



## Research Article

# Comparing FAMACHA® scores and hematological parameters in Nachi, Beetal and Pak Angora goats naturally infected with *Haemonchus contortus*

Mubashar Hassan<sup>1</sup>, Zohaib Saeed<sup>1\*</sup>, Aftab Shaukat<sup>2</sup>, Muhammad Abdullah Qureshi<sup>3</sup>, Muhammad Tahir Aleem<sup>1</sup> and Zaid Ahmed<sup>4</sup>

<sup>1</sup>Department of Parasitology, University of Agriculture Faisalabad, Faisalabad 38000

<sup>2</sup>College of Veterinary Medicine, South China Agricultural University, Guangzhou, 540642

<sup>3</sup>Faculty of Veterinary Science, University of Agriculture Faisalabad

<sup>4</sup>Livestock and Dairy Development Department, Ministry of Livestock, Government of Punjab, Pakistan

\*Correspondence: [zohaibsaeedahmad@gmail.com](mailto:zohaibsaeedahmad@gmail.com)

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## ABSTRACT

*Haemonchus contortus*, also known as “barbar’s pole” worm, is a cosmopolitan aggressive blood-feeding parasite of small ruminants belonging to the phylum Nematelminths. It causes severe infection of gastrointestinal tract in goats and sheep with high mortality rate. Because of Severe losses in capital, controlling *H. contortus* is a prime consideration for farmers and scientists. Irrational use of anthelmintic drugs because of late diagnosis led to the development of resistance in parasites for these drugs. The researchers suggest multiple diagnostic tools, but they may be expensive, have a later interpretation of the results, or need a high level of expertise, making them practically unfeasible to be used instantly on farms. Rapid, early, and economical diagnosis is the prime thing for identifying the problem. FAMACHA® is a visual aid for diagnosing *H. contortus* based on the mucosal color. In this research, results of the FAMACHA card were used to compare fecal egg counts, packed cell volume, and hemoglobin levels in three breeds of goats i.e., “Beetal” Nachi and Pak Angora. FEC values showed a positive correlation with the FAMACHA® visual scores, while PCV and hemoglobin values showed a negative correlation. This suggested that FAMACHA® can help assess the severity of *H. contortus* infection, but it cannot be used for clinical interpretation of *H. contortus*.

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## Introduction

Parasites are the major life threat for all domesticated animals, especially for ovines. They reside in different body parts of humans and animals and cause severe life-threatening problems. (Saeed et al. 2023). Goats are ruminant animals commonly present all over the world and they remain prone to parasitic infections (Arsenopoulos et al. 2021). Gastrointestinal helminths are among the major parasites which remain to infect goats all over the world (Abbas et al. 2020). These parasites are commonly present

because their eggs are in the environment and remain entering the animal body with food and water (Saeed and Alkheraije 2023). All the animals can get them, and they remain feeding on the animals for a long period. The major problem with these parasites is that clinical signs of these parasites are produced after a long time (Aslam and Saeed). Helminths not only continue to consume a major part of the food but also provide harm to the animals (Raza et al. 2010). Parasitic infection mostly causes gastrointestinal problems, blood loss, protein loss, emaciation, chronic constipation,

and diarrhea and may cause mortalities. These problems can be resolved by treatment at the early stages of life.

Early diagnosis is the key tool for saving the life of the animal and to avoid severe economic losses. Treatment of gastrointestinal worms can only occur when worms are diagnosed at the early stages of life (Bharti et al. 2018). Late treatment is not only difficult but requires much more medication, which is a greater cause of public health and resistance issues besides economic concerns. For early detection of parasitic infections, signs resulting from the pathologies of parasites are very helpful (Abbas et al. 2023). Gastrointestinal parasites are known for causing anemia because of their blood-feeding habits (Read 1968). Anemia or blood deficiency leads to icterus or jaundice, which is the yellowing of the mucous membrane. The extent of color shift depends upon the loss of blood (Reuben 2012).

The quickest way to check the parasite burden is visual observation. Visual observation is a very easy way for the determining the worm load in animals, but this method requires some standardizations. (Jalil et al. 2021). The standardization can be done using a FAMACHA® card. The FAMACHA® is a well-known system for estimating the extent of the change of mucous membranes by comparing them

with the colors present on the card (Sargison et al. 2021). FAMACHA® denotes that the anemia is present but the association with the parasite burden is questionable (Conradie van Wyk 2012). Anemia or paler mucous membranes can be because of any reason, and they must not point to the parasite burden (Roberts 2016). Using anthelmintics based on the FAMACHA® card can be a risky scene.

