Journal of Civil, Construction and Environmental Engineering
2019; 4(6): 100-106
http://www.sciencepublishinggroup.com/j/jccee
doi: 10.11648/j.jccee.20190406.12
ISSN: 2637-3882 (Print); ISSN: 2637-3890 (Online)

Case Report

Drainage and Water Logging in Pabna Municipality of Bangladesh: A Case Study

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To cite this article:

Mohammad Atauzzaman, Muhammad Rokib Uddin, Nanda Ram Barman. Drainage and Water Logging in Pabna Municipality of Bangladesh: A Case Study. *Journal of Civil, Construction and Environmental Engineering*. Vol. 4, No. 6, 2019, pp. 100-106.
doi: 10.11648/j.jccee.20190406.12

Received: December 16, 2019; **Accepted**: January 4, 2020; **Published**: January 21, 2020

Abstract: The increasing quantity of sewage flow is a growing environmental problem in many developing cities like Pabna. Pabna bears a moderate and pleasant climate and the rainy season comes here at the end of June and stays up to September. People have been facing water logging problem particularly during rainy season for several decades. Improper drainage facility causes water logging, thus leading to serious public health risk and environmental degradation. This paper presents the existing drainage system and water logging problem of ward no. 5 of Pabna municipality. The valuable information was collected from the householders through questionnaire and field visit to the study area during May, 2018 to April, 2019. The ward map, sewer network maps, rainfall data, etc. were collected from Pabna Municipality and Bangladesh Water Development Board. The sewer network maps were superimposed on GIS-based map of Pabna city. The collected information and data were then analysed. The existing sewer system would be capable to accommodate the present and future (up to 2050) sewage flows and is not able to accommodate the storm flows generated from the study area. However the capacity of sewer decreases due to sedimentation of sludge, accumulation of solid waste, vegetation in drains, discontinuity of drains, etc., thus causing water logging in the study area. About 80% of the study area is being affected by water logging in the rainy season every year. The study helps understand the nature, type and magnitude of drainage and water logging problem faced by the dwellers of Pabna municipality.

Keywords: Sewage Flow, Storm Flow, Water Logging, Health Risk, Environmental Degradation

1. Introduction

Wastewater is the liquid waste that may include domestic and industrial discharges as well as storm water, infiltration and inflow. Developing countries rarely have sufficient fund to invest in the large number of sewerage schemes required [1]. In Bangladesh drainage planning is unfortunately the most neglected component of city planning and management activities. Drainage work is done mostly on an ad-hoc basis, often overtaking drainage planning [2].

Water logging is found in the areas where soil remains saturated with water. The water-logged condition is a result of blockage of water on the land surface controlled by geology, topography, drainage, and the amount of water supplied to the site [3]. The urban area has been experiencing water logging for last few years even a little rain causes a serious problem for certain areas. The increase in urbanization without sufficient drainage facility results in water logging, thus leaving parts of urban area inundated for several days. The urban area suffers from drainage congestions and water logging especially during rainy season, causing an unhealthy environmental condition and inconvenience to the residents including damages to the infrastructure, loss of business and spreading of diseases [4]. The effects of water logging on city life are damage of structures and infrastructures, disruption of traffic movement and normal life, destruction of vegetation and aquatic habitats, loss of income potentials, etc. [5]. Water logging is not only related to heavy rainfall and extreme climatic events, but also related to changes in the built-up areas themselves. When the water cannot go off because of

any kind of constrain it makes a water logged condition in that places [6].

Water logging is one of the major environmental problems and challenges of socio-economic growth in the south-western part of Bangladesh [7]. The capital city of Bangladesh, Dhaka, is facing extensive water logging during the monsoon (May to October) as a regular phenomenon due to fast and unplanned urbanization, thus creating adverse social, physical, economic and environmental impacts [8]. Netrokona municipality is one of the A-class category municipalities of Bangladesh and facing water logging problem due to unplanned and unstable urban infrastructural development. Poor drainage system is one of the most liable factors for environmental deterioration and affects the environment as well as public health by enhancing frequent flash floods and spreading diseases [9].

