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Grazing Management Effects on Plant Functional Groups in Sahand summer Rangelands, Northwest, Iran

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Author
Morteza Mofidi-Chelan, *Ph.D.*[1*]
Esmaeil Sheidai-Karkaj, *Ph.D.*[1]

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[1]Assistant Professor, Faculty of Natural Resources, Department of Range and Watershed Management, Urmia University, Urmia, Iran

*** *Correspondence***
Address: West Azerbaijan province, Urmia, 11 km road of Serow, Nazlu Pardis, Faculty of Natural Resources.
Postal code: 5756151818.
Cell Phone Number: +989148400047
Telephone Number: +98(44)32752741
Fax Number: +98(44)32779558
E-mail: m.mofidi@urmia.ac.ir

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ABSTRACT

Aim: This study was conducted to compare the effects of three types of light, medium, and heavy grazing intensity on the plant functional groups across the Sahand summer rangeland.
Materials & Methods: First, three areas with different grazing intensities were selected according to the field observations and collected information from herders. Then, the random systematic approach was applied to plant sampling across the selected sites. Afterward, six transects were randomly established in the selected sites separately, where ten plots were then localized on the compounding transects. Finally, the properties of plant functional groups were captured on the plot scale.
Findings: The results of the Duncan test indicate a significant difference in the average production, canopy cover percentage, and litter percentage across the studied sites under different grazing intensities. The average characteristics of all plant functional groups in sites with different grazing intensities have a significant difference at the level of 1%. In this regard, the highest averages with 487.8 kg. ha^{-1}, 62.7%, and 12.5% are related to the site with light grazing, respectively. Results revealed that the properties of perennial grasses and forbs in the region under light grazing intensity are higher than two other studied regions, which were under medium and heavy grazing.
Conclusion: The finding of this research implied that the livestock grazing intensity could significantly affect the palatability classes and growth form of plants. Therefore, changes in grazing intensity are recommended as a management tool in rangeland improvement to improve vegetation characteristics and move vegetation towards equilibrium.

Keywords: Growth form, Grazing intensity, Mountain rangelands, Palatability classes.

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Introduction

Rangelands cover approximately half of the whole area in Iran. As the result of unstable use, recently, the high-quality species have been reduced to such extent of the invader species such as *Peganum harmala* L.*, Euphorbia sp., Bromus tectorum* L.*,* is increased [1]. In most rangeland ecosystems, unpleasant species have disappeared, and soil is faced with erosion [2]. Canopy cover reduction associated with increased soil compaction and erosion is the dominant driver of grassland degradation. Reduced canopy cover and plant litter can intensify the direct effects of raindrops on the soil by increasing soil crusting and erosion, reducing soil permeability [3, 4]. According to the surveys, overgrazing can result in soil degradation by destroying soil characteristics, dramatic consequences on plant community and nutrient cycling [5, 6], and caused the remarkable decline of ecosystem services. Literature shows that the biomass, organic carbon, and total nitrogen content in soil can increase by eliminating the grazing in overgrazed areas [7]. Also, the vegetation cover, dry matter production, many palatable species [8], and species composition [9, 10] can significantly increase compared to the areas still under grazing.

