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Reference Intervals of Hematological Parameters in a Large Sample of the Turkish Population in the Çukurova District of Türkiye

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ABSTRACT

Objective: A complete blood count (CBC) analysis is an essential laboratory test for the diagnosis, treatment, and follow-up of numerous health problems. The aim of this study was to evaluate the reference intervals for CBC parameters of hemoglobin (Hb), hematocrit (Hct), white blood cell (WBC), platelet (Plt), and mean platelet volume (MPV) for the adult population in the Çukurova district of southern Türkiye.

Materials and Methods: Data of 117,759 donors (112,557 males) 18–65 years of age who presented at the Çukurova University Blood Center between January 2015 and June 2020 for blood donation were included in the analyses. All of those who met the World Health Organization blood donor criteria were included in the study. Hematological reference intervals, stratified by age and gender, were compared.

Results: The mean age of the donors was 37±9.8 years. The median parameter value was Hb: 15.4 g/dL, Hct: 46, WBC: 7.1x103/µL, Plt: 238x103/µL, and MPV: 8.3 fL. Comparison of the parameters between sexes revealed that Hb ($p<0.001$) and Hct ($p<0.001$) levels were significantly higher in males, while WBC and Plt counts were significantly higher in females ($p<0.001$ for each). The MPV values were similar.

Conclusion: The reference ranges for CBC parameters as evaluated by sex and age group were clinically reasonable and in accordance with the literature data. However, given the single-center design of this study, additional studies with greater detail are needed to more fully assess the reference intervals of the general population in the region.

Keywords: Hematocrit, hemoglobin, leukocyte, platelet

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INTRODUCTION

A complete blood count (CBC) is the most frequently requested laboratory assessment in hospital admissions. CBC parameters are essential for diagnosis, directing treatment, and monitoring follow-up and adverse events. The hemoglobin (Hb) and hematocrit (Hct) values and the white blood cell (WBC) and platelet (Plt) counts are particularly important CBC parameters (1). Hb transports oxygen from lungs to tissues and carbon dioxide from tissues to lungs. The Hb level is determined by measuring the globulin molecules in the erythrocytes (2). The Hct value measures the volume of erythrocytes in the blood. Hb, however is measured directly (3). WBCs are an important part of the immune system response. Thrombocytes are produced by megakaryocytes in the bone marrow and have hemostatic functions. The mean platelet volume (MPV) is obtained from thrombocyte histograms and shows the size of the Plts and the response of the bone marrow (4).

Reference values are produced based on scientific studies. They can be affected by factors such as age; sex; race; socioeconomic status; geography; exposure to chemical, physical, and biological agents; and ecological features (5). Reference intervals in Türkiye are generally determined based on European population samples, however, reference intervals should be evaluated based on the population for whom they will be applied.

The objective of this research was to evaluate and identify reference intervals for CBC parameters of Hb, Hct, WBC, Plt, and MPV for the adult population in the Çukurova district of Türkiye.

MATERIALS and METHODS

Ethics Committee Approval

This study was approved by the Ethics Committee of Çukurova University (no: TTU 2021-111/77).

The data of a total of 117,759 donors (5,202 females, 112,557 males) between 18 and 65 years of age who presented at the Çukurova University Blood Center between January 2015 and June 2020 for a blood donation were included in the analyses. The general health questionnaire for donors was used for data collection and verification

Table 1. Demographic characteristics of the participants

	All (n=117,759)	Females (n=5202)	Males (n=112,557)	p
Age, years, mean±SD	37±9.8	36.1±10.8	37±9.8	<0.001
median (min–max)	36 (18–65)	35 (19–65)	36 (18–65)	
Age groups, n (%)				<0.001
≤25 years	15,683 (13.3)	1,090 (21)	14,593 (13)	
26–35 years	39,522 (33.6)	1,589 (30.5)	37,933 (33.7)	
36–45 years	38,073 (32.3)	1,361 (26.2)	36,712 (32.6)	
>45 years	24,481 (20.8)	1,162 (22.3)	23,319 (20.7)	
Heart rate, bpm, mean±SD	83.39±51.51	86.63±117.87	83.24±46.17	<0.001
median (min–max)	81 (0–8036)	82 (7–7836)	80 (0–8036)	
Temperature, °C, mean±SD	36.99±47.67	37.14±54.4	36.98±47.34	<0.001
median (min–max)	36 (3–37.02)	36 (11–36.62)	36 (3–37.02)	
Weight, kg, mean±SD	83.01±22.48	71.16±12.03	83.56±22.7	<0.001
median (min–max)	81 (1–974)	70 (19–173)	82 (1–974)	
Height, cm, mean±SD	174.46±10.55	163.67±9.78	174.96±10.31	<0.001
median (min–max)	175 (1–785)	165 (1–317)	175 (1–785)	
Systolic BP, mmHg, mean±SD	87.69±52.83	77.12±52.03	88.18±52.82	<0.001
median (min–max)	114 (1–199)	104 (10–195)	115 (1–199)	
Diastolic BP, mmHg, mean±SD	55.17±34.02	51.08±34.67	55.36±33.98	<0.001
median (min–max)	71 (6–901)	70 (6–116)	71 (6–901)	