However, the present study area Pabna municipality is one of the developing cities of Bangladesh and expanding rapidly with an enormous growth of population at a rate of around 3% a year. Pabna has been developed with fast and unplanned urbanization for recent years. It is observed temporary water logging during heavy rainfall or a specific season in some parts of Pabna municipality, posing a serious management threat. The present study aimed to investigate the existing drainage system of ward no. 5 of Pabna municipality, to identify the specific problems associated with wastewater collection and disposal, to provide some suggestive measures for proper disposal of wastewater.

2. Materials and Methods

The present study focuses mainly on drainage system of ward no. 5 of Pabna municipality. The valuable information was collected during consultations with the householders and respective officials of Pabna Municipality and Bangladesh Water Development Board. The collected information and data were then analyzed. The detail of data collection and analysis is given below.

2.1. Study Area

Pabna is one of the oldest districts of Rajshahi Division of Bangladesh. It lies between 23°48" and 24°21" north latitudes and between 89°00" and 89°44" east longitudes [10]. Pabna city is the administrative capital of Pabna district. It is situated at 24°00'47" N and 89°12'54" E and at a distance of 216 km from Dhaka. A location map of Pabna is given in Figure 1.

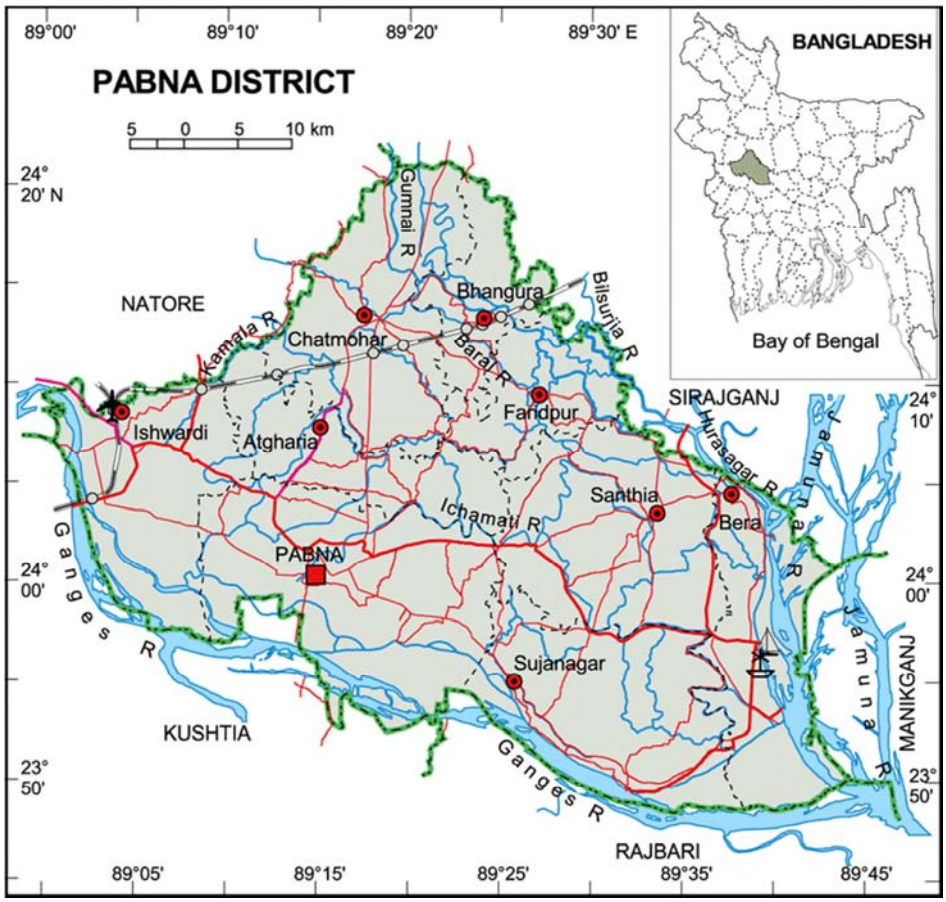

Figure 1. *Location map of the study area [11].*

Pabna municipality has an area 27.27 sq.km, ward 15, holdings 33217, population 144442 [12]. The ward map of Pabna municipality is shown in Figure 2. The present study area is ward no. 5 of Pabna municipality with an area 1.61 sq.km and estimated present population 11222.

