TÜBİTAK

Turkish Journal of Veterinary and Animal Sciences

http://journals.tubitak.gov.tr/veterinary/

Research Article

Turk J Vet Anim Sci
(2020) 44: 632-640

doi:10.3906/vet-1911-70

Biosecurity levels of livestock enterprises in Turkey and factors affecting these levels

Mehmet Ferit CAN[1,*], Nuri ALTUĞ[2], FerhanKAYGISIZ[3]

[1]Department of Animal Health Economics and Management, Faculty of Veterinary Medicine, Hatay Mustafa Kemal University, Hatay, Turkey
[2]Department of Internal Medicine, Faculty of Veterinary Medicine, Tekirdağ Namık Kemal University, Tekirdağ, Turkey
[3]Department of Animal Breeding and Husbandry, Faculty of Veterinary Medicine, İstanbul University-Cerrahpaşa, İstanbul, Turkey

Received: 20.11.2019 • **Accepted/Published Online:** 23.03.2020 • **Final Version:** 02.06.2020

Abstract: Biosecurity (BS) is a multidimensional preventive medicine approach that has health, technical, and financial aspects. The purpose of this study was to determine the differences of the BS scores belonging to the livestock enterprises depending on the geographical region and breeding types and to predict the socioeconomic factors having an impact over the BS level. The study was conducted with 517 breeders who live in 7 different regions of Turkey. The results have revealed that the enterprises performing "beef cattle fattening and dairy cattle breeding together" have higher BS scores than the enterprises in the other breeding category ($P < 0.01$). The differences between the technical and financial scores according to geographical regions were statistically significant ($P < 0.01$). The regions categorized as "west" have the highest score and "south" have the lowest score. It was determined that as the "educational level of the breeder" and "enterprise scale" increased, the BS score significantly went up. The regression model was found significant as a whole ($P < 0.01$) and the independent variables explained the variation in the technical and financial BS scores to be 14.6% and 12.7%, respectively. Dissemination of education/training practices and increasing enterprise scales will positively affect the level of BS in the sector.

Keywords: Biosecurity, breeder, disease, economic, livestock enterprises

1. Introduction

Biosecurity (BS) is a multidimensional preventive medicine approach that has health, technical, and financial aspects. In terms of animal health, BS can be defined as the "set of management practices" protecting the farm against new disease factors, and restricting or minimizing the spread of disease in the herd [1–5]. Planned and accurate implementation of BS provides serious benefits to animal health directly and to the animal food chain and public health indirectly. In addition, biosecurity can substantially mitigate financial losses associated with important infectious diseases that may possibly occur in the future. The gains in question are not only at the farm or regional levels, but sometimes they create positive externalities (benefits for the food industry, public health, foreign trade, animal welfare, etc.) at also the national and international levels. From this point of view, it is understood that biosecurity in livestock is not only a subject with technical limits but also a broad concept with financial and economic dimensions [6–9].

When the literature related to the field is reviewed, it is seen that the breeders around the world prefer various BS practices (vaccination, test, isolation, quarantine, disinfection and disinfestation of materials and barns, protection measures for visitors, cleaning and disinfection of vehicles, training, record keeping, etc.) which vary from country to country in different combinations for different animal types and breeding (poultry, pig, sheep, dairy and livestock farming, etc.) patterns [5,10–14].

It is stated that breeders are generally aware of the importance of BS practices but they do not implement them completely or they carry only a few of them into effect. "Cost," "time," and "ease of implementation" are undoubtedly the most important factors in the adoption of BS practices by livestock enterprises. However, the impact of other variables apart from these can also be mentioned. In the selection and frequency of BS practices, physical, geographical, epidemiological, socioeconomic, cultural characteristics, and legal regulations play a decisive role [9,13,15]. In addition, it can be stated that the traditional and social media elements broadcasting in the field of animal husbandry in the recent years have been influential on the breeder behaviours as much as the relevant ministries and professional organizations have. By considering the abovementioned facts, there is a need to predict which socioeconomic factors play roles on the

* Correspondence: mferitcan@yahoo.com

BS levels of different typesof livestock enterprises in any country.