Rangelands can be identified as a natural ecosystem that includes both living and non-living components with complex relationships. Therefore, change in one component may have either a negative or positive effect on the other components [1]. Change in vegetation caused by environmental changes and the pressure imposed by livestock grazing is one of the rangeland ecosystem's characteristics. Trend analysis of two adjacent rangelands ecosystems with different grazing intensities is a widely used method to study the nexus among rangeland components. Also, it is the most considered method in evaluating applied management approaches and strategies in a region [11]. Therefore, the study of vegetation changes under different intensities of livestock grazing is of particular importance in the future management of rangeland habitats. Samadi Khanghah [12] also revealed that enclosure had increased the canopy cover percentage, species diversity, and density, but sometimes, non-observance of exclosure will annoy the achievement of the expected objectives and planned results. In this regard, Ahmad Khani [13] reported that vegetation factors (density of herbaceous forbs, grasses, shrubs) in two enclosed areas and under grazing were significantly different, and the application of exclosure has increased the density and canopy cover of existing vegetative forms. Bakhshi [14] also reported that livestock grazing will increase the abundance of plant families, including Poaceae, Zygophyllacea in the site because of increasing species such as *Peganum harmala* L. and *Poa bulbosa* L. Van der Merwe [15], also reported stocking pressure and time had significant impacts on species composition. Increasing grazing time was essential for total plant cover, perennial grass cover, and palatable shrub cover. Annual grass cover decreased over time, whereas other plant groups and rangeland conditions were fixed. Ehsani [16] reported that the results showed the carbon of both underground and aboveground biomass in low grazing sites was more significant than the high and moderate grazing sites, which were 1.17, 1.07, and 0.567 $t.ha^{-1}$, respectively. In a study, Motamedi [17] studied the characteristics change of the *Artemisia fragrans* Willd. species in mountainous Artee misia shrublands for their different grazing intensity effect (light, medium, and heavy). The results showed a significant difference in the viewpoint of aboveground biomass, the average diameter of the crown, height, crown surface, and plant volume within the selected sites. Motamedi [18], in other regions, on studying the son sequences of various grazing intensities such as low, moderate, and

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high on the biomass of *Artemisia fragrans* Willd. Species showed a significant difference between the measured parameters (except for the area and diameter of the collar) under three grazing intensities. Samadi Khangah [12] investigated the effect of a 19-years research exclusion on plants and soil characteristics. The Results demonstrated that vegetation traits, including density and canopy cover of forbs and grasses and total canopy cover, were significantly different between the exclusion and control site($p<0.05$).

Respectively. Numerous studies show that different intensities of livestock grazing in different regions have different effects on rangeland vegetation. This research, as a novelty, it is tried to conduct a comprehensive analysis of vegetation using the variation in plant functional groups attributes. Therefore due to the variety of climatic conditions, vegetation, and different physical characteristics of rangelands, as well as the fact that most reclamation projects of Rangeland development in watersheds, despite spending large budgets, fail due to lack of accurate monitoring and evaluation, it is necessary to address this issue on a case-by-case basis in each region. We tested the following hypothesis: (i) Changes in livestock grazing intensity can cause changes in the characteristics of plant functional groups. (ii) Changes in livestock grazing intensity can cause changes in plant composition in rangeland. Therefore, the current research was done to investigate the changes in vegetation in the region due to different intensities of livestock grazing to recognize the positive and negative effects of different types of grazing intensities in the region to recommend livestock grazing management in the region a restoration operation.

Materials & Methods

Study area

The mountain rangelands, which are located at 37°27′N and 46°33′E, 30 km far from the Maragha city, were adopted in this study (Figure 1). The selected area is representative rangeland of the Sahand Mountains in East Azerbaijan province, northwest Iran. The region is from a semiarid climate and varies on an elevation belt of 1900 m a.s.l. According to the statistic, the region receives approximately 322 mm precipitation annually. Its annual mean temperature is about 12.5°C [19].

The soil, which is uniformly extended in the study area, is benefited by the clay loam texture. Available geological maps imply that sedimentary rocks of Pliocene dominate the study area to Quaternary ages [20]. The plant community includes the *Agropyron trichophorum* (Link) K. Richt., *Cousinia commutata* Bunge, *Bromus tomentosus* Boiss., *Festuca ovina* L. *Euphorbia* spp., *Cirsium arvense* (L.) Scop, scattered *Thymus* spp and *Astragalus* spp. The area has used mainly by sheep and goats. The drainage system of the region finally led to Lake Urmia. Three grazing sites in this rangeland were selected to assess the impacts of grazing pressure on soil characteristics.

Grazing sites

The selected triple sites, which have the same environmental conditions, have been affected by various levels of grazing based on the livestock density. All those areas were located on the southern part of Sahand Mountains altitudes, varied from 1900 to 1950, with smooth slope. The dominant grazing livestock in the region is the Ghezel sheep breed.