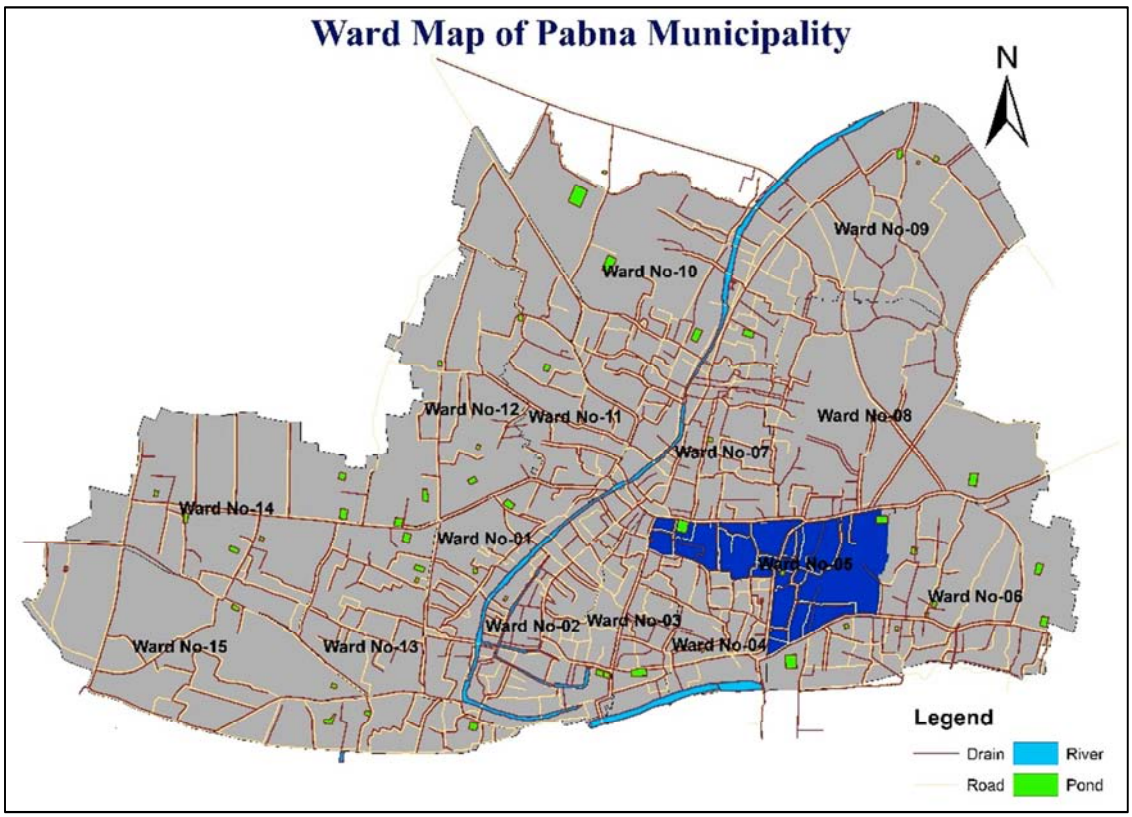

Figure 2. *Ward map of Pabna municipality [13].*

2.2. Data Collection and Analysis

Primary data were collected through questionnaire to the householders in the way of formal and non-formal interviews and field visit during May, 2018 to April, 2019. The ward map, drainage layout, etc. were collected from the respective officials of Conservancy Department of Pabna Municipality and rainfall data of Pabna Sadar from Bangladesh Water Development Board, Pabna. The sewer network maps have been superimposed on GIS-based map of Pabna city. The collected information and data were then analysed to investigate the present condition of wastewater and storm water management system of ward no. 5 of Pabna municipality.

2.3. Population Projection

The present population of a community is obtained from the recent census. The geometric progression method is the most widely used method for predicting the future population [1]. The future population of the study area was estimated using the following equation:

$$P_n = P_0[1 + r]^n \quad (1)$$

Where, P_n = future population after n years
P_0 = present population
r = population growth rate

2.4. Estimation of Sewage Flow

The estimation of quantity of wastewater or sewage flow generated by a community is important for the design of wastewater disposal system. Sewerage system is usually designed for the future population. The quantity of wastewater is obtained as a function of water use or water consumption per capita per day. Water consumption per capita per day is 120 lpcd for Pabna District [1]. The actual sewage flow was taken as 85% of the water consumption. The wastewater generated in the study area was estimated as follows:

$$Q_w = 0.85fqP_n \quad (2)$$

Where, Q_w = wastewater or sewage flow
q = water consumption per capita per day (taken as 120 lpcd for Pabna)
P_n = future population after n years
f = peak factor (taken as 3.0 for small area)