Rational recommendations on holistic biosecurity approaches can only be accomplished after various stages are completed. One of the most important ways to make progress on BS at the enterprise and national levels is to know the current situation/score regarding BS and breeder behaviours. In this way, the general situation can be compared with other enterprises, regions, and countries. Subsequently, similarities and differences should be determined according to regions and enterprise types in terms of BS. In the last phase, rational regulations and precautions at the enterprise and/or national level(s) can be put into effect by predicting the factors affecting the BS level and preference.

In the literature review, there was no study addressing this issue with its technical and economic dimensions throughout Turkey. The purpose of the current study was to determine the difference in the BS scores belonging to livestock enterprises depending on the geographical regions and breeding types (I) and to predict the socioeconomic factors having an impact on the BS level (II). It is expected that results would be helpful for livestock stakeholders in decision-making procedures.

2. Materials and methods

2.1. Research area and sample size

The study was conducted between February 2015 and November 2017 in 18 provinces and 7 different regions of Turkey. The required data were collected by a face-to-face survey with different types of livestock enterprises. The minimum sample size was determined by the following formula [16].

$$n = \frac{N}{1 + N(e^2)}$$

In this formula, "n" indicates the sample size, "N" indicates the number of livestock enterprises reported as 1,838,970 for Turkey, and "e" indicates the accepted maximum error margin accepted as 5% [17]. The distribution of the enterprise number, calculated as 400 with the help of the formula, was made in proportion to the enterprise number that the regions have [18]. Considering that there might be inconsistent or incomplete answers, the study was completed with the participation of 519 livestock enterprises.

2.2. Questionnaire and cost categories

In the first part of the questionnaire, some technical, socioeconomic, and demographic information of the breeders and enterprises were questioned. The second part consisted of 21 questions about the frequencies and costs of biosecurity practices. In the selection of the questions, preliminary surveys and literature reports were used as a base.

In the study, the preference frequency of every practice (0: never, 1: sometimes, 2: often, 3: always) was questioned and the "technical BS scores" were obtained from the sum of the responses. "Financial BS scores" were created by multiplying the technical score and the cost category of each practice. In the cost classification of the practices, 1st and 3rd inter-quartile range values of the biosecurity expenses per livestock unit (LU) were used. While coding the cost category of each practice, the low-cost practices lower than the 1st quartile value were accepted as "3," the medium-cost practices between the 1st and 3rd quartiles were accepted as "2," and the high-cost practices higher than the 3rd quartile value were accepted as "1." In other words, the low-cost practices were represented with a higher score in the data set [5,10–12]. In addition, the number of animals of different species, breeds, and ages in the enterprise was converted into LU which is a standard unit [19,20]. In this way, the cost of the BS practices per animal and the enterprise sizes were more accurately determined and compared.

2.3. Hypothesis

In this study, the researchers tested 7 different hypotheses given below by considering the literature reviews and the observations in the field:

H_1: There are significant differences between BS scores according to different breeding types.

H_2: There are significant differences between BS scores according to different geographical regions.

H_3: The level of education has a positive effect on BS scores and explains the model significantly.

H_4: Income level has a positive effect on BS scores and explains the model significantly.

H_5: LU in the enterprise has a positive effect on BS scores and explains the model significantly.

H_6: The age of the breeder has a positive effect on BS scores and explains the model significantly.

H_7: The professional experience of the breeder has a positive effect on BS scores and explains the model significantly.

2.4. Data editing, statistical analyses and regression model

The geographical regions close to each other were unified and analysed by grouping: north (I), south (II), central (III), east (IV), and west (V). Enterprise/breeding types were classified and compared as follows: only sheep breeding (I), sheep and goat breeding together (II), sheep, goat, and bovine breeding together (III), only beef cattle fattening (IV), only dairy cattle breeding (V), and beef cattle fattening and dairy cattle breeding together (VI).

In the selection of parametric or nonparametric test, data type, and its attribute, scatter diagrams and normality tests were taken into consideration. The Kolmogorov-Smirnov and Shapiro-Wilk tests were used to evaluate if

data were normally distributed. After one-way ANOVA analysis, the Games-Howell post hoc test was used to identify which group means differed, as Levene's test for equality of variances indicated unequal variances. The differences at the level of $P < 0.05$ were accepted as significant in the comparison of the subgroups and determination of the relationships between the variables. Data were initially entered and managed in Microsoft Excel 2013. All statistical analyses were performed with IBM SPSS Statistics for Windows, Version 23.0.

