandemic Urban Design and Economic Factor

Today we are living in an era that is calling for historical paradigm shift in urban planning theories and practices. Crisis we are experiencing today holds great health threats with governments trying to adapt and implement new polices and planning practices (Crawford et al., 2010). In 2010 – exactly 10 years before the Covid-19 planners like Crawford and companions published in "Planning Theory & Practices" – that provided an interface between urban planning and public health (Ng, 2020). This publication identified that interlink between urban form and health originated in late 19th century in Europe due to health concerns in urban slums of rapidly industrializing cities. Ng (2020) documented that in current pandemic situation mankind is in sheer need to secure healthy and sustainable environment for long term. Corbera, et al., (2020) debated for evolving an ethics of caution to deal with inequalities that COVID-19 has reinforced (Corbera et al., 2020). Globally, over half of the total population in some sort of lockdown situation constrained to their neighborhoods and homes (Bhardwaj et al., 2020). Although this has triggered many challenges and untold disruption, it has also converted into a period of consideration. At the center of the Covid-19 pandemic is greater emphasis and attention on the interrelationship between health and modern urban lifestyles (Jassanoff et al., 2021).

Looking at the larger perspective, urbanization impacts all walks of human existence including society, politics, economy, population and culture and follows a S-shaped curve (Yang et al., 2020). Almost a same pattern was followed in entire world during course of last century with an average rate of over 70% (Budde & Neumann, 2019). Global experience has shown that urban disease gradually appears when urbanization rate increases than 50% (Clevenger & Andrews, 2017; Vögele, 2000). First and foremost, Covid-19 pandemic is a health crisis that is rapidly translating into the economic crisis- although not the 1st one of its nature in past hundred years (McKee & Stuckler, 2020). Undoubtedly, economic losses in current pandemic are huge and it has devastatingly hit the individuals, families' companies and so on. Covid-19 was struck in China first, where industrial production decreased up to 13% and a 21 % downfall in seasonally adjusted sales rates. Some sectors have collapsed almost completely. It is predicted that US economy could shrink by 24% in second quarter of 2020, more than twice as much as any decline ever recorded (Enserink & Kupferschmidt, 2020).

By understanding a relationship between a pandemic, urban planning and economy, an enormous load of research has been published focusing on disasters on cities and necessary adaptation measures, recovery and planning that need to implement in order to deal with catastrophes. Urban research associated to previous outbreaks is majorly focused on subjects such as discriminations that make marginalized and poor groups more susceptible to pandemics (Sharifi, 2020). It's worthwhile to notice that a pandemic that necessitate for quarantine and social distancing for its control can seriously disrupt the economic and social setups. It work in an altogether different manners for peoples having access to free healthcare systems as compared to folks who have to choose whether to go to work when ill or to starve(Connolly, Ali & Keil, 2020; Koltai et al., 2020).

The economic factor which caused to declare garden cities as utopias has yet same role in the game (Fishman, 1982). Rather space scarcity is worse than the Howard's time. Therefore, lowering down of per acre density will be as impossible in post COVID-19 era as it has remained earlier. Under-developed countries can't afford this luxury. It will also not be possible across the board even for every developed country. By finding any solution to control future pandemics in post COVID-19 cities, one cannot be unreasonable in economic factor. Otherwise, solution would be impracticable. So instead of dealing in area density, planners and managers need to focus on room density. Vertical living with low room density in mix use/multifunctional buildings/intermittent zoning/mix land-use zoning along with appropriate open spaces (indoor, outdoor) for light, ventilation and recreation/leisure can be an effective and affordable option (Marcus & Sarkissian,

1986). However, need to interact will be required to control by providing alternate options of interaction.

None of the city can continue the ongoing lock down limitlessly (Shin, 2021). Until discovery of the cure for this deadly virus, social and urban life has to be managed by safe social distancing. Thus, there is a dire need to map out the capacity of the urban centers to maintain social distancing in order to uphold social life as well as to stop the sprawl of this disease (Adolph et al., 2021; Durante, Guiso & Gulino, 2021). It is also required to identify the grey areas in design and management of existing dwelling. So that corrective measures can be adopted.