2.5. Estimation of Storm Flow

The rational method can be applied to estimate the flow rate of storm water. The co-efficient of runoff was assumed to be 0.6 for the catchment area [1]. The storm flow reaching the sewer was estimated for a rainfall scenario with a 5-year return period using the following equation:

$$Q_s = CIA \quad (3)$$

Where, Q_s = Storm flow
C = Run-off coefficient
I = Intensity of rainfall with a 5-year return period
A = Catchment area

2.6. Determination of Capacity of Sewer

The continuity equation can be used for determining the capacity of sewer to flow wastewater or storm water generated [14]. The capacity of sewer in the study area was determined as follow:

$$Q = AV \quad (4)$$

Where, Q = Capacity of sewer
A = Area of sewer
V = Velocity of flow

3. Results and Discussion

In this study the existing drainage system of ward no. 5 of Pabna municipality was investigated. Primary and secondary data were collected from the householders and respective officials of Pabna Municipality and Bangladesh Water Development Board and then analysed to develop an understanding of the existing drainage system. The results obtained from this study are discussed below.

3.1. Estimation of Sewage Flow and Capacity of Sewer

An approach was used to estimate the sewage flow generated within the catchment of the study area. The approach involved estimation of population under the catchment from the population census of Pabna city 2011 and then estimation of sewage generation assuming a generation rate of 120 lpcd. The population and growth rate of ward no. 5 of Pabna municipality in 2011 were 9046 and 2.73% respectively [9]. The present population in 2019 was estimated as 11222. Table 1 shows the estimated sewage flows that could potentially reach sewer network. Considering accumulation of sludge within sewers, the capacity of sewers were assumed to be equivalent to 70% of the full flow capacity. The capacity of existing sewer is 0.29 m^3/s with a flow velocity of 0.83 m/s. The existing sewer system would be able to accommodate the present and increased sewage flow in the future up to 2050. During field visit it was seen that the sewage flow is below minimum velocity of 0.6 m/s at some locations and stagnant at some locations due to sedimentation of sludge, accumulation of solid waste, vegetation in drains, discontinuity of drains, etc.

Table 1. *Estimated sewage flows that could potentially reach sewer network.*

Ward No.	Year	Sewage flow (m^3/s)	Flow velocity (m/s)	Sewer capacity (m^3/s)	Remarks
5	2019	0.040	0.83	0.29	The existing sewer with a grade of 1:1000 is capable to accommodate the present and future (up to 2050) sewage flows.
	2025	0.047			
	2030	0.053			
	2035	0.061			
	2040	0.070			
	2045	0.080			
	2050	0.092			

3.2. Estimation of Storm Flow and Water Logging

Pabna has a tropical monsoon climate with four climatological seasons: pre-monsoon (March to May), monsoon (June to September), post-monsoon (October to November) and dry season (December to February). The monsoon is the rainy season with heavy rainfall. The daily rainfall recorded in Pabna Sadar during January to December 2018 is shown in Figure 3. The maximum daily rainfall in 2018 was 60 mm. The average annual rainfall of Pabna Sadar in the year of 2009 to 2018 was 1516 mm and a maximum of 2161 mm in 2017.