Shepherds herd the livestock during the warm seasons of spring and summer. The grazing period is from March to August, and during this period, the sheep and goats are on the rangeland all day; afterward, they return at night to be milked. The livestock density per unit area was used as an indicator for grazing intensity to represent cumulative grazing intensity. The livestock breeders

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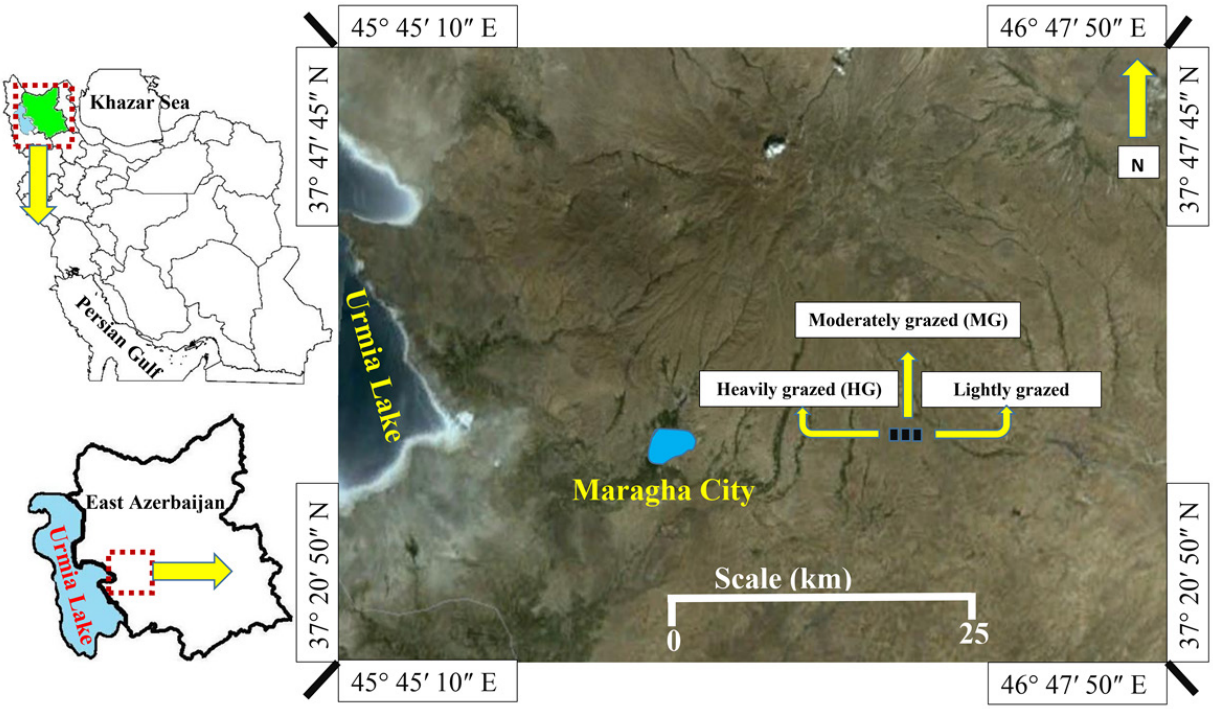

Figure 1) Grazing sites in Iran, East Azerbaijan Province, and the Sahand Mountains area.

reported these numbers and reported that these areas had been utilized in such an approach for recent decades. A key site with 1-2 ha as a sampling site was considered for each grazing intensity. The following paragraph has described the levels of grazing at the studied sites.

Lightly grazed (LG): livestock are observed on rare occasions, the soil surface is almost entirely covered by vegetation (over 85%), and stocking rates are varied from 2 to 2.5 livestock units per ha.

Moderately grazed (MG): this area is relatively far from settlements, but grazing takes place regularly; livestock number is approximately 3–4 livestock units per ha; vegetation cover is 60–75%. Its stocking rate is considered equal to the grazing capacity of the rangeland [40].

Heavily grazed (HG): this area includes the rangelands located at the surrounding villages and trampling, being almost constantly grazed and trampled by herd; vegetation in most cases is less than 35%, and the sign of rill erosion is evident on the soil surface. Its stocking rate is 4.5–5 livestock units per ha.