RESULTS

Mathematical Model

Despite the fact that dwellings with more opens space or sparsely populated areas provide better opportunity for social distancing and hygiene maintenance never the less it seems social distancing is the function of room density (RD). Thus, social distancing is inversely proportional to room density provided that hygiene remains constant. The concept can be explained with the help of following mathematical model;

$$SD \propto \frac{1}{RD}$$

Where SD stands for social distancing and RD denotes the room density
By converting the function into equation

$$SD = h\,x\,\frac{1}{RD}$$

Where; h denotes the overall hygiene, which should be considered as product of personal and communal hygiene?

$$h = hp\ x\ hc$$

Where, hp stands for personal hygiene which includes bathing/washing, nail cutting, hair cutting/removal, toilet practices, use of liquors, smoking trend in individuals of a society, organ health, use of personal protective equipment.
hc stands for communal hygiene which include living conditions, quality of water, air & soil, sewerage disposal solid waste management in the community.
Availability of open spaces adds betterment in the effort to maintain social distancing. So, social distancing is directly proportional to availability of open spaces (OS).

$$SD \propto OS$$

By converting the function into equation:

$$SD = h\,x\,OS \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (ii)$$

By adding both the equations

$$2SD = \left(h\,x\,\frac{1}{RD}\right) + (\,h\,x\,OS) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (iii)$$

Taking h common at right side of equation (iii)

$$2SD = h\left(\frac{1}{RD} + OS\right)$$

Diving both side of equation with 2

$$SD = \frac{h}{2}\left(\frac{1}{RD} + OS\right) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (iv)$$

Denominator 2 with hygiene (h) provides with to lower down the weightage of h in the equation as better standards of hygiene lower down the conscious effort to maintain social distancing.

Add and subtract need to interact with each other

$$SD = \frac{h}{2}\left(\frac{1}{RD} + OS\right) + NtI - NtI \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (v)$$

Need to interact will arise as a result of social requirement, religious obligations, economic activity, entrainment requirement etc. It is expected to ascend in the form of desire for Need to Interact and will descent in the form of Alternate for Need to Interact. So NtI of addition is dNtI and NtI of subtraction is aNtI. Hence,equation will become as following;

$$SD = \frac{h}{2}\left(\frac{1}{RD} + OS\right) + dNtI - aNtI \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (vi)$$

Effect of dNtI will be zero on effort to attain social distancing if appropriate aNtI is available.
Replace h with (hpxhc) in equation (vi)

$$SD = hp\ x\frac{hc}{2}\left(\frac{1}{RD} + OS\right) + dNtI - aNtI \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (vii)$$

Open Spaces

Open spaces are of two types:

i. Indoor (voids, patios, open to sky, corridors, common areas for leisure etc. within the building)

In usual daily life, only a fraction of time is spent outside and most of it is consumed indoor. For any building, its respective form and function is generally defined by space enclosed by built mass. However, unbuilt spaces/voids are an antithesis of these occupied spaces, in a given built fabric, which is essentially the empty space. The formats in which indoor open spaces are available is vital for social distancing (Nicolle, 2007).

ii. Outdoor (green area, parks, play grounds, buffer zones etc. in the area).

According to the report published on "Streets as Public Spaces" and "Drivers of Urban Prosperity" by "Global Urban Observatories Unit" of UN-Habitat Unit of UN-Habitat streets of asphalt and hardscaped will be counted as public space same as the landscaped plazas and leafy parks., these will make up together 45-50% of land area of a city's, with 15-20% open space and 30-35% area occupied as streets (Bair, 1968).