BP: Blood pressure; Min–Max: Minimum–maximum; SD: Standard deviation

of reference ranges and laboratory tests. All of those meeting the criteria to be a blood donor according to World Health Organization guidelines were included in the study (6). Female donors with an Hb value of 12.5–16.5 g/dL and male donors with a value of 13.5–18 g/dL were included in the study. Pregnant, lactating, or menstruating women and those with a cancer diagnosis, unregulated hypertension, chemotherapy treatment, kidney disease, history of thalassemia or sickle cell anemia, or an unexplained fewer/infection in the previous month were excluded. The Hb, Hct, WBC, and Plt values were evaluated according to age groups: ≤25 years, 26–35 years, 36–45 years, and >45 years.

Statistical Analyses

All of the analyses were performed using IBM SPSS Statistics for Windows, Version 24.0 (IBM Corp., Armonk, NY, USA). The data were summarized using frequency tables and descriptive statistics. An independent sample t-test or the Mann-Whitney U test was used to compare 2 independent groups based on whether the normal distribution assumptions were met or not, respectively. Comparison of continuous data between >2 groups was performed using the Kruskal-Wallis non-parametric analysis of variance test, and post hoc pairwise comparisons were performed using the Mann-Whitney U test with the Bonferroni correction.

RESULTS

The data of a total of 117,759 donors were included in the analyses. In all, 95.6% of the donors were male (n=112,557). The mean age of the participants was 37±9.8 years. Comparison of demographic characteristics between sexes revealed that the females were significantly younger (p<0.001), had a significantly higher heart rate (p<0.001) and body temperature (p<0.001), and significantly lower anthropometric measurements (weight and height, p<0.001 for both) and blood pressure (systolic and diastolic, p<0.001 for both). Additionally, the distribution of males and females according to age group was significantly different (p<0.001). The proportion of females ≤25 years of age and >45 years of age and the proportion of males aged 26–35 years and 36–45 years was higher than that of the opposite sex. The general demographic characteristics of the participants are presented in Table 1.

The median parameter value in the study group was Hb: 15.4 g/dL, Hct: 46, WBC: 7.1x103/μL, Plt: 238x103/μL, and MPV: 8.3 fL. Comparison of the parameters between sexes revealed that Hb (p<0.001) and Hct (p<0.001) levels were significantly higher in males, while the WBC (p<0.001) and Plt (p<0.001) counts were significantly higher in females. The MPV values were similar between the sexes. The median and range values for each CBC parameter are presented in Table 2. A detailed distribution of Hb and Hct values by age (18–65 years) is presented in the Supplementary Appendix 1 and 2 and illustrate that males had significantly higher Hb and Hct levels in every age category (p<0.05 for all). Changes seen in CBC parameters with increasing age in both sexes are presented in Figure 1.

The CBC parameter values according to age group and sex are presented in Table 3. The distribution of the parameter values among the age groups was significantly different for both sexes (p<0.05), with the exception of the Plt count in females (p=0.643). More specifically, the Hb level of female donors ≤25 years old was lower

Table 2. Comparison of blood parameters between sexes

	All (N=117,759) Mean±SD Median (min–max)	Females (n=5202) Mean±SD Median (min–max)	Males (n=112,557) Mean±SD Median (min–max)	p
Hb, g/dL	15.40±1.08 15.4 (10.3–18.0)	13.60±0.80 13.5 (10.3–18.0)	15.48±1.01 15.5 (10.7–18.0)	<0.001
Hct	45.94±2.95 46 (31.8–54.0)	41.30±2.32 41 (31.8–53.4)	46.13±2.80 46.1 (32.6–54.0)	<0.001
WBC, $10^3/\mu L$	7.28±1.60 7.1 (4.0–13.2)	7.40±1.59 7.3 (4.0–13.2)	7.26±1.60 7.1 (4.0–13.2)	<0.001
Plt, $10^3/\mu L$	243.16±48.77 238 (150.0–450.0)	267.51±55.09 262 (150.0–450.0)	241.89±48.11 237 (150.0–450.0)	<0.001
MPV, fL	8.40±1.03 8.3 (5.8–12.8)	8.41±1.02 8.3 (5.9–12.6)	8.40±1.03 8.3 (5.8–12.8)	0.50