With the established multiple linear regression model (MLRM), the effects of the candidate independent variables on the technical and financial BS scores were analysed using the least squares method. The independent candidate variables in the model were (I) education (dummy variable, primary school, and lower were coded as 0 while high school and upper were coded as 1), (II) income, (III) LU, (IV) age, and (V) professional experience. The dependent variables in the model were technical and financial BS scores. While the linear relationship between the dependent and independent variables was examined with scatter diagrams, the presence of the autocorrelation and multiple linear correlation was tested with Durbin-Watson and variance inflation factors (VIF) respectively. The logarithmic transformation (log10) was performed to reduce the negative effect of the income-related surplus values on the model and bring the distribution closer to normal. Goodness of fit was evaluated by adjusted r-square which was used to calculate the proportion of variation in the dependent variable.

MLRM is generally formulated as follows: $Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \ldots \beta kXk + Ɛ$.

Here, Y is the dependent variable, X is the independent i.e. determining variable, k is the independent variable number, β_0 is the fixed coefficient, β is the successive variable coefficient, and Ɛ is the chance error term [21,22]. As a result, the final variables in the models for the technical and financial BS Scores are as follows:

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 \log 10 X_2 + \beta_3 X_3.$$

Here, "Y" is the technical or financial "BS" score, X_1 is the "LU i.e. herd size," X_2 is the "income level of the breeder," and X_3 is the "educational level of the breeder."

3. Results

As a result of the research, it was determined that the obtained findings verified the H_1, H_2, H_3, H_4, and H_5 hypotheses, but did not support the H_6 and H_7 hypotheses. The BS scores and regression model results of the biosecurity practices according to their frequencies, cost categories, enterprise type, and geographical regions for Turkey have been summarized in Tables 1–4.

The average score and cost category for each of 21 different BS practices are shown in Table 1. The most striking situation in the table is that although the BS practices numbered 1 and 4 are included in the lowest cost category, they were not preferred. In addition to that, interestingly only two biosecurity practices have a technical median score of 3.

When Table 2 is considered, it is seen that the score obtained for all enterprises (26.20) corresponds to 42% of the maximum possible score of 63 points that can be obtained if each of the BS application gets 3 point. The lowest and highest scores belonged to "sheep breeding enterprises (type 1)" and "beef cattle fattening and dairy cattle breeding enterprises (type 6)," respectively. The results of the variance analysis show that there are significant differences among the technical scores (F:7.671 and $P < 0.01$) and among the financial scores (F:19.898 and $P < 0.01$) according to the enterprise types (see Table 2). Multiple comparisons (post hoc tests) reveal that the scores for enterprise types 1, 4, and 5 are significantly lower than the score for enterprise type numbered "6" ($P < 0.01$). The findings obtained to verify the H_1 hypothesis claim the difference among the enterprise types.

It is understood from Table 2 that the western and southern regions of Turkey are clearly separate from other regions. There are significant differences among the technical scores (F:28.361 and $P < 0.01$) and financial scores (F: 51.799 and $P < 0.01$) according to the geographical regions. Multiple comparisons for the technical scores reveal that there are significant differences between the "north" and "central," "north" and "south," and "north" and "west" as well as between the "south" and all other regions. Multiple comparisons for the financial scores show that there are significant differences between the "south" and "west" with all regions ($P < 0.01$). The findings obtained to verify the H_2 hypothesis claim the difference between the regions.

When Table 3 is analysed, it is seen that there are significant relationships between the characteristics of the breeder except for age and the BS scores. The "educational level," "income," and "enterprise scale" of the breeder increase in parallel with the BS scores positively and significantly. There is a negative relationship between the experience and BS scores.

When Table 4 is considered, it is seen that the created model is significant as a whole and the independent variables included in the model have a positive effect on the BS score. Tolerance and VIF values show that there are no autocorrelation and multiple linear correlations in the model. Education, income, and LU are significant predictors of the BS scores both in the technical and financial aspects. A small value of adjusted R square indicated that only a small proportion of variance in the dependent variable was explained. The independent variables in the model reveal the variation in the technical and financial BS scoresto be 14.6% and 12.7%, respectively. The increase in the

Table 1. Biosecurity (BS) frequencies, scores, and cost categories for Turkish livestock enterprises.