Vegetation sampling and analyses

This study was conducted in the spring of 2020. Sampling procedures across the tripe sites were performed separately using a systematic randomized approach. Six transects 100-m long were placed randomly in each site, and ten plots with an area of 1 m^2 (n= 120) were placed at equal distances along each transect (n=12). The factors including species present, plant species yield, canopy cover percentage, percentage of ground covered by litter, and bare ground were recorded inside each plot. Canopy cover percentage, total yield, and composition were estimated separately for each plant functional group of palatability classes and growth forms in each plot. The palatability of plant species was firstly assessed based on available works of literature, and then they checked with native herders of the region. The rangeland condition and trend were assessed based on standard protocols. The yield was measured by cutting at the end of the flowering stage of critical species. According to the dominant

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Table 1) Some environmental properties of the study area.

Grazing sites	Dominant Plants	Slope (%)	Aspect	Soil texture	Elevation	Distance from the village (km)
Lightly grazed (LG)	*Agropyron trichophorum - Bromus tomentosus - Astragalus spp*	20-30	South	Clay loam	1940	4
Moderately grazed (MG)	*Astragalus spp - Anaual forbs - Anaual grass*	20-30	South	Clay loam	1930	3
Heavily grazed (HG)	*Astragalus spp - Cousinia spp - Anaual grass*	20-30	South	Clay loam	1910	1.5

Table 2) Results of Duncan's test and mean comparison of rangeland plant characteristics at three grazing sites.

Grazing sites	Range Condition (Based on the four-factor method)	Rangeland trend (Based on scoring soil and vegetation properties)	Canopy cover (%)	Yield (kg. ha^{-1})	Litter (%)
Lightly grazed (LG)	Good (44)	Positive (+3)	62.7 ± 0.43a	487.8 ± 11.43a	12.5 ± 0.22a
Moderately grazed (MG)	Fair (26)	Positive (+2)	55.4± 0.28b	384.9 ± 8.67b	11.3 ± 0.47a
Heavily grazed (HG)	Fair (26)	Negative (-4)	31.4 ± 0.96c	197.5 ± 9.55c	4.73 ± 0.84b

Different letters in a column for each parameter show a significant difference at the P<0.05 level.

plants of the area, the plot size was selected to be 1*1 m [21]. The plants were dried, weighed, and divided into various growth forms in kg.ha^{-1} for each. Anderson Darling and Levene's tests were applied to test data normality and homogeneity of variance at the 5% probability level. One way- ANOVA was performed, and Duncan's tests were applied to compare the means at the 5% probability level ($P < 0.05$). All statistical analyses for each of the measured variables were performed in SPSS24.

Findings

Some environmental properties of rangeland in the triple studied regions with different grazing levels are presented in table 1.
Table 2 shows the results for the Duncan test mean comparison of vegetation characteristics, the condition, and trend of rangeland in the triple studied regions with different grazing levels. The results indicated that significant differences at the level of 1% were shown in terms of average production, canopy cover percentage, and litter percentage across the studied sites under different grazing intensities.
Table 3 shows the mean and results of the Duncan test comparing the mean of growth forms at three grazing pressure. The results of the Duncan test show that all characteristics mean all growth forms (perennial grass, perennial forbs, annual grass, annual forbs, and shrubs) at sites with different grazing intensities have a significant difference at the level of one percent. Results revealed that the average production, canopy cover percentage, and composition of perennial grass and forbs in the region with light grazing intensity is higher than the other two sites under medium and heavy grazing intensities.

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Table 3) Results of Duncan's test and mean comparison of growth forms properties at three grazing sites.