Hb: Hemoglobin; Hct: Hematocrit; MPV: Mean platelet volume; Plt: Platelet; SD: Standard deviation; Min–Max, Minimum–maximum; WBC: White blood cell

than that of the donors 26–35 and 36–45 years of age, and all were lower than the donors >45 years of age (p<0.001). A similar distribution pattern was also present for Hct values (≤25 years, 26–35 years, 36–45 years, >45 years) (p<0.001). A comparison of the WBC count between age groups among females revealed a significant difference (p=0.024). The group that was ≤25 years old had a significantly lower WBC count than the group that was 36–45 years old. There was also a significant difference between age categories in female MPV results (p=0.001). The MPV value of the groups ≤25 years of age and 26–35 years of age were similar and lower than that of the groups 36–45 years of age and >45 years old.

The distribution of Hb level values according to age group was significantly different among male donors (p<0.001). The lowest values were in donors >45 years old, followed by the 36–45 age group, and both were lower than those 26–35 years old and ≤25 years old. The Hb level tended to decrease with increasing age. The same distribution pattern was present for the Hct level (>45 years, 36–45 years old, 26–35 years, ≤25 years) (p<0.001), and the Hct level decreased with increasing age. The distribution of the WBC count also differed significantly between groups (p<0.001). The highest values were observed in donors 36–45 years old and the lowest values were in the ≤25 years group (≤25 years, 26–35 years, >45 years old, 36–45 years). Plt counts revealed that the groups aged ≤25 years and 26–35 years were similar and lower than those of the groups of donors 36–45 years old and >45 years old (p<0.001). Finally, the distribution of MPV was also significantly different according to age group among the males (p<0.001). The value was lowest among those aged >45 years (>45 years, ≤25 years, 26–35 years, 36–45 years).

DISCUSSION

This study aimed to evaluate the reference intervals of CBC parameters used in the Çukurova district of Türkiye using the data of 117,759 blood donors without an active complaint at the time of presentation to the Çukurova University Blood Center for donation. Gessese et al. (7) conducted a similar study with blood donors in Northeast Ethiopia to establish unique hemogram reference parameters. The primary motivation for evaluating the reference intervals is the hypothesis that regional differences in population characteristics might affect the appropriateness of the reference intervals of CBC parameters. Although we did not evaluate the effects of population characteristics on CBC parameters, evidence in the literature suggests that there may be regional differences in the reference intervals of blood components. Ittermann et al. (8) reported results of an examination of the blood components of 2967 participants in Northeastern Germany in 2010. Reference intervals were calculated according to the guidelines of the Clinical and Laboratory Standards Institute and the authors noted that the Hb, Hct, and WBC intervals were lower, and that the mean corpuscular volume and mean corpuscular Hb values were higher than the reference intervals in use.

The primary outcomes of the present study were the significantly lower Hb and Hct values in females at every age 18–65. There was a decrease in males and an increase in females with aging. This pattern is clinically reasonable and has been replicated in studies in the literature. Qiao et al. (9) reported that Hb, red blood cells, Hct, and mean corpuscular Hb results were lower in females than males at every age. The gap narrows after 40 years of age, as the values tend to decrease in males and increase in females after 40. The lower levels of Hb and Hct in females are thought to be related to menstrual blood loss, and the higher levels in men are associated with the stimulatory effect of androgens on erythropoiesis (10). The decrease in Hb level with increasing age among males in our study is also consistent with the literature data. Ji et al. (11) and Abdullah et al. (12) evaluated gender-related trends in Hb level and reported that the values decreased with increasing age, which is supported by our results. The increase in Hb level with increasing age among women is associated with the cessation of menstrual cycles.

WBC, neutrophil, and monocyte absolute counts are generally higher in women than men; however, there is no significant change with increasing age. Generally, the absolute lymphocyte count tends to decrease with aging among men due to atrophic changes in the thymus, but the reason for a decrease in women is not yet clear (9). Our results showed that the WBC count was higher among females in each age group.