No	Biosecurity practices	Technical score (median)[a]	Cost category[b]
1	I attend the training on biosecurity practices.	0	3
2	I keep a regular record of the sick animals.	1	3
3	I allow only the obligatory visitors to enter the enterprise.	1	3
4	I give protective clothing to visitors.	0	3
5	I meet all the breeding needs from my own enterprise.	2	1
6	I get the health checks of newly purchased animals done in the first place.	1	2
7	I disinfect the vehicles entering my enterprise.	1	3
8	I observe the newlypurchased animals in a separate section for at least one week.	0	1
9	I conduct laboratory tests on the animals I buy in terms of the infectious and important diseases.	0	2
10	I regularly vaccinate animals against common diseases.	2	2
11	I graze my animals independently from other herds.	1	1
12	I keep my distance to the nearest farm over 2 km.	0	1
13	I regularly follow the procedures against pests like insects and mice.	2	3
14	I regularly clean and disinfect my barn.	2	1
15	I regularly perform liming in my barn.	2	3
16	I use supplements (vitamins, minerals, and feed additives).	2	2
17	I keep the animals showing disease symptoms in a separate section.	2	1
18	I put the animals showing disease symptoms into an examination and treatment process.	3	2
19	I dispose the animals that do not give a response to the treatment.	2	2
20	I am careful not to exchange tools/equipment with other enterprises unless I have to.	1	2
21	I use different clothing and boots when I enter my barn.	3	2

[a]0: Never, 1: Sometimes, 2: Often, 3: Always.
[b]3: Low-cost practice, 2: Medium-level cost practice, 1: High-cost practice.

educational level, income, and enterprise scale/LU makes significant contributions to the BS scores. The findings in Table 4 verify the H_3, H_4, and H_5 hypotheses but they do not support the H_6 and H_7 hypotheses.

4. Discussion

This study draws a general framework regarding the attitudes and behaviours of the cattle and sheep breeders in Turkey on 21 different BS practices. Detecting the similarities and differences between the BS levels of the livestock enterprises located in different geographies and having different breeding types provided an integrated approach to the topic. Subsequently, the hypothesis was analysed in more details and the variables having a significant impact on the BS scores were attempted to be predicted.

Although the average BS scores obtained for the enterprises and Turkey are not very low, they are below the scores that developed countries have [23,24]. However, it is known that even developed countries have some important problems regarding BS at the farm level [13,25,26]. The role of breeders in the present level of BS in Turkey is undoubtedly important. However, breeders cannot be held responsible for the failure entirely. The policy and equipment deficiencies of the professional organizations and related public institutions regarding the struggle against animal diseases, in addition to the epidemiological risks and problems carried by the geography of the country (conflicts and political instability in neighbouring countries such as Iraq and Syria), also have an impact on the current result. Furthermore, it should be taken into account that the high input costs and fluctuations in the product prices negatively affect the Turkish livestock sector and incomes of the breeders, and this situation can push the concepts of quality and hygiene into the background. Because, it can be said that quality and hygiene generally depend on income which is slightly more important than other factors [5,27–31].

One of the most striking points in the study is the truth that the precautions included in the low-cost category

Table 2. BS scores for the different geographical regions and different types of enterprises in Turkey.