This study was performed to estimate the correlation of FAMACHA® on three different breeds of Goat, Pak Angora, Nachi, and Beetal at two different locations and their FAMACHA Values were compared to actual worm burdens and hematological parameters of these parasites.

**Materials and Methods**

**Animals**

Adult, non-pregnant goats of Pak-Angora and Beetal breeds were selected randomly at “Pak-Angora farm Rakh Khery Wala, Layyah” and “University of Agriculture, Faisalabad” farm. 120 animals were selected from each farm. No dewormer was applied to the goats 3 months before the study and all the animals were being reared on the semi-intensive system. Ear tagging of selected animals was done and the experiment protocols were followed.



**Fig. 1:** Map of District Punjab province, Pakistan. Stars showing the districts of research stations.

**FAMACHA Observation**

FAMACHA® card was observed with the mucous membrane following the methods of (Şahin et al. 2021) All the animals were numbered between 1 to

5, on visual matching with the FAMACHA® card, where 1 represented the normal color and 5 represented severe anemia.

#### **Fecal Egg Counting**

Fecal egg counting was done according to the parameters of (Nielsen 2021) Fresh fecal samples were obtained from the rectum of the animals. Mashed and put for centrifugal separation of the eggs and counting on McMaster chamber. The eggs were identified according to the standard keys of (Nielsen et al. 2010).

#### **Blood Sample Collection**

Blood samples were collected from the jugular veins of the animals using sterile syringes in the vacutainers following the protocols of (Huntington et al. 1989). The collected blood samples were preserved and transported to the lab in the cold chain for estimation of hemoglobin and Packed Cell values.

#### **Results and Discussion**

The maximum number of goats was recorded at categories 3 (43.75%) and 4 (27.5%) FAMACHA scores, respectively. The association of FAMACHA, EPG, and PCV were shown in Figure 1. The correlation of FAMACHA with EPG and PCV was found negative (i.e. -0.0886 & -0.118, respectively) whereas FAMACHA correlation with PCV was found positive (i.e. 0.197) (P value > 0.05) chart showed a positive correlation with PCV and fecal egg count. Several true positives, false positives, true negatives, and false negatives had been seen in our study (Tables 1, 2 and 3)

Goats are precious assets that play a vital role in the national GDP (Dera et al. 2023; Utrari et al. 2023). They are reared for dairy and milk purposes although their skin and hide are also a valuable part, the primary purpose remains milk and meat. Estimation of worm burden is crucial for livestock management (Abbas et al. 2020). In this study, we have performed experiments on the results of PCV and FAMACHA. The FAMACHA system has high specificity and low sensitivity, considering a FAMACHA score of 3 or greater as anemic (Di Loria et al. 2009). Various researchers have done this work (Kaplan et al. 2004; Burke et al. 2007; Scheuerle et al. 2010; Cintra et al. 2018; Ferreira et al. 2019; Adamu et al. 2020).

Similar studies have been conducted by Kaplan et al (2004), where they have stated that the FAMACHA can be used as a source of early diagnosis of sheep and goats. Their results were in line with current studies. Likewise, Şahin et al (2021) have also conducted research and have proved that the FAMACHA can be used for the early detection of worms and is a good source for the estimation of worm burdens. A similar study by Sunder et al (2019) also reveals that the FAMACHA gives true positive values for animals with higher FAMACHA score, which means the accuracy of FMACHA is higher in more anemic animals. However, the

studies of Cintra et al (2018) are not in line with the current study. They conducted FAMACHA diagnostics and concluded that the FAMACHA is unreliable and gives false negative results for estimating worm burden.

PCV did not directly correlate with FC values in this experiment. This can be attributed because the PCV and hemoglobin concentration are two contrasting parameters to estimate the anemic condition. An animal can be anemic because of low hemoglobin, and only a decrease in cell count is not the major factor in declaring an anemic (Faris et al. 2022). Similar studies have been conducted by multiple other scientists, and they have stated that the PCV values are not a measure to match with FAMACHA (Ciappesoni and Goldberg 2018; Shastry and Belurkar 2019).