City Planners may decide about maximum possible or attainable percentage of open spaces with little variation from afore stated standards keeping in view factors like area density, vegetation cover, weather conditions, culture trends etc. (Iqbal, Khan, and others, 2020). Inappropriate of OSs will be depicted by zero and will be with 1 (½ value for Indoor and ½ will be for Outdoor) if these are appropriate (as per decided percentages). Out of one, half value is for Indoor and half is for out door. Numerical value of OSs will be put as ½ in equation OSs these are appropriate in the area. Operative part of OSs is Outdoor but appropriateness of Indoor OSs is basic condition to make the Outdoor part of OSs operational, which is explained below;

Suppose, standard for OSs in X city is;

Outdoor=35% (10% open spaces+25% roods)

Indoor=20% (5% open to sky/voids/leisure places+15% corridors/stairs/escalators)

Scenario-I

When estimation is made, actual values are;
Outdoor=36%
Indoor=17%
Numeric Value of Open Spaces is;
OSs=½ (on account of appropriate outdoor %age)

Appropriateness of OSs=0 as basic condition *i.e.,* %age of Indoor is not fulfilled. Therefore, this value can be used in equation.

Scenario-II

When estimation is made, actual values are;
Outdoor=29%
Indoor=21%
Numeric Value of Open Spaces is;
OSs=0 (on account of Inappropriate outdoor %age)

Appropriateness of OSs=0 as basic condition *i.e.,* %age of Indoor is fulfilled but %age of Outdoor itself is not up to the standard

Scenario-III

When estimation is made, actual values are;
Outdoor=35%
Indoor=20%
Numeric value of Open Spaces is;
OSs=½ (because appropriateness of Indoor is just indicative as basic condition only)

Appropriateness of OSs is 1 as basic condition *i.e.,* %age of Indoor is fulfilled and %age of Outdoor itself is up to the standard. Therefore, this value can be used in equation.

Need to Interact

dNtI one score will be given to every desire for need to interaction like living with spouse, kids rearing, religious gatherings, purchasing, work (job/business) social functions, entertainment events etc.

aNtI one score will be given to every alternate for need to interaction

dNtI – aNtI=3 will be considered as best situation where 1 for living with spouse, 1 for kids rearing and 1 is for religious need to interact

Social Distancing

Mathematical model is depicting that SD is function of room density, hygiene, and need to interact. The values of these parameters will affect the figure of SD calculated by this model.

The calculated value of SD is expected to oscillate on both sides of zero. The value will indicate following situation provided that value of h is not zero.

SD with isolation 1
SD with standard living 2
SD with progressive living 3
SD with happy living 4
SD weakening for 4-7

SD ignored 8 and onward

Zero or negative value means non conducive conditions for SD urgent intervention is required.

Now consider the ideal situation of social distancing;

$$SD = hp\ x \frac{hc}{2}\left(\frac{1}{RD} + OS\right) + dNtI - aNtI$$

$$SD = (2x1)½\ (½ + ½) + 7 - 5$$

Where value of hp 2, hc is 1, RD is ½, OS is ½, dNtI is 7(living with spouse, kids rearing, religious gatherings, purchasing, work (job/business), social functions, entertainment events) and aNtI is 5 (religious gatherings, purchasing, work (job/business) social functions, entertainment events)

$$SD = (2)½\ (1) + 7 - 5$$
$$SD = 1 + 2$$
$$SD = 3$$

Which means Social Distancing with progressive living is safely possible in the city.

Now consider the case of another society where people do not want opt aNtI for religious gathering;

$$SD = hp\ x \frac{hc}{2}\left(\frac{1}{RD} + OS\right) + dNtI - aNtI$$
$$SD = (2x1)½\ (½ + ½) + 7 - 5$$

Where value of hp 2, hc is 1, RD is ½, OS is ½, dNtI is 7(living with spouse, kids rearing, religious gatherings, purchasing, work (job/business), social functions, entertainment events) and aNtI is 4 (purchasing, work (job/business) social functions, entertainment events)

$$SD = (2)½\ (1) + 7 - 4$$
$$SD = 1 + 4$$
$$SD = 3$$

Which means Social Distancing with happy living is safely possible in the city.

SD ranked at 3 will denote the progressive living and should be considered ideal in such pandemic situation. Any value other than 3 represents a compromised situation of effective SD and required to bring back to ideal value.