Classified Regions and Enterprises		N	%	Technical score [a] (X ± SD)	Financial score [b] (X ± SD)
A. Livestock enterprise types	I. Only sheep breeding	42	8.12	24.00 ± 7.27	46.50 ± 14.22
	II. Sheep and goat breeding	32	6.19	26.38 ± 7.65	52.41 ± 15.72
	III. Sheep, goat, and bovine breeding	52	10.06	25.49 ± 9.06	50.75 ± 18.88
	IV. Only beef cattle fattening	45	8.70	25.09 ± 6.83	54.02 ± 19.25
	V. Only dairy cattle breeding	195	37.72	24.44 ± 8.71	52.92 ± 23.05
	VI. Beef fattening and dairy breeding	151	29.21	29.64 ± 8.29	73.20 ± 25.70
	F value and significance level			F: 7.671 and P < 0.01	F: 19.898 and P < 0.01
B. Classified regions	I. North (Black Sea)	73	14.12	23.85 ± 5.44	48.78 ± 11.62
	II. South (Mediterranean)	73	14.12	18.32 ± 6.52	36.19 ± 13.36
	III. Central (Central Anatolia)	104	20.12	27.77 ± 8.23	55.91 ± 16.31
	IV. East (Eastern and Southeastern)	67	12.96	27.25 ± 8.60	54.20 ± 16.56
	V. West (Marmara and Aegean)	200	38.68	29.03 ± 8.38	73.27 ± 27.57
	F value and significance level			F: 28.361 and P < 0.01	F: 51.799 and P < 0.01
	Countrywide	517	100	26.20 ± 8.58	58.17 ± 24.24

[a] It was obtained by the summing up the practice frequencies of 21 BS items.
[b] It was obtained by multiplying the technical score and cost category.

Table 3. The relationships between the BS scores and socioeconomic features of the breeders.

Socioeconomic features	Technical BS score		Financial BS score	
	Coefficient	P-value	Coefficient	P-value
Age of the breeder	-0.014	P > 0.05	0.010	P > 0.05
Years of occupational experience	0.114	P < 0.05	-0.107	P < 0.05
Educational level	0.320	P < 0.01	0.359	P < 0.01
Income level	0.264	P < 0.01	0.251	P < 0.01
Employee number	–0.096	P < 0.05	–0.165	P < 0.01
Enterprise scale (LU)	0.347	P < 0.01	0.336	P < 0.01

such as "receiving training on biosecurity" and "giving protective clothing to the visitors" are not preferred by the breeders at all. The reason why these options are not preferred despite the cost and practice conveniences may be that they are not well understood or adequately explained. In addition, breeders are generally convinced by observing familiar enterprises instead of learning about them through reading and listening [9]. Therefore, model breeders should be invited to the trainings implemented for the spread of these practices throughout the country. In addition, with the financial support to be provided by the public, it can be ensured that breeders are directed to low-cost and easy BS practices.

The findings revealed that practices such as "vaccination," "cleaning and disinfection of barns," and "treatment process of the sick animals" are frequently or always preferred, which coincides with previous studies [5,23,26]. Offering positive results in the short term is among the most important factors for the preference of these practices at a high rate. At this point, it will be useful to point out a reality observed in the field. In practice, some of the frequently-preferred practices such as vaccination, disinfection, and treatment are not duly performed all the time. It can even be said that the number of enterprises applying these practices accurately is low [5,11,28,29].

Observing significant differences among the livestock enterprises of different types in terms of BS scores is an expected result of our study. However, it is surprising that the scores of the enterprises specialized in standardized breeding are lower than the enterprises in a composite/

Table 4. Model results for the technical (model-1) and financial (model-2) BS scores.

Models	B	Adj.R^2	F	Sig F	β	P	Durbin-Watson	Tolerance	VIF
Model-1		0.146	19.771	0.000			1.179		
Constant	5.466								
Education	2.501				0.124	0.019		0.941	1.063
Income	3.840				0.156	0.005		0.842	1.188
LU	0.154				0.260	0.000		0.873	1.146
Model-2		0.127	16.979	0.000			1.145		
Constant	11.813								
Education	4.592				0.111	0.038		0.941	1.063
Income	7.666				0.242	0.007		0.841	1.188
LU	0.294				0.151	0.000		0.873	1.145

mixed structure. Although the enterprises are carefully categorized during the study, especially "only dairy cattle breeding" and "cattle fattening and dairy cattle breeding" enterprises can be confused in Turkey's conditions. One of the reasons is that the enterprises engaged in dairy cattle breeding do not sell out the male calves especially during the seasons when the meat prices are high but breed them or sell them as sacrificial animals (related to the sacrificial ritual of the Muslims performed once a year). Another reason is that the enterprise types can be entered incorrectly in the national databases and enterprise records. Beside this, it should be noted that the face-to-face survey sometimes have to be carried out in outside of the livestock enterprises.