Growth form	Site	Yield (kg. ha^{-1})	Composition (%)	Canopy cover (%)	Sig
Perennial grasses	LG	145.3 ± 4.45a	29.78 ± 0.93a	18.42 ± 0.21a	0.000**
	MG	95.3 ± 2.43b	24.75 ± 0.93a	13.74 ± 2.93b	
	HG	28.3 ± 0.93d	14.32 ± 0.93b	4.46 ± 0.54c	
Annual grasses	LG	70.2 ± 2.83a	14.39 ± 0.93b	9.01 ± 0.13b	0.000**
	MG	84.5 ± 3.46b	21.95 ± 0.93a	12.15 ± 1.78a	
	HG	48.2 ± 2.58c	7.28 ± 0.93c	2.32 ± 0.61c	
Perennial forbs	LG	125.3 ± 8.63a	25.68 ± 0.93a	16.10 ± 2.93a	0.000**
	MG	105.7 ± 4.65a	27.46 ± 0.93a	15.24 ± 2.61a	
	HG	22.4 ± 3.53b	11.34 ± 0.93b	3.62 ± 0.14b	
Annual forbs	LG	56.6 ± 3.73a	11.60 ± 0.93c	7.29 ± 1.33b	0.000**
	MG	65.5 ± 4.36a	17.01 ± 0.93a	9.42 ± 1.22a	
	HG	29.4± 2.11b	14.88 ± 0.93b	4.65 ± 0.78c	
Shrubs	LG	90.4 ± 6.24a	18.53 ± 0.93b	11.61 ± 2.94a	0.000**
	MG	33.9 ± 1.33c	8.80 ± 0.93c	4.84 ± 0.31b	
	HG	69.2 ± 3.66b	35.03 ± 0.93a	11.47 ± 1.69a	

Different letters in a column for each parameter show a significant difference at the P<0.05 level.

Figures 2- 4 show the results of the Duncan test for mean comparison of the palatability classes across the triple sites under different levels of grazing. Also, the average production, canopy cover percentage, and palatability classes show a significant difference at the level of one percent. According to the results, the average production, canopy cover percentage, and composition percentage of class I plants in the region with light grazing intensity are higher than two under medium and heavy grazing intensities. Class II plants were more dominant in the area under moderate grazing intensity.

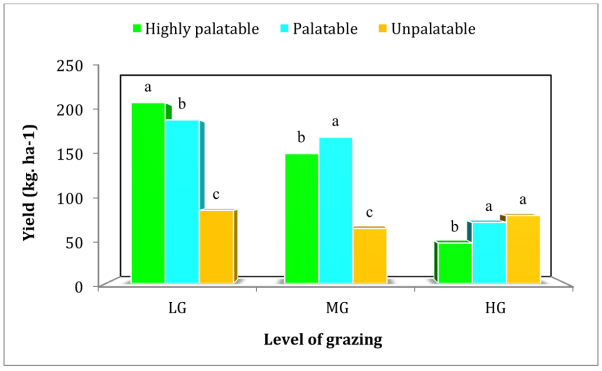

Figure 2) Results of Duncan's test and mean comparison of palatability classes yield at three grazing sites.

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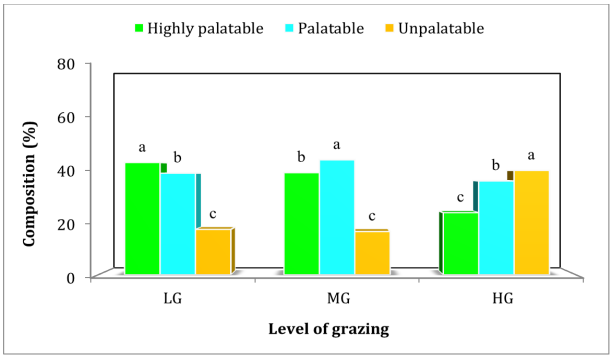

Figure 3) Results of Duncan's test and mean comparison of palatability classes Composition at three grazing sites.

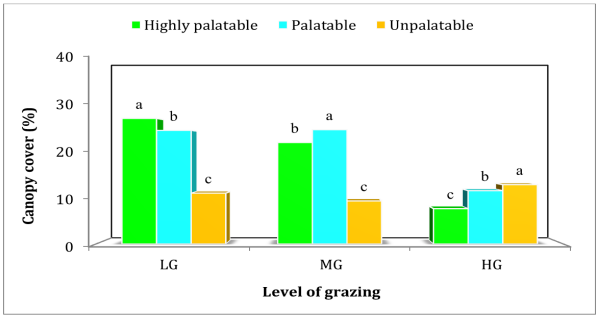

Figure 4) Results of Duncan's test and mean comparison of palatability classes Canopy cover at three grazing sites.

Discussion

Proper and efficient management of rangeland ecosystems requires adequate information concerning the grazing intensity and its impact on the characteristics of different plant species in rangelands. The results showed a significant relationship between livestock grazing intensity and changes in palatability and the growth form of plants in the region. According to the results, the amount of production, canopy cover percentage, and plant litter percentage was decreased due to increased grazing pressure which finally led to a change in the condition and trend of the rangeland. The decline in canopy cover itself can result in decreased productivity as well. Bakhshi [9] reported a decrease in production with increasing grazing intensity. Wang and Wesche [24] and Yuan [25, 26] have pointed on a reduction in vegetation, aerial and belowground biomass. The results of Khosravi [27] indicate a significant relationship between some parameters related to vegetation, such as volume and weight of shoot and belowground organ. According to Yates [28], the vegetation has increased under light grazing and exclosure by improving soil conditions (temperature, humidity, nutrient cycle). Reduction of palatable species and carbohydrate reserves associated with drought and erosion events would be the likely reasons for the reduction of production in the areas under heavy grazing intensity [29], which results have approved of the current study where a significant decrease in the canopy, production, and density of annual grasses and shrubs in the areas under heavy grazing intensity was confirmed. In this regard, [12, 24]. Also, the most important and influential factors are soil seed banks and seed entry of target species from the environment [29]. In light grazing, the herbaceous species (grass and forbs) have recovered their strength due to rest and therefore covered a larger area of the rangeland [30]. In other words, the plant community is moving towards the establishment and growth of perennial grass, and then the other plants in the composition with the other growth forms are reduced over time which eventually the community moves towards its balance and climax condition [31].

According to the results, an increase was observed for the percentage of the canopy, production, and density of Class I and Class II plants under light grazing, while results suggest a decrease in the percentage of the canopy, production, and density of Class III plants where these findings are accordance with [32, 33, 34, 35, 36, 37]. Some studies have shown a direct relationship between the biomass reduction of the aboveground and underground organ of plants with the grazing intensity and harvesting volume. For example, Motamedi et al. (2016) showed a significant difference between the root and abo-

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veground biomass of *Artemisia fragrans* under three grazing intensities [18]. The increase in the composition of class I palatable plants within the light grazing site is mainly related to the perennial grass family, which seems to be more sensitive to grazing than other plant species. The relative abundance of palatable plants in light grazing sites can be explained by the relative abundance of grass and forb species [29]. In other words, any grazing can reduce food production in the arid and semiarid regions worldwide. Once the nutrient matter is reduced within the plant body, the metabolism, storage of carbohydrates, and root growth are reduced, ultimately declining yield. Repeating grazing on rangeland plants in arid and semiarid regions is more than grazing intensity because grazing (even light) each time, the plant metabolism is disturbed, and the plant is weakened [7, 39, 20].

Conclusion

The results revealed a significant relationship between livestock grazing intensity and changes in the characteristics of palatable classes and the growth form of plants. Different livestock grazing intensities in the rangeland can be considered management and a measurement tool. Generally, light grazing plays a crucial role in improving rangeland conditions, and its positive effects on a variety of plant compounds as well as plant types deserve attention. In addition, the rangelands with light grazing are more ecologically stable than the rangelands, which are under heavy grazing due to their more diverse assemblies and the consequent balanced presence of plant species with variable ecological ranges. According to the results, it can be concluded that overgrazing endangers the stability of rangeland ecosystems by causing adverse changes in vegetation characteristics. Light grazing creates suitable conditions for establishing reliable forage species, seeding conditions in the field, and revitalizing plant species. The sequence of plant community succession flow with the creation of a suitable microclimate and soil evolution, and declining species reappear in the field of plant types, and the number of invasive and increasing species decreases. Thus, by creating an opportunity to establish plant species, soil evolution, and suitable microclimate, the conditions for the presence of palatable and high-quality forage species will be supplied. Therefore, changes in grazing intensity are recommended as a management tool in rangeland improvement to improve vegetation characteristics and move vegetation towards equilibrium.

Authors' Contributions: Mofidi-Chelan M. (First author), Introduction author/Methodologist/Main Researcher (60%); Sheidai-Karkaj E. (Second author), Statistical analyst/ Discussion author (40%).
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