Table 3. Complete blood count parameters according to sex and age groups

Age groups	Females Mean±SD Median (min–max)	p	Post-hoc significance*	Males Mean±SD Median (min–max)	p	Post-hoc significance*
Parameters						
Hb		<0.001	1<2~3<4		<0.001	4<3<2~1
≤25 years	13.47±0.78			15.54±1.01		
	13.4 (10.7–16.5)			15.5 (10.7–18.0)		
26–35 years	13.58±0.78			15.55±1.02		
	13.5 (10.3–17.8)			15.5 (11.7–18.0)		
36–45 years	13.61±0.82			15.47±1.01		
	13.5 (10.3–18.0)			15.4 (11.0–18.0)		
45+ years	13.74±0.80			15.37±1.02		
	13.7 (11.0–16.8)			15.3 (10.9–18.0)		
Hct		<0.001	1<2~3<4		<0.001	4<3<2~1
≤25 years	40.77±2.20			46.24±2.80		
	40.5 (32.9–48.9)			46.2 (35.4–54.0)		
26–35 years	41.21±2.22			46.26±2.79		
	41.0 (32.7–51.0)			46.2 (33.6–54.0)		
36–45 years	41.38±2.40			46.10±2.79		
	41.0 (31.8–53.4)			46.1 (32.6–54.0)		
45+ years	41.92±2.40			46.01±2.83		
	41.6 (37.0–50.1)			45.9 (33.1–54.0)		
WBC		0.024	1<3		<0.001	1<2<4<3
≤25 years	7.34±1.83			6.95±1.78		
	7.2 (4.0–37.9)			6.8 (3.6–50.5)		
26–35 years	7.44±1.92			7.24±2.01		
	7.3 (4.0–38.0)			7.1 (2.6–160.0)		
36–45 years	7.54±1.88			7.43±1.77		
	7.4 (4.0–38.5)			7.3 (2.9–51.7)		
45+ years	7.40±1.54			7.36±1.68		
	7.3 (4.0–12.0)			7.2 (1.7–50.0)		
Plt		0.643	–		<0.001	1~2<3~4
≤25 years	269.55±55.75			239.85±47.60		
	263.0 (150.0–464.0)			235.0 (88.0–494.0)		
26–35 years	267.50±54.71			240.77±47.63		
	262.0 (150.0–470.0)			236.0 (22.0–918.0)		
36–45 years	266.84±56.76			243.64±48.84		
	262.0 (143.0–450.0)			238.0 (55.0–639.0)		
45+ years	267.67±54.20			242.83±48.76		
	261.0 (150.0–513.0)			238.0 (55.0–504.0)		
MPV		0.001	1~2<3~4		<0.001	4<1<2~3
≤25 years	8.31±1.02			8.38±1.03		
	8.2 (5.7–15.1)			8.3 (5.2–13.6)		
26–35 years	8.42±1.02			8.43±1.04		
	8.3 (5.6–12.5)			8.4 (4.6–15.1)		
36–45 years	8.47±1.03			8.42±1.02		
	8.4 (4.1–12.3)			8.4 (4.1–13.9)		
45+ years	8.43±1.04			8.34±1.01		
	8.4 (5.0–12.0)			8.2 (5.3–15.1)		

*: In post-hoc significance, the age groups are 1: ≤25 years old, 2: 26–35 years old, 3: 36–45 years old, 4: >45 years old. Hb: Hemoglobin; Hct: Hematocrit; MPV: Mean platelet volume; Plt: Platelet; SD: Standard deviation; Min–Max: Minimum–maximum; WBC: White blood cell

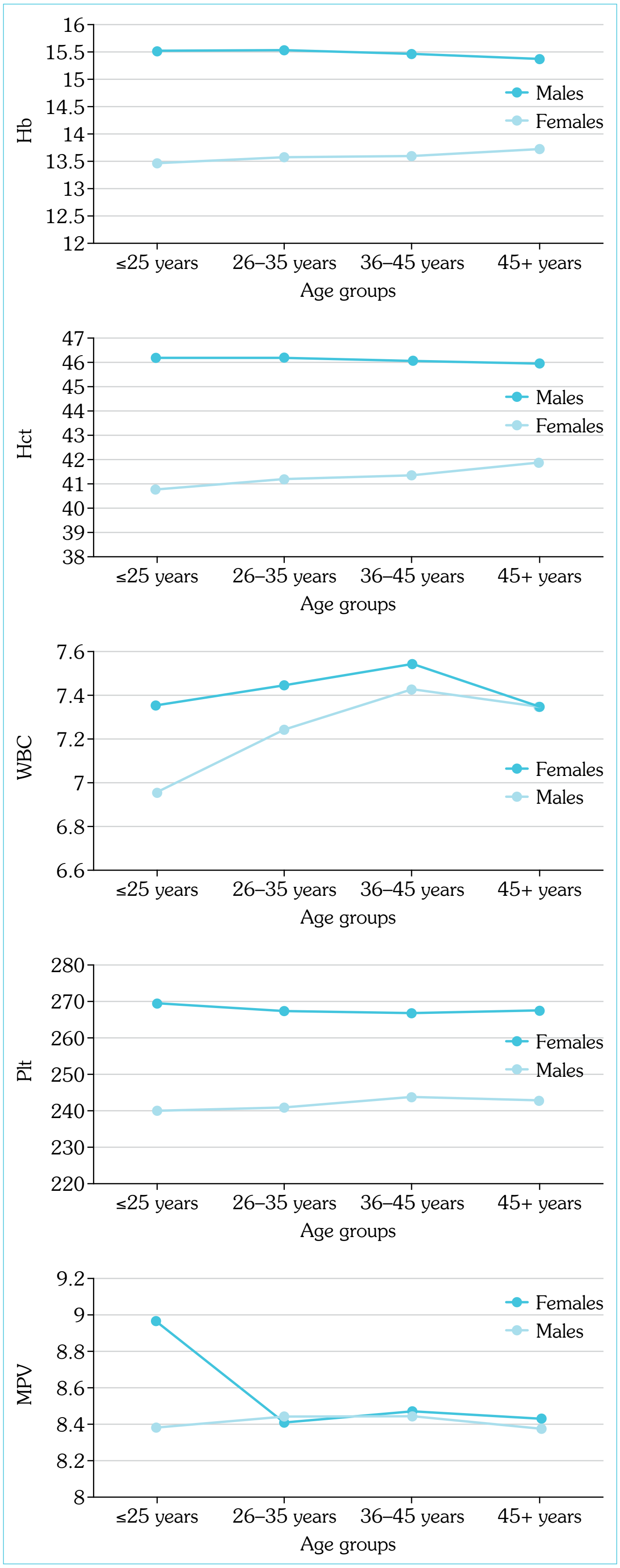

Figure 1. Changes in CBC parameters according to sex and age groups

Plts play a role in hemostasis, endothelial repair, atherogenesis, and thrombus formation. The Plt count can be associated with both vascular and non-vascular deaths. Wang et al. (1) evaluated the Plt indices in the general population in Taiwan and reported that the Plt count decreased with aging. This might also be associated with the increased survival probability of individuals with a lower thrombocyte count, which could also be regarded as a survival bias (13). Qiao et al. (9) reported that the Plt count was higher among females in each age group and tended to decrease after 40 years of age. The procalcitonin level also follows the age and sex pattern of the Plt count. In our study, the Plt counts were higher in females at every age. Of course, this might also be associated with the high level of estrogen in the bloodstream, which stimulates thrombocyte production (14). Moreover, total iron reserves are generally low among females due to their menstrual cycles, and a low iron level is a well-known stimulator of thrombocyte production (15).

Our results yielded a comparable MPV level in both sexes. Several previous studies have also reported this similarity. Reports of Chinese and Indian populations have also suggested that the MPV level was not associated with ethnicity (16). Studies of Western populations have provided analogous findings; e.g., Joergensen et al. (17) reported in a study conducted in Denmark that the MPV level was stable across age and sex.

This study is not without limitations. The most prominent are that the study data were from a single center, the number of females was significantly lower than that of males, and individuals <18 years of age and >65 years of age were not included. However, there is a lack of such data from the Turkish population, and this study will be a valuable asset for evaluating the hematological parameters used in this country.

CONCLUSION

As a result, it appears that some CBC parameters may be dependent on age and gender. Each age has its own hematological values and these parameters can be affected by variables such as menstrual cycle and menopause in women, age-related cancer, and poor nutrition in older age, especially in men. In addition, the genetic characteristics and nutritional habits of societies contribute to these distributions. This study is the first to be conducted with such a large series and contains data specific to each age group and gender.

Ethics Committee Approval: The Çukurova University Non-Interventional Clinical Research Ethics Committee granted approval for this study (date: 21.05.2021, number: TTU 2021-111/77).

Informed Consent: Written informed consent was obtained from patients who participated in this study.

Peer-review: Externally peer-reviewed.

Author Contributions: Concept – GGK, ŞMY; Design – GGK; Supervision – GGK, Dİ; Resource – GK, GGK, BG; Materials – GGK, GK, ŞMY; Data Collection and/or Processing – GGK, Dİ, GK; Analysis and/or Interpretation – GK, GGK; Literature Search – GGK, Dİ; Writing – GGK, AK, Dİ; Critical Reviews – AK, BG.

Conflict of Interest: The authors have no conflict of interest to declare.

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Appendix 1. Hemoglobin levels by age and sex category

Age, years	Female (n=5202)			Male (n=112557)			p
	n	Mean±SD	Median (min–max)	n	Mean±SD	Median (min–max)	
18	–	–	–	109	15.40±0.93	15.3 (13.5–17.6)	<0.001
19	38	13.17±0.73	12.9 (11.8–15.2)	517	15.34±0.96	15.3 (13.5–17.6)	<0.001
20	88	13.37±0.77	13.4 (10.7–15.7)	1025	15.46±0.98	15.5 (13.5–18.0)	<0.001
21	145	13.46±0.82	13.3 (11.0–16.3)	1455	15.48±1.00	15.5 (13.5–18.0)	<0.001
22	181	13.50±0.75	13.4 (11.1–15.7)	2170	15.56±1.02	15.6 (12.7–18.0)	<0.001
23	232	13.51±0.79	13.4 (10.7–16.4)	2910	15.57±1.02	15.6 (12.3–18.0)	<0.001
24	205	13.40±.69	13.3 (12.2–15.5)	3017	15.58±1.02	15.6 (10.7–18.0)	<0.001
25	201	13.60±0.84	13.5 (12.0–16.5)	3390	15.57±1.01	15.6 (12.0–18.0)	<0.001
26	232	13.48±0.72	13.4 (12.4–15.5)	3597	15.58±1.00	15.6 (12.7–18.0)	<0.001
27	170	13.54±0.72	13.5 (12.5–16.1)	3557	15.55±1.03	15.5 (12.5–18.0)	<0.001
28	173	13.58±0.74	13.6 (11.4–15.8)	3502	15.56±1.02	15.6 (12.9–18.0)	<0.001
29	133	13.51±0.88	13.5 (10.3–17.8)	3856	15.55±0.99	15.5 (12.2–18.0)	<0.001
30	149	13.62±0.78	13.5 (12.2–16.1)	3695	15.59±0.99	15.6 (12.2–18.0)	<0.001
31	121	13.68±0.80	13.6 (12.5–15.9)	3787	15.53±1.03	15.5 (11.7–18.0)	<0.001
32	167	13.63±0.85	13.5 (12.3–16.9)	3804	15.52±1.02	15.5 (12.4–18.0)	<0.001
33	153	13.56±0.75	13.5 (12.5–16.0)	3976	15.56±1.01	15.5 (13.0–18.0)	<0.001
34	128	13.55±0.72	13.5 (12.0–15.4)	4134	15.51±1.01	15.5 (13.2–18.0)	<0.001
35	163	13.76±0.83	13.7 (12.5–16.3)	4025	15.51±1.02	15.5 (12.6–18.0)	<0.001
36	126	13.57±0.88	13.4 (11.5–16.4)	4133	15.51±1.01	15.5 (12.0–18.0)	<0.001
37	134	13.64±0.87	13.5 (11.9–18.0)	3813	15.52±0.99	15.5 (13.5–18.0)	<0.001
38	161	13.74±0.87	13.7 (12.5–16.9)	4332	15.45±0.99	15.4 (11.3–18.0)	<0.001
39	153	13.53±0.69	13.5 (12.3–15.3)	4230	15.49±1.01	15.5 (12.7–18.0)	<0.001
40	158	13.60±0.76	13.6 (12.3–15.5)	3968	15.46±1.02	15.4 (12.0–18.0)	<0.001
41	143	13.61±0.84	13.5 (12.5–16.8)	3767	15.44±1.02	15.4 (11.4–18.0)	<0.001
42	126	13.63±0.85	13.5 (12.0–16.4)	3682	15.48±1.00	15.5 (12.7–18.0)	<0.001
43	150	13.60±0.83	13.5 (10.7–16.9)	3298	15.47±1.03	15.5 (11.0–18.0)	<0.001
44	111	13.47±0.82	13.3 (10.3–16.3)	2731	15.39±1.01	15.4 (13.0–18.0)	<0.001
45	99	13.68±0.67	13.7 (12.5–15.7)	2758	15.41±1.02	15.4 (13.1–18.0)	<0.001
46	139	13.64±0.86	13.6 (11.0–15.6)	3181	15.39±0.99	15.4 (13.4–18.0)	<0.001
47	112	13.67±0.82	13.6 (12.1–16.5)	2564	15.41±1.04	15.4 (12.9–18.0)	<0.001
48	110	13.63±0.83	13.5 (12.5–15.8)	2204	15.39±1.01	15.4 (13.2–18.0)	<0.001
49	105	13.77±0.86	13.6 (12.3–16.8)	1988	15.39±1.01	15.4 (11.7–18.0)	<0.001
50	79	13.59±0.76	13.5 (12.3–16.2)	1846	15.42±1.02	15.4 (13.3–18.0)	<0.001
51	88	13.81±0.72	13.8 (12.5–16.5)	1572	15.37±1.02	15.4 (13.5–18.0)	<0.001
52	74	13.76±0.73	13.7 (12.5–15.5)	1437	15.31±0.99	15.3 (13.5–18.0)	<0.001
53	62	13.89±0.80	13.8 (12.5–15.9)	1151	15.39±1.02	15.4 (13.2–18.0)	<0.001
54	74	13.72±0.77	13.7 (12.5–16.3)	1421	15.33±1.06	15.3 (11.2–18.0)	<0.001
55	82	13.71±0.78	13.5 (12.3–15.8)	1283	15.36±1.02	15.3 (11.9–18.0)	<0.001
56	61	13.75±0.73	13.7 (12.2–15.8)	1016	15.32±1.02	15.2 (11.3–18.0)	<0.001
57	29	13.92±0.96	13.6 (12.6–16.3)	849	15.34±1.07	15.3 (10.9–18.0)	<0.001
58	42	14.05±0.75	14.1 (12.6–15.5)	672	15.31±1.02	15.2 (13.5–18.0)	<0.001
59	25	13.91±0.90	13.7 (12.1–15.5)	521	15.29±0.98	15.2 (13.4–18.0)	<0.001
60	27	13.89±0.69	13.8 (12.6–15.5)	570	15.35±1.02	15.3 (13.5–17.9)	<0.001
61	20	13.81±0.77	13.9 (12.5–15.1)	363	15.31±1.04	15.2 (12.5–18.0)	<0.001
62	11	13.83±0.78	13.8 (12.7–15.3)	235	15.33±1.06	15.3 (13.5–18.0)	<0.001
63	7	14.07±0.19	14.1 (13.7–14.3)	152	15.31±0.98	15.2 (13.4–17.9)	<0.001
64	11	13.69±0.87	13.7 (12.7–15.5)	190	15.22±0.98	15.1 (13.5–18.0)	<0.001
65	4	13.88±1.25	13.8 (12.5–15.5)	104	15.22±1.00	15.2 (13.4–18.0)	0.038

SD: Standard deviation; Min–Max: Minimum–maximum

Appendix 2. Hematocrit levels by age and sex category

Age, years	Female (n=5202)			Male (n=112557)			p
	n	Mean±SD	Median (min–max)	n	Mean±SD	Median (min–max)	
18	–	–	–	109	46.03±3.04	46.1 (40.0–53.4)	<0.001
19	38	40.37±2.29	40.0 (36.5–46.0)	517	45.56±3.01	45.5 (40.0–53.5)	<0.001
20	88	40.33±2.10	40.0 (32.9–48.6)	1025	45.99±2.89	45.9 (40.0–54.0)	<0.001
21	145	40.60±2.17	40.3 (36.9–48.9)	1455	46.03±2.85	46.0 (40.0–54.0)	<0.001
22	181	40.76±2.25	40.4 (33.3–48.4)	2170	46.21±2.77	46.2 (36.8–54.0)	<0.001
23	232	40.81±2.26	40.6 (34.4–47.3)	2910	46.33±2.77	46.3 (35.4–54.0)	<0.001
24	205	40.75±2.02	40.5 (37.8–46.3)	3017	46.34±2.79	46.4 (36.0–54.0)	<0.001
25	201	41.14±2.27	41.0 (37.0–48.8)	3390	46.37±2.73	46.4 (38.0–54.0)	<0.001
26	232	41.05±2.05	40.9 (38.0–47.3)	3597	46.35±2.76	46.3 (40.0–54.0)	<0.001
27	170	41.11±2.08	41.0 (38.0–46.9)	3557	46.33±2.81	46.4 (38.5–54.0)	<0.001
28	173	41.19±2.16	41.0 (37.4–47.2)	3502	46.31±2.80	46.3 (39.0–54.0)	<0.001
29	133	40.99±2.42	40.8 (32.7–51.0)	3856	46.27±2.74	46.2 (39.5–54.0)	<0.001
30	149	41.15±2.30	40.9 (37.4–48.7)	3695	46.39±2.79	46.3 (35.6–54.0)	<0.001
31	121	41.28±2.34	41.0 (38.0–48.6)	3787	46.21±2.81	46.3 (33.6–54.0)	<0.001
32	167	41.32±2.31	40.9 (38.0–47.4)	3804	46.16±2.80	46.1 (34.9–54.0)	<0.001
33	153	41.22±2.13	40.9 (38.0–46.5)	3976	46.30±2.76	46.3 (38.0–54.0)	<0.001
34	128	40.99±2.01	41.0 (38.0–45.9)	4134	46.17±2.79	46.1 (38.1–54.0)	<0.001
35	163	41.78±2.38	41.5 (38.0–48.7)	4025	46.14±2.79	46.1 (35.0–54.0)	<0.001
36	126	41.37±2.64	40.8 (36.7–50.0)	4133	46.17±2.77	46.1 (36.4–54.0)	<0.001
37	134	41.49±2.72	41.1 (37.0–53.4)	3813	46.18±2.78	46.2 (40.0–54.0)	<0.001
38	161	41.57±2.44	41.4 (38.0–50.0)	4332	46.07±2.75	46.1 (32.6–54.0)	<0.001
39	153	41.19±2.18	41.0 (36.2–37.5)	4230	46.14±2.78	46.1 (40.0–54.0)	<0.001
40	158	41.44±2.26	41.0 (38.0–49.7)	3968	46.10±2.83	46.0 (33.8–54.0)	<0.001
41	143	41.22±2.38	40.7 (38.0–49.7)	3767	46.01±2.84	46.0 (33.7–54.0)	<0.001
42	126	41.40±2.20	41.0 (38.0–48.2)	3682	46.20±2.80	46.1 (38.0–54.0)	<0.001
43	150	41.31±2.48	41.0 (31.8–52.6)	3298	46.11±2.82	46.1 (35.2–54.0)	<0.001
44	111	41.18±2.44	41.0 (33.7–50.0)	2731	45.97±2.77	45.9 (39.5–54.0)	<0.001
45	99	41.74±2.31	41.6 (38.0–48.1)	2758	46.02±2.81	45.9 (40.0–54.0)	<0.001
46	139	41.51±2.31	41.3 (38.0–49.0)	3181	45.99±2.74	45.9 (40.0–54.0)	<0.001
47	112	41.45±2.40	41.0 (37.7–49.0)	2564	45.97±2.84	45.9 (39.0–54.0)	<0.001
48	110	41.62±2.43	41.1 (37.1–48.4)	2204	45.95±2.82	45.9 (37.9–54.0)	<0.001
49	105	41.87±2.57	41.6 (37.0–50.1)	1988	46.00±2.88	45.9 (35.5–54.0)	<0.001
50	79	41.70±2.24	41.6 (38.0–50.0)	1846	46.12±2.86	46.0 (39.4–54.0)	<0.001
51	88	41.97±2.25	41.9 (38.3–49.0)	1572	45.92±2.83	45.9 (40.0–54.0)	<0.001
52	74	41.72±2.02	41.6 (38.0–46.4)	1437	45.89±2.80	45.7 (40.0–54.0)	<0.001
53	62	42.46±2.43	42.2 (38.4–47.3)	1151	46.09±2.87	45.9 (40.0–54.0)	<0.001
54	74	41.94±2.46	41.6 (38.0–49.1)	1421	46.11±2.90	46.0 (33.4–54.0)	<0.001
55	82	42.15±2.48	42.2 (38.0–48.2)	1283	46.08±2.83	46.0 (39.4–54.0)	<0.001
56	61	42.06±2.54	41.8 (37.6–48.4)	1016	45.89±2.80	45.7 (39.4–54.0)	<0.001
57	29	41.66±2.49	41.2 (37.9–38.1)	849	46.04±2.94	46.1 (33.1–54.0)	<0.001
58	42	42.78±2.47	42.6 (38.9–48.8)	672	46.17±2.94	46.2 (40.0–54.0)	<0.001
59	25	43.04±2.48	43.4 (38.0–47.6)	521	45.79±2.74	45.7 (40.0–54.0)	<0.001
60	27	42.96±2.51	42.4 (39.1–49.0)	570	46.15±2.92	46.2 (40.0–53.8)	<0.001
61	20	42.42±1.89	42.1 (39.4–45.4)	363	46.06±2.90	46.2 (39.0–54.0)	<0.001
62	11	42.06±2.25	41.9 (38.9–46.0)	235	46.08±2.88	46.1 (40.0–53.4)	<0.001
63	7	43.20±1.40	43.1 (41.2–44.8)	152	46.20±2.65	46.1 (41.0–53.9)	0.003
64	11	42.40±2.23	42.5 (38.8–45.4)	190	45.99±2.73	45.9 (40.3–54.0)	<0.001
65	4	42.40±2.18	42.3 (40.0–45.1)	104	46.03±2.58	45.9 (40.4–53.7)	0.007

SD: Standard deviation; Min–Max: Minimum–maximum