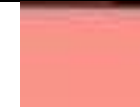











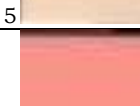









Researchers have tested that high sensitivity is more desirable than high specificity because an animal may die if you do not treat a false negative report, while there is a negligible disadvantage to treating a false positive case (Cintra et al. 2018). A higher Sensitivity is seen in our studies as the ratio of false positive results is far greater than false negative ones in contrast (Burke et al. 2007). Low specificity is observed as the sensitivity is higher due to more false positive results in our studies. This might be due to the presence of more anemic animals on farms. Due to more False-negative results, the cost of treatment is increased as we use more dewormers; however, treating a false-positive animal is not a big problem compared to not treating the false-negative. Our primary concern is decreasing the worm load on farms; for this purpose, we can use the FAMACHA system to detect worm load (Molla et al. 2023). Animals with high worm loads are culled or segregated from the other animals on the farm (Shifaw et al. 2023), which may be essential to minimize the farmer's loss. The FAMACHA system is very cost-effective for the farmer as by using this system, the farmer can reduce his cost on anthelmintics. Its most substantial benefit is that it can conserve the population of *H. contortus* in refugia. When the worms are not exposed to anthelmintics, resistance will not be developed, which will ultimately benefit the farmer. The FAMACHA system has been proven to be a worthy tool for the detection of animals that require treatment.

#### **Conclusion**


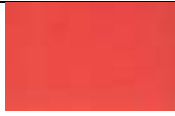






The study concludes that the FAMACHA system is a helpful tool for the estimation of worm burden (*H. contortus*) in small ruminants and can give a near approximation of worm burdens, but it is not a reliable tool for the estimation of anemia. The FAMACHA system only detects the animals infected with *H. contortus* while it is unable to determine the worm load caused by any other parasite. The estimation of FAMACHA scores cannot be taken as a single reliable source for the estimation of anemia

in the blood. Further studies are needed to address the exact estimation of worm burdens and hematological values in goats.


**Table 1:** Colour Meter Readings Nachi Goat & FAMACHA

Sr. No.	Hb	PCV	EPG	FAMACHA Values	FAMACHA Eye Score	Color Meter eye score	Color Meter reading
1	5.6	16	600	X 5086 Y 5484 Z3735	 5		X0858 Y1106 Z0000
2	6.0	18	800	X2782 Y 2892 Z1729	 4		X0930 Y1177 Z0000
3	6.6	22	500	X2782 Y 2892 Z1729	 4		X0905 Y1044 Z0345
4	6.2	16	1900	X 5086 Y 5484 Z3735	 5		X0485 Y0553 Z0032
5	6	18	600	X 5086 Y 5484 Z3735	 5		X0770 Y1003 Z0000
6	6.4	18	2100	X 5086 Y 5484 Z3735	 5		X0849 Y1136 Z0033
7	5.2	16	1500	X 5086 Y 5484 Z3735	 5		X3668 Y2675 Z0000
8	6.2	20	800	X2782 Y 2892 Z1729	 4		X0930 Y1177 Z0000
9	5.6	20	1200	X2782 Y 2892 Z1729	 4		X0905 Y1044 Z0345
10	6.4	21	1000	X 2638 Y 2628 Z 1469	 3		X0485 Y0553 Z0032
11	6.00	17	1800	X 2638 Y 2628 Z 1469	 3		X0770 Y1003 Z0000
12	5.4	14	3000	X 5086 Y 5484 Z3735	 5		X0849 Y1136 Z0033

13	6.4	18	1900	X 5086 Y 5484 Z 3735	5		X3668 Y2675 Z0000
14	6.6	18	1200	X 2638 Y 2628 Z 1469	3		X0930 Y1177 Z0000
15	5.4	20	2300	X2782 Y 2892 Z1729	4		X0905 Y1044 Z0345
16	6.4	22	1500	X2782 Y 2892 Z1729	4		X0485 Y0553 Z0032
17	3	6.6	1300	X2577 Y 2272 Z 2003	2		X0770 Y1003 Z0000
18	6.8	21	1900	X 2638 Y 2628 Z 1469	3		X0849 Y1136 Z0033
19	6.4	20	1400	X 2638 Y 2628 Z 1469	3		X3668 Y2675 Z0000
20	6.8	21	2100	X2782 Y 2892 Z1729	4		X0930 Y1177 Z0000
21	6.4	20	1500	X2782 Y 2892 Z1729	4		X0905 Y1044 Z0345
22	6.6	17	1800	X 2638 Y 2628 Z 1469	3		X0485 Y0553 Z0032
23	5.2	18	1800	X 5086 Y 5484 Z 3735	5		X0770 Y1003 Z0000
24	6.2	22	3100	X2782 Y 2892 Z1729	4		X0849 Y1136 Z0033
25	5.6	16	2200	X2782 Y 2892 Z1729	4		X3668 Y2675 Z0000