Room Density and Hygiene Aspects

Parameters are needed to be described and given numeric values to find out meaningful output from results of the model. Room density (*RD*) as per actual by will be round off in whole number as per standard mathematical rules. Notes:

i. Keeping in view the standard room size of 10' x 12', there is remotest chance of social distancing if room density is 3 or higher

ii. RD 4 or more means poor hygiene

Personal hygiene can't be zero in any society despite its poor situation. Therefore, it will be given the numeric value from 1-3 depending upon the actual situation in the area. Whereas communal hygiene can be zero if appropriate effort is not being made by institutions to make it better as is the case of many cities of developing countries. Therefore, it will be given the numeric value from 0-2 depending upon the actual situation in the area.

hp; poor 1, standard 2, Over conscious 3

hc; poor 0, standard 1, Over conscious 2

This model points out the area where corrective measures are required. e.g. if one gets an undesired value of personal hygiene and organ health.

DISCUSSION

The authors discuss the limitations of the developed model in post-pandemic urban design the article considers the basis for such modelling. It means that it's a concern of health department and medical practitioners. Likewise, if a deformed value of the Room Density is obtained. Then it would be a matter of institutional handling dealing with infrastructure planning, design and construction.

These are elaborated below.

Density measurements serve as "tool-kit" for design professionals. Density measures are used because of their assumed relationship to urban form. The architect mulling over the optimal housing mix for residential projects, the urban planner submitting zoning modifications to planning commission, the engineers calibrating a land use model, or the urban designer sketching the layout of a neighborhood. There is not much research about the density measurements and standards and is often related to specific type of dwelling (Mocine, 1958; Nogami, 1976). However, for the sake of measurement here considered was room size of 10' x 12', necessary to maintain a distance of six feet between the individuals and to ensure the comfortable living.

The human body can provide places for disease-causing germs and parasites to grow and multiply. These places include the skin and in and around the openings to the body. It is less likely that germs and parasites will get inside the body if people have good personal hygiene habits. Personal hygiene includes hand washing (after defecating, after cleaning a child who has defecated, before eating or handling food bathing and laundering (Drexler, 2010).

Some health measures can be undertaken only by the community as a whole; these include water source protection, proper disposal of solid waste and excreta, wastewater drainage, controlling pet animal rearing and market hygiene (Nicolle, 2007).

Taking into account a relationship between both pandemic and urban design as well as economy, the features of strategic management regarding the developed innovative model of urban design could be an issue for future research.

CONCLUSION

Strategic planning and urban designed in post-pandemic economy are in process of understanding, estimating and coping up with the impacts of COVID-19. Although, medical science is still struggling to find the cure while planners and policy makers are fighting to minimize the damage. Life patterns have already been changed in entire realm. The outbreak has raised serious question about the urban planning as this disease has emerged as anti-urban. So far housing patterns/ practices in whole world seems to exacerbate the problem. Meaning of affordable and secure housing have changed altogether.

In a COVID-19 regime, explanation of affordable and secure housing should ensure effective and friendly social distancing which allows residents to secure basic necessities, requirements and task of daily life by minimizing the risk of disease spread. While proposing this model, affordability and land use patterns were given priority as availability of land is a major point of concern. Health

density was considered as a function of room density. Minimum dimension of room required to maintain hygienic life considering the affordability was adopted. Personal hygiene is as important as keeping the minimum required distance to avoid the disease. Smallest number of personal hygiene parameters adopted by WHO were used for the modeling that ensure individual's health and are easy to adopt and maintain. Importance of open spaces either indoor or outdoor cannot be questioned. These are design elements created for recreation or increasing neighborhood's aesthetic value and are essential part of healthy human living.

The authors consider the strategic planning approach in post-pandemic urban design. Mathematical model developed in the article have provided basis for such modeling. The meanings of social density could be ranked as ideal in such pandemic situation or by any value representing a compromised situation of effective social distance and required to bring back to ideal value. This model also points out the area where corrective measures are required. The suggested approach will also help out to find the gapes in the existing urban design causing hurdles in an operative social distancing and to remove them. The recommendations could be a matter of institutional handling dealing with infrastructure planning, design and construction.

AUTHOR CONTRIBUTIONS

All the authors contributed substantially to the entire work reported in this paper. They read and approved the final manuscript, which is a novel and original research work by the core research group.

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CONFLICTS OF INTEREST

The authors confirm that there is no conflict of interests to declare for this publication.

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