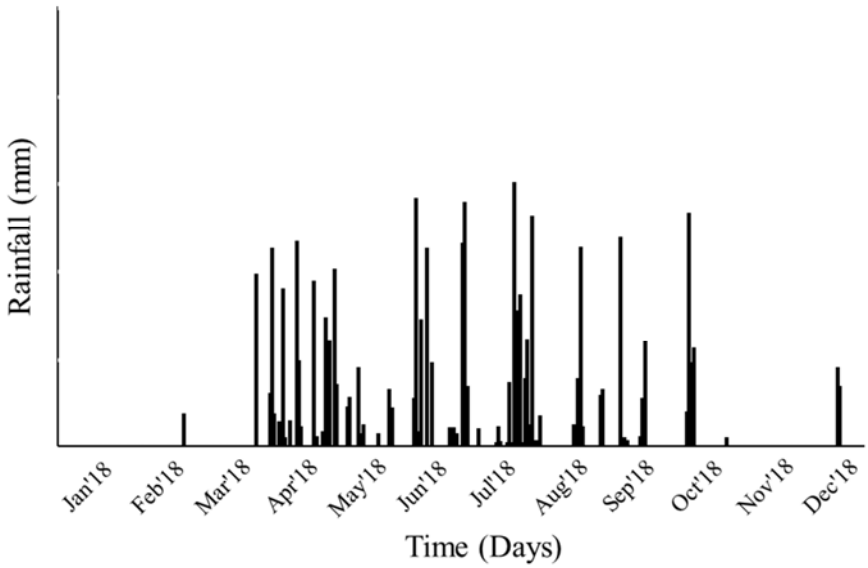

Figure 3. *Daily rainfall recorded in Pabna during January to December 2018 [15].*

The storm flows that reach sewer during wet season was estimated considering the catchment area contributing to sewer of the study area and a rainfall scenario with a 5-year return period. Currently, the sewer system carries entire sewage flows (i.e., dry weather flow from about November to April) that reach sewer network. However, during rainy season, when both storm and sewage flows start to reach the sewers (from around May until October) through the same sewer network. The most probable flows coming from the surrounding areas were determined approximately based on questionnaire and field visit. Table 2 shows the estimated storm flows that could potentially reach sewer network. The storm flows from the study area is more than the capacity of existing sewer, thus causing water logging in this area during rainy season.

Table 2. *Estimated storm flows that could potentially reach sewer network.*

Ward No.	Area (sq.km)	Storm flow (m^3/s)	Most probable storm flow		Remarks
			(%)	(m^3/s)	
4	1.61	34.08	50	17.04	The most probable storm flows from surrounding areas were determined based on questionnaire and field visit.
5	1.61	34.08	100	34.08	
6	2.41	51.01	60	30.61	
8	2.41	51.01	40	20.40	

Figure 4. *Water logging in the study area during rainy season.*

The existing sewer system of ward no. 5 of Pabna municipality would be capable to accommodate the present and future sewage flows and is not able to accommodate the storm flows generated from the study area. Water logging occurs due to insufficient sewers, sedimentation of sludge, accumulation of solid waste within sewer, vegetation in sewers, etc. About 80% of the study area is being affected by water logging during rainy season every year. Wastes remained on roadsides, dustbins and into open drains indiscriminately and uncollected waste indiscriminately accumulated into drains cause the blockage of open drains, resulting a clogging of wastewater flow and water logging specially in the rainy season. Figure 4 shows water logging in the study area during rainy season. Wastes are also be carried away by runoff to the ponds, lakes, and rivers, affecting those ecosystems. Water logging is now becoming a great problem. Proper maintenance of sewers should be needed throughout the year especially at rainy season to increase the capacity of sewer.

3.3. Suggestive Measures

Dwellers of ward no. 5 of Pabna municipality are not satisfied with the existing drainage system. Cares should be taken at the time of collection and disposal of wastewater and/ or storm water to improve the existing drainage capacity. Sufficient drains should be constructed at study and surrounding areas. Drains should be cleaned regularly to avoid the blockage of drains. Public awareness, sufficient fund and more manpower are required for proper management of drainage system. Pabna municipality may take the responsibility to manage the entire drainage system. There are some ponds in the study area which may be used for the storage of storm water especially during rainy season. The existing drainage layout and water bodies of Pabna municipality is shown in Figure 5. There are also some canals and khals which may be used as sewer to pass storm water during rainy season. The Ichamati river is passing through middle of the Pabna municipality along north-south direction. The sewage and/ or storm flows may be ultimately

disposed to the Ichamati river system.

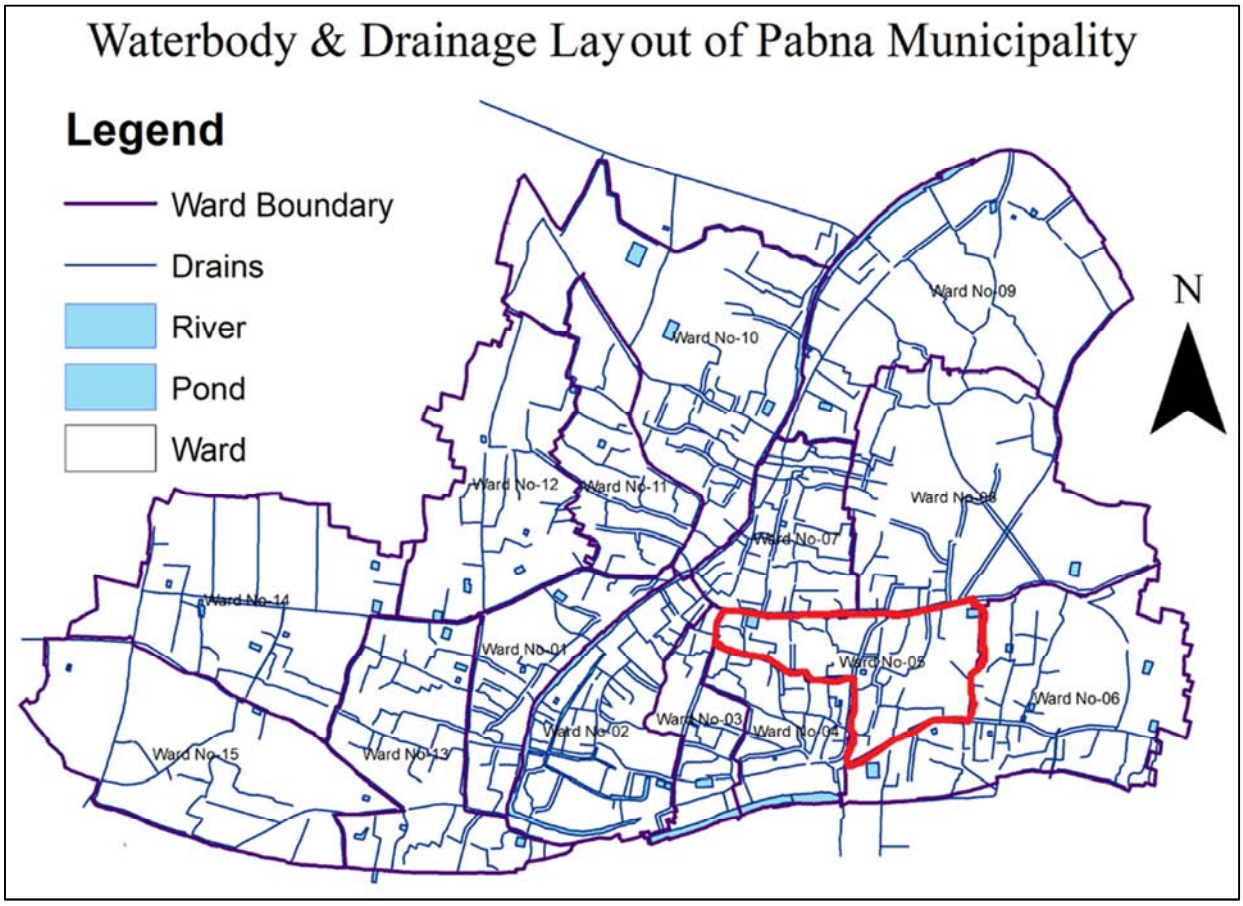

Figure 5. *Existing drainage layout and water bodies in Pabna municipality.*

4. Conclusion

Pabna is one of the developing cities of Bangladesh. The wastewater generation rate is being increased day by day here. The existing sewer system of ward no. 5 of Pabna municipality with a capacity of sewer 0.29 m^3/s at a velocity of 0.83 m/s would be able to accommodate the increased sewage flow up to 2050. The total catchment area of the study area is about 1.61 sq.km. The sewer system is not able to accommodate the storm flows about 34.08 m^3/s generated from the study area and 68.05 m^3/s drained from the surrounding areas. However the capacity of sewer decreases due to sedimentation of sludge, accumulation of solid waste, vegetation in drains, etc., thus causing water logging in this area. Water flow becomes stagnant at some locations due to discontinuity of drains to the surrounding areas. Starting from the local wastewater management, one can expect safe and healthful environment for national and international level.

Acknowledgements

The authors would like to express thanks to Ayesha Siddika, Lecturer of Department of Civil Engineering at Pabna University of Science and Technology, Pabna for her valuable suggestion and co-operation during the study.

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