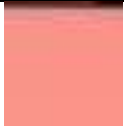

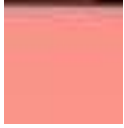















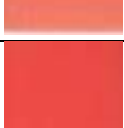



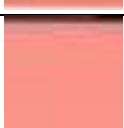


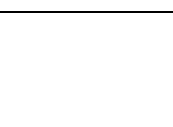
26	5.2	18	2600	X2782 Y 2892 Z1729	4		X0930 Y1177 Z0000
27	6.4	16	1800	X 2638 Y 2628 Z 1469	3		X0485 Y0553 Z0032
28	6.6	22	2400	X 5086 Y 5484 Z3735	5		X0905 Y1044 Z0345
29	6.2	15	600	X2782 Y 2892 Z1729	4		X0485 Y0553 Z0032
30	6	20	500	X 2638 Y 2628 Z 1469	3		X0770 Y1003 Z0000
31	6.4	20	1900	X2782 Y 2892 Z1729	4		X0849 Y1136 Z0033
32	5.2	1300	1800	X 5086 Y 5484 Z3735	3		X3668 Y2675 Z0000
33	5.2	1300	1500	X 5086 Y 5484 Z3735	5		X3668 Y2675 Z0000

**Table 2:** Color Meter Readings of Pak Angora Goat & FAMACHA

Sr. No.	Hb	PCV	EPG	FAMACHA values	FAMACHA Score	Eye	Color Meter eye score	Color Meter reading
1	6	14	2000	X 5086 Y 5484 Z3735	5			X3398 Y4276 Z000
2	6.4	16	1500	X2782 Y 2892 Z1729	4			X2825 Y1979 Z0000
3	6.8	14	1400	X 5086 Y 5484 Z3735	5			X0849 Y1136 Z0033
4	6.8	18	1900	X 5086 Y 5484 Z3735	5			X3668 Y2675 Z0000
5	6	20	1300	X2782 Y 2892 Z1729	4			X0376 Y0533 Z0158
6	7.4	14	1600		3			X0858 Y1106 Z0000
7	6.8	16	1200	X 5086 Y 5484 Z3735	5			X0930 Y1177 Z0000
8	6.2	17	1500	X2782 Y 2892 Z1729	4			X0905 Y1144 Z0345
9	5.4	15	2300	X2782 Y 2892 Z1729	4			X0770 Y1003 Z0000
10	6.6	18	1600	X2577 Y 2272 Z 2003	2			X0849 Y1136 Z0033
11	7.00	20	1300	X 2638 Y 2628 Z 1469	3			X3668 Y2675 Z0000
12	6.6	22	1400	X2577 Y 2272 Z 2003	2			X0376 Y0533 Z0158

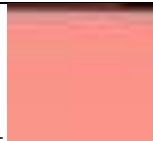



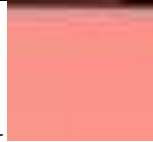

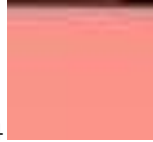

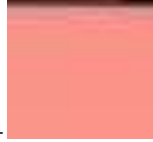

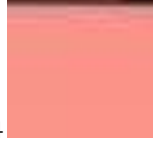

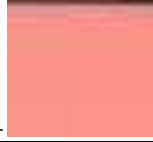

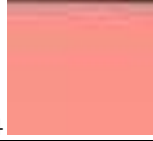



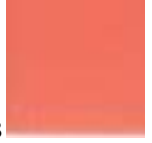

13	6.4	15	600	X 2638 Y 2628 Z 1469	3		X0129 Y0163 Z0000
14	5.4	15	2400	X 2309 Y 2070 Z 1650	2		X4302 Y7702 Z0000
15	5.6	13	1900	X 2638 Y 2628 Z 1469	3		X1007 Y1104 Z0285
16	6.00	17	1300	X 2309 Y 2070 Z 1650	2		X0858 Y1106 Z0000
17	6.2	18	1500	X 2638 Y 2628 Z 1469	3		X0930 Y1177 Z0000
18	5.6	12	1900	X2782 Y 2892 Z1729	4		X0905 Y1044 Z0345
19	5.8	13	1500	X 2638 Y 2628 Z 1469	3		X0485 Y0553 Z0032
20	7.2	17	900	X2577 Y 2272 Z 2003	2		X0770 Y1003 Z0000
21	6.4	10	1600	X2782 Y 2892 Z1729	4		X0849 Y1136 Z0033
22	5.8	14	2400	X 2638 Y 2628 Z 1469	3		X3668 Y2675 Z0000
23	5.6	13	1500	X2782 Y 2892 Z1729	4		X0376 Y0533 Z0158
24	6.2	14	1200	X 2638 Y 2628 Z 1469	3		X0129 Y0163 Z0000
25	6.8	6.4	2000	X2782 Y 2892 Z1729	4		X0849 Y1136 Z0033


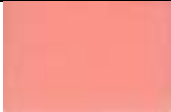
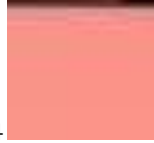

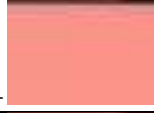
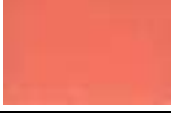


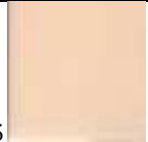

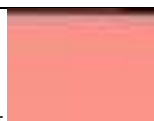

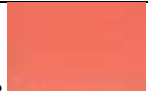

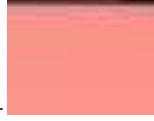







26	6	14	1300	X2782 Y 2892 Z1729			X3668 Y2675 Z0000
27	7.6	18	2000	X2782 Y 2892 Z1729	4 		X0376 Y0533 Z0158
28	5.8	13	1600	X 5086 Y 5484 Z3735	5 		X0129 Y0163 Z0000
29	7.4	12	1600	X 2638 Y 2628 Z 1469	3 		X1007 Y1104 Z085
30	6.8	12	1200	X 5086 Y 5484 Z3735	5 		X0858 Y1106 Z0000
31	6.2	14	1500	X2782 Y 2892 Z1729	4 		X0930 Y1177 Z0000
32	6.8	16	900	X 5086 Y 5484 Z3735	5 		X0905 Y1044 Z0345
33	5.6	17	700	X 2638 Y 2628 Z 1469	3 		X0485 Y0553 Z0032
34	6.6	16	1600	X2577 Y 2272 Z 2003	2 		X0770 Y1003 Z0000
35	7.00	15	1300	X 2638 Y 2628 Z 1469	3 		X0849 Y1136 Z0033
36	6.6	18	1400	X2577 Y 2272 Z 2003	2 		X3668 Y2675 Z0000
37	6.6	20	1800	X 2638 Y 2628 Z 1469	3 		X0376 Y0533 Z0158
38	5.8	22	1000	X2782 Y 2892 Z1729	4 		X0121 Y0209 Z0060

39	5.4	19	2400	X2577 Y 2272 Z 2003	2		X0129 Y0163 Z0000
40	6.00	13	1300	X2577 Y 2272 Z 2003	2		X1007 Y1104 Z0285
41	6.2	13	1500	X 2638 Y 2628 Z 1469	3		X0858 Y1106 Z0000
42	6.4	14	1600	X 2638 Y 2628 Z 1469	3		X1007 Y1104 Z0285
43	5.6	17	1900	X2782 Y 2892 Z1729	4		X0930 Y1177 Z0000
44	5.8	18	1500	X 2638 Y 2628 Z 1469	3		X0905 Y1044 Z0345
45	7.2	12	800	X2577 Y 2272 Z 2003	2		X0485 Y0553 Z0032
46	7.2	13	900	X2577 Y 2272 Z 2003	2		X0639 Y0760 Z0000
47	6.4	15	1600	X2782 Y 2892 Z1729	4		X0770 Y1003 Z0000
48	5.8	17	2400	X 2638 Y 2628 Z 1469	3		X0849 Y1136 Z0033
49	5.6	10	1500	X2782 Y 2892 Z1729	4		X3668 Y2675 Z0000
50	7.2	14	0	X2577 Y 2272 Z 2003	2		X0376 Y0533 Z0158
51	6.4	13	900	X2782 Y 2892 Z1729	4		X0121 Y0209 Z0060
52	6.4	20	2400	X 2638 Y 2628 Z 1469	2		X0129 Y0163 Z0000
53	5.6	18	1500	X2782 Y 2892 Z1729	4		X0849 Y1136 Z0033

**Table 3:** Color Meter Readings of Beetal Goat & FAMACHA

Sr. No.	Hb	PCV	EPG	FAMACHA Values	FAMACHA Score	Eye	Color Meter Eye Score	Color Meter Values
1	6.2	21	600	X2782 Y 2892 Z1729	4			X 0382 Y 0393 Z 0200
2	6.6	22	1200	X 2638 Y 2628 Z 1469	3			X 0771 Y 0775 Z 0449
3	7	20	600	X2782 Y 2892 Z1729	4			X 0452 Y 0407 Z 0209
4	7	8	1200	X2782 Y 2892 Z1729	4			X 0801 Y 0825 Z 0371
5	6	18	600	X2782 Y 2892 Z1729	4			X 0532 Y 0540 Z 0399
6	6	18	1200	X 2638 Y 2628 Z 1469	4			X 4829 Y 1034 Z 0059
7	4	8	600	X2782 Y 2892 Z1729	4			X 0801 Y 0813 Z 0546
8	6.6	4	000	X2782 Y 2892 Z1729	4			X 0572 Y 0602 Z 0215
9	4	8	600	X 5086 Y 5484 Z3735	5			X 0950 Y 0904 Z 0714
10	6.8	21	2000	X 2638 Y 2628 Z 1469	3			X 0765 Y 0770 Z 0348

11	5.2	19	1100	X 2638 Y 2628 Z 1469	3			X 0382 Y 0393 Z 0200
12	6.6	17	1900	X2782 Y 2892 Z1729	4			X 0771 Y 0775 Z 0449
13	6.2	14	1600	X2782 Y 2892 Z1729	4			X 0452 Y 0407 Z 0209
14	5.4	18	1600	X2782 Y 2892 Z1729	4			X 0801 Y 0825 Z 0371
15	6.4	18	1800	X 5086 Y 5484 Z3735	5			X 0532 Y 0540 Z 0399
16	5.6	17	1700	X2782 Y 2892 Z1729	4			X 4819 Y 1034 Z 0059
17	3	19	1100	X 2638 Y 2628 Z 1469	3			X 0738 Y 0758 Z 0409
18	6.4	17	700	X2782 Y 2892 Z1729	4			X 0572 Y 0602 Z 0215
19	6.2	18	2200	X 2638 Y 2628 Z 1469	3			X 0950 Y 0904 Z 0714
20	6	20	1800	X2782 Y 2892 Z1729	4			X 0765 Y 0770 Z 0348

21	6.4	20	1100	X2577 Y 2272 Z 2003	2		X 0382 Y 0393 Z 0200
22	5.2	18	800		3		X 0771 Y 0775 Z 0449
23	6.2	16	1900	X2577 Y 2272 Z 2003	2		X 0452 Y 0407 Z 0209
24	6.2	20	1500	X 2638 Y 2628 Z 1469	3		X 0801 Y 0825 Z 0371
25	6.4	18	1000	X2782 Y 2892 Z1729	4		X 0532 Y 0540 Z 0399
26	6	14	1600	X 2638 Y 2628 Z 1469	3		X 4829 Y 1034 Z 0059

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#### Ethical Statement

No Ethical permissions were required for this article.

#### Availability of Data and Material

The data can be obtained from the corresponding author on a reasonable request.

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#### Consent to Participate

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All the authors gave their consent for equal participation.

#### Consent for Publication

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#### Competing Interest

The authors declare that they have no relevant financial or non-financial interests to disclose.

#### Author Contribution

MH, ZS, and MAQ performed research, MTA, AS and ZA conducted the statistical analysis. All the authors equally contributed in drafting the manuscript. ZS revised and finalized the manuscript.

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