One of the important points in the study is the geographical similarities and differences. While the central, eastern, and northern regions of the country have similar scores in terms of BS, the western and southern regions of the country differ from the other regions significantly. Although it is known that the eastern part of the country is at a lower status than the other regions in terms of socioeconomic and cultural aspects, it is surprising to see that the lowest score belongs to the Mediterranean region. The main reasons why the Mediterranean region got the lowest score could be the facts that tourism and greenhouse farming are more predominant than livestock breeding. Beside this, nomadic animal husbandry and intense refugee movements also may have contributed to this situation.The regions categorized as the west have the highest score by far, and this is an expected result due to the high level of education and occupational organization and the proximity of the enterprises located in these regions to the big cities and markets.

The findings revealed that there is a relationship between the increase in the "income," "enterprise scale," and "education" levels of enterprises and their BS scores,which coincides with certain studies [5,6,8,32]. There are also studies showing that the findings partially coincide or do not coincide at all [13,14].The findings obtained from this study reveal that a breeder with increased knowledge and financial opportunities behaves more carefully and sensitively about preventive medicine. The negative significant relationship between the BS practices and "years of experience" can be explained by the lower level of education of the elderly breeders and their positive attitude towards traditional methods. As it known, breeders' economic choices can also be affected by psychological, social, and emotional factors. For this reason, behavioural economics plays an important role in their decision-making processes [5].

When the variables effective on BS scores are considered as a model, it is observed that education, income, and enterprise scale/LU explain only a small part of the variance on the score of biosecurity (~14%). The beta coefficients prove that education and income have the strong positive effect on BS score. The results are partially coherent with some of the previous studies that they report significant effect of the farmers' age, knowledge and education level, and enterprise scale (farm-size) on the model [13,33]. In this study, the relatively low adjusted R square value indicates that many other influential factors, likely to exist, are missing from the model and these variables may be effective on the scores. Therefore, in further studies to be conducted on the subject, it would be useful to include more socioeconomic, epidemiological, geographical, climatic, and cultural variables that are directly or indirectly related to the enterprise or breeder. This approach may provide a more explanatory model on the BS level. Although low R square value can be simply attributed to the above-mentioned factors, we think that

the method of data collection used in our study could also be responsible for it. In other words, questionnaires alone may not provide sufficient or reliable information to decision-makers. Therefore, the researchers,having a checklist about BS measures, should personally note down BS practices in detail by visiting the enterprises rather than collecting data through questionnaire as much as possible. This approach may put forward time and cost-related disadvantages, but it will make positive contributions to the reliability of the results and the explanatory power of the model.

It is observed that when breeders prefer a practice or its frequency, they focus on the "convenience," "cost," and "time" concepts. In fact, these concepts provide the answer to the question of "whether a BS practice is worth implementing". Many researchers emphasize that the investment made on a BS plan appropriate for the needs and realities of an enterprise or region leads to significant economic and/or financial gains. The right action to take at this point is to calculate whether a BS practice offers higher benefits than costs to the enterprise. While doing so, it is important to take into consideration some points. For example, making a decision by looking at the total result of a common plan consisting of a few BS practices may be misleading. The reason for this is the risk of including a practice whose cost is higher than its benefit in the plan by not noticing it. The best way to prevent this risk is to make a separate "cost-benefit analysis" for each practice. If the analysis exceeds the enterprise scale and gains a sectoral or national qualification, many variables such as the potential environmental and economic impacts, foreign trade, and consumer welfare should be added to the model [9,27,34].

Considering the current situation in the country along with the global obligations, standards, and recommendations established by international organizations (especially World Trade Organization-WTO and World Organisation for Animal Health-OIE), regionalization, zoning, and compartmentalization should be examined more carefully by the government [35]. For example, geographical location and animal movements in Turkey indicate that Thrace and the Eastern Black Sea regions are more isolated than others. There are also socioeconomic and cultural differences between the regions. This may bring some advantages to the regions, and, of course, requires a different national biosecurity plan. Except for a few studies carried out in different cities of Turkey, official reports and statistics can give us some information and insights about the entire picture. In Turkey, there are nearly 1.8 million livestock enterprises, most of which are small family-type enterprises and have a mixed-crop livestock production. Almost 18% of the population is employed in agriculture and a steady decline has been observed in this rate. When it comes to animal health politics, some health-related measures, such as vaccinations against most common diseases, financial support for enterprises free of contagious diseases, and animal disease compensation payments, have been implemented by veterinary authorities for many years in Turkey. However, some important diseases including FMD and brucellosis, which can cause trade restriction, have not yet decreased to the desired incidence values [17,28,29]. Due to the fact that the abovementioned factors have a direct or indirect influence on biosecurity issues, it can be said that the increasing farm size and specialization and declining share of the population employed in agriculture will positively affect the BS levels in Turkey.

It is not sufficient to only know the technical, managerial, and financial capacities of enterprises, public authorities, or professional organizations before initiating the preparation process of BS plans regarding farm animals. In addition to these, the current and future status of the socioeconomic, demographical, epidemiological, geographical, and climatic conditions should also be foreseen. In this way, an integrated approach will significantly increase the chance of success of BS plans. Also the collaboration among stakeholders, such as policy-makers, breeding organizations, industry representatives, researchers, and veterinarians, is crucial for obtaining good results from the national BS programs. The improvement in the BS status of Turkey, which acts as a bridge and barrier between Asia and Europe, will not only increase the breeder profitability and productivity but also make positive contributions to the international animal and public health standards and trade.

In conclusion, the current study provided clues to the decision-makers regarding how to improve the BS level of the livestock sector in Turkey. The findings of the study reveal that an improvement that will be achieved in the education, income, and enterprise scales will increase the BS scores/levels of livestock enterprises. At this point, the training activities to be organized by professional organizations, universities, and the relevant ministry will be useful. In addition, bringing the model enterprises forward and arranging livestock support by taking into account the BS status of enterprises can make significant contributions to the sector. As the rational and strategic implementation of the BS plans will also lead to improvements in animal health and public health, it will reduce financial losses at the farm and national level.

Acknowledgment
Many thanks to Turkish livestock producers who allowed us to collect data on their farms.

References

1. Cox B. Biosecurity-the economics and benefits-are we fooling ourselves? In: Poultry Service Industry Workshop; Alberta, VA, USA; 2005. Pp. 33-43.
2. Gunn GJ, Heffernan C, Hall M, McLeod A, Hovi M. Measuring and comparing constraints to improved biosecurity amongst GB farmers, veterinarians and the auxiliary industries. Preventive Veterinary Medicine 2008; 84: 310-323.
3. Moore DA, Merryman ML, Hartman ML, Klingborg DJ. Comparison of published recommendations regarding biosecurity practices for various production animal species and classes. Journal of the American Veterinary Medical Association 2008; 233: 249-256.
4. Fasina FO, Lazarus DD, Spencer BT, Makinde AA, Bastos ADS. Cost implications of African Swine Fever in smallholder farrow-to-finish units: economic benefits of disease prevention through biosecurity. Transboundary and Emerging Diseases 2012; 59: 244-255.
5. Can MF, Altuğ N. Socioeconomic implications of biosecurity practices in small-scale dairyfarms. Veterinary Quarterly 2014; 34: 67-73.
6. Fraser RW, Williams NT, Powell LF, Cook AJC. Reducing campylobacter and salmonella infection: two studies of the economic cost and attitude to adoption of on-farm biosecurity measures. Zoonoses and Public Health 2010; 57: 109-115.
7. Jia B, Hilaire SS, Singh K, Gardner IA. Biosecurity knowledge, attitudes and practices of farmers culturing yellow catfish (*Pelteobagrusfulvidraco*) in Guangdong and Zhejiang provinces, China. Aquaculture 2017; 471: 146-156.
8. Pinior B, Firth CL, Richter V, Lebl K, Trauffler M et al. A systematic review of financial and economic assessments of bovine viral diarrhea virus (BVDV) prevention and mitigation activities worldwide. Preventive Veterinary Medicine 2017;137: 77-92.
9. Can MF. Farm level biosecurity: Challenges and suggestions. Dairy andVeterinary Science 2018; 7: 1-3.
10. Pinto CJ, Urcelay VS. Biosecurity practices on intensive pig production systems in Chile. Preventive Veterinary Medicine 2003; 59: 139-145.
11. Nöremark M, Frössling J, Lewerin S. Application of routines that contribute to on-farm biosecurity as reported by Swedish livestock farmers. Transboundary and Emerging Diseases 2010; 57: 225-236.
12. Brennan ML, Christley RM. Biosecurity on cattle farms: a study in North-West England. PLoS One 2012; 7: e28139.
13. Toma L, Stott AW, Heffernan C, Ringrose S, Gunn GJ. Determinants of biosecurity behaviour of British cattle and sheep farmers-a behavioural economics analysis. Preventive Veterinary Medicine 2013; 108: 321-333.
14. Kouam MK, Moussala JO. Assessment of factors influencing the implementation of biosecurity measures on pig farms in the western highlands of Cameroon (Central Africa). Veterinary Medicine International 2018; 2018: 1-9.
15. Vaillancourt JP, Carver DK. Biosecurity: perception is not reality. Poultry Digest 1998; 57:28-36.
16. Israel, GD. Determining sample size. Fact Sheet PEOD-6, Institute of Food and Agricultural Sciences, University of Florida. Florida, US: University of Florida; 1992.
17. Turkey Ministry of Agriculture and Forestry General Directorate of Food and Control. Number of Enterprises, Technical Report. Ankara, Turkey: Turkey Ministry of Agriculture and Forestry; 2019 (in Turkish).
18. Turkey Statistical Institution. Animal production statistics: thematic map of cattle distribution by provinces. Publication number of 24656. Ankara, Turkey: Turkey Statistical Institution; 2018 (in Turkish).
19. Çetin B. Agricultural Economics. 1st ed. Bursa, Turkey: Dora Publications; 2010 (in Turkish).
20. Li Q, Amjath-Babu TS, Zander P. Role of capitals and capabilities in ensuring economicresilience of land conservation efforts: A case study of the grain for green project in China's Loess Hills. Ecological Indicators 2016; 71: 636-644.
21. Agha SR, Alnahhal MJ. Neural network and multiple linear regression to predict school children dimensions for ergonomic school furniture design. Applied Ergonomics 2012; 43: 979-984.
22. Arı A, Önder H. Regression models used for different data structures. Anadolu Tarım Bilimleri Dergisi 2013; 28, 168-174 (in Turkish with an abstract in English).
23. Casal J, Manuel AD, Mateu E, Martin M. Biosecurity measures on swine farms in Spain: perceptions by farmers and their relationship to current on-farm measures. Preventive Veterinary Medicine 2007; 82: 138-150.
24. Backhans A, Sjölund M, Lindberg A, Emanuelson U. Biosecurity level and health management practices in 60 Swedish farrow-to-finish herds. Acta VeterinariaScandinavica 2015; 57: 14.
25. Sarrazin S, Cay AB, Laureynz J, Dewulf J. A survey on biosecurity and management practices in selected Belgian cattle farms. Preventive Veterinary Medicine 2014; 117: 129-139.
26. United States Department of Agriculture. Animal and plant health inspection service. NAHMS dairy 2002, part III: reference of dairy cattle health and health management practices in the United States. Fort Collins, US: USDA; 2002.
27. Can MF, Yalçın C. The Cost-benefit analysis of alternative brucellosis control strategies in Turkey. Kafkas Üniversitesi Veteriner Fakültesi Dergisi 2014; 20: 103-109.
28. Turkey Ministry of Agriculture and Forestry. Annual Report. Ankara, Turkey: Turkey Ministry of Agriculture and Forestry; 2018 (in Turkish).
29. World Organization of Animal Health. OIE fact sheets, official disease status. Paris, France: World Organization of Animal Health; 2019.

30. Can MF. The interaction of Turkey livestock policies with the EU and its potential outcomes. Atatürk Üniversitesi Veteriner Bilimleri Dergisi 2018; 13: 242-250 (inTurkish with an abstract in English).

31. Petersen E, Baekeland S, Memish ZA, Leblebicioglu H. Infectious disease risk from the Syrian conflict. International Journal of Infectious Diseases 2013; 17: e666-e667.

32. Can MF, Ataseven V, Yalçın C. Estimation of production and reproductive performance losses in dairy cattle due to bovine herpesvirus 1 (BoHV-1) infection. Veterinarski Arