INTRODUCTION
Pregnancy is defined as a physiological condition in which generally there is no adverse effect on the health of a pregnant woman. Many hormonal, hemodynamic, and hematological changes take place during pregnancy and these all changes are natural adaptations of body. For example, during pregnancy, hemostatic changes such as an increase in total blood volume take place which later helps to overcome the complication of hemorrhage at the time of delivery [1]. Hematological parameters indicate the immunological, nutritional, and hemostatic condition of a pregnant woman and are considered as major factors affecting the pregnancy [2,3]. These hematological parameters for pregnant women include hematocrit (HCT), total red blood cell (RBC) count, total leukocytes count, mean corpuscular volume (MCV), mean corpuscular hemoglobin (Hb) (MCH), MCH concentration (MCHC), differential leukocytes count, and platelet count [4].

During pregnancy, a slight rise in plasma renin and decrease in atrial natriuretic peptide (ANP) activity suggests that rise in plasma volume is due to an underfilled vascular system which is a result of systemic vascular dilatation and increased capacitance, instead of actual blood volume expansion, which may produce opposite hormonal changes [i.e., decrease plasma renin and increased ANP levels] [5,6]. In healthy non-pregnant females, Hb 12 g/dl is considered as the lowest normal value. According to the World Health Organization, ideal values for Hb should be maintained at or above 11.0 g/dl, and in the second trimester should not fall below 10.5 g/dl [7]. During pregnancy, physiological stress induced by pregnant state causes leukocytosis. White cell count may rise typically up to 6000/cumm [8].

There are many studies in healthy pregnant females, which show a decrease in platelet count, specifically in the last trimester of pregnancy. This condition called "Gestational thrombocytopenia" is a result of hemodilution, increased activation, and destruction of platelets [9]. The present study aims to investigate the changes in hematological profile in pregnancy.

METHODS
This study was carried out in the Department of Biochemistry, Santosh College and Hospital, Ghaziabad (National Capital Region). Ethical approval was taken from the Institutional Ethics Committee with reg. no. F. no: SU/2015/793(9) Dated: 17/06/2015; then, a written informed consent was obtained after explaining procedures to the participants.

Females in the first, second, and third trimesters of pregnancy, coming for a routine examination in the outpatient department of obstetrics and gynecology were included in this study. Participants who have any history of alcoholism, smoking, malabsorption, and kidney-related diseases are not included and also pregnant females with any history of neural tube defect are not included in this study. Similar aged group non-pregnant females of hospital staff are taken as control. The exclusion criteria for the control group were the same as like in the pregnant group.

Blood samples of 5 ml from each participant were collected by venipuncture with a prerequisite of 8-10 h fasting. Complete blood count analyzed using an automated cell counter. This instrument works on the principle of flow cell cytometry. Statistical analysis was done by SPSS 17.0 using Window R 3.2.3 interface and p-value was obtained. Analysis of variance with post hoc test used for analyzing the correlation
between the groups and within the group among the three trimesters with hematological indices.

RESULTS
A total of 160 participants of the lower-middle socioeconomic class were taken in this study. Table 1 shows the baseline characteristics of controls and pregnant females in all groups. When compared between controls and pregnant, no statistically significant differences in age, height, and weight were observed.

Table 2 indicates as a significant difference in leukocytes (p<0.000), HCT (p<0.000), Hb% (p<0.000), MCV (p<0.000), MCH (p<0.000), and MCHC (p<0.000), but no significant difference in erythrocytes count (p=0.118) has been observed. Significant difference in leukocytes (p<0.05), Hb (p<0.05), and HCT (p<0.05) observed in the first, second, and third trimesters when compared to controls, but no significance in MCV (p=0.05) and MCH (p=0.05) found on comparison between control and third trimester. However, significant difference in MCHC observed during the first, second, and third trimesters compared to controls.

DISCUSSION

The present study was conducted on pregnant females coming for a regular checkup in Santosh Medical College and Hospital. The hematological parameter in the first, second, and third trimesters of the pregnant group and age-matched controls assessed, and it has been observed that there are marked changes in the hematological profile during pregnancy. Significant difference observed in HR (p<0.000), systolic blood pressure (SBP) (p<0.001), and pulse pressure (PP) (p<0.000). Furthermore, a significant difference observed in SBP (p=0.05) and PP (p<0.05) between the second and third trimesters compared to the control group. Normally in pregnant women, up to the middle of pregnancy, blood pressure falls and then rises up to the day of delivery, with final indices similar to it was at the beginning of pregnancy [10]. Arterial hypertension during pregnancy is one of the major causes of perinatal mortality and morbidity [11]. Routine monitoring of BP is important for diagnosing pre-eclampsia/eclampsia [10] as this may lead to many complications such as brain hemorrhage in the pregnant female, premature delivery, and fetal hypoxia [12]. In the present study, we observed a rise in resting heart rate (RHR) in the first, second, and third trimesters of pregnancy as found in earlier literature. Initially, during the first trimester, RHR increases abruptly followed by a moderate rise till the end of pregnancy [13]. A significant difference in all parameters such as white blood cell (p<0.000), HCT (p<0.001), Hb% (p<0.001), MCV (p<0.001), MCH (p<0.001), and MCHC (p<0.001) observed. Erythrocyte count values (p<0.118) in between the first, second, and third trimesters compared to the control group do not show any statistically significant. The decrease in levels of Hb and HCT observed in the first, second, and third trimesters of pregnancy which is characteristic features of anemia, whereas reduced MCV shows the presence of a high number of abnormal small-sized RBCs in circulation. As per the existing literature, the increased level of serum iron and ferritin is associated with increased values of MCH, whereas higher values of weight and TIBC are associated with lower values of MCH. Therefore, decreased values of MCH were observed with iron deficiency. Hb (p<0.05) and HCT levels (p<0.05) during the first, second, and third trimesters compared with controls, significant reduction found. Earlier also it was reported by Ullah et al. that during the third trimester of pregnancy as a result of increased fetus requirement, high anemia seen [14]. James et al. also stated that during pregnancy, relative reduction in HCT may be due to increased volume of plasma which causes hemodilution, hormonal changes, increased infection rate, and some other condition that may cause iron deficiency and retention of fluid [15]. On analysis of the first, second, and third trimesters, the mean (SD) leukocyte values 4.12±0.41, 5.19±0.63, and 6.35±1.04 were found, respectively. According to Chandra et al. [16], during pregnancy, leukocyte count increases up to the reference range 6000 cells/cumm. Pughikumo et al. [17] and Costantine [18] also reported that during pregnancy, leukocyte values were significantly higher than non-pregnant controls. Pregnancy imposes physiologic stress on the body, implicated as a possible cause of leukocytosis, and development of fetal immunity pathways also suggested as a possible reason [19].

CONCLUSION

In the present study, it is concluded that leukocytes, Hb, and HCT values show a statistically significant difference in between trimesters (p<0.05), suggesting the importance of routine-based obstetric evaluation and hematological profile. All hematological parameters should be properly interpreted to recognize and avoid pregnancy-related late complications both in mother as well in the fetus.

Table 1: Average baseline characteristics of controls and study population of pregnant females with the first, second, and third trimesters

| S. No. | Parameter | Controls (n=40) | First trimester (n=40) | Second trimester (n=40) | Third trimester (n=40) | p-value (ANOVA) |
|-------|-----------|----------------|------------------------|------------------------|------------------------|----------------|
| 1.    | Age (years) | 22.25±2.45 | 21.30±1.73 | 22.23±1.90 | 22.80±1.70 | 0.11 |
| 2.    | Height (cm) | 157.1±5.81 | 158.7±5.62 | 157.9±5.69 | 155.10±6.73 | 0.108 |
| 3.    | Weight (kg) | 60.21±3.90 | 66.52±7.91 | 67.42±6.35 | 0.118 |
| 4.    | HR (bpm)    | 80.0±1.91 | 83.3±2.64 | 83.2±2.70 | 0.000 |
| 5.    | SBP (mm Hg) | 119.96±5.96 | 112.11±3.05 | 121.95±3.13 | 0.001 |
| 6.    | DBP (mm Hg) | 77.4±4.52 | 77.4±5.96 | 77.58±2.09 | 0.473 |
| 7.    | PP (mm Hg)  | 42.4±9.35 | 44.7±2.53 | 44.39±2.23 | 0.000 |

Data expressed as mean±SD. SBP: Systolic blood pressure, DBP: Diastolic blood pressure, PP: Pulse pressure, HR: Heart rate. *Controls versus first trimester; p<0.05, @ Controls versus second trimester; p<0.05, # Controls versus third trimester; p<0.05

Table 2: Hematological parameters in control and first, second, and third trimesters of pregnancy

| S. No. | Parameter | Controls | First trimester | Second trimester | Third trimester | p-value (ANOVA) |
|-------|-----------|----------|----------------|-----------------|---------------|----------------|
| 1.    | WBC (cells/cumm) | 4.12±0.41 | 4.12±0.41* | 5.19±0.63 | 6.35±1.04 | 0.000 |
| 2.    | RBC (cells/cumm) | 3.11±0.45 | 3.11±0.45* | 3.04±0.47 | 3.19±0.46 | 0.118 |
| 3.    | HCT (%) | 37.6±1.21 | 37.6±1.21 | 37.31±1.52 | 37.49±1.45 | 0.000 |
| 4.    | Hb (g/dl) | 10.20±1.15 | 10.20±1.15* | 10.08±1.24 | 9.62±0.88 | 0.000 |
| 5.    | MCV (fl/cell) | 123.49±22.20 | 123.06±19.42 | 125.65±22.12 | 124.90±22.69 | 0.000 |
| 6.    | MCH (pg/cell) | 33.26±5.05 | 33.26±5.05 | 33.75±5.71 | 27.25±14.41 | 0.000 |
| 7.    | MCHC (g/dl) | 27.14±3.31 | 27.14±3.31* | 26.84±3.37 | 22.09±1.07 | 0.000 |

Data expressed as mean±SD for 40 subjects in each group. Controls versus first trimester; p<0.05, controls versus second trimester; p<0.05. *Controls versus third trimester; p<0.05. ANOVA: Analysis of variance, WBC: White blood cell, HCT: Hematocrit, MCV: Mean corpuscular volume, MCH: Mean corpuscular hemoglobin, MCHC: Mean corpuscular hemoglobin concentration, RBC: Red blood cell
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AUTHORS’ CONTRIBUTIONS

Manisha Baghel and Sudhir Modala designed the model and the computational framework, analyzed the data, and carried out the implementation. Manpreet Saini and Mamta Kandwal performed the calculations, discussed the results, and review the final manuscript with input from all authors.

CONFLICTS OF INTEREST

Nil.

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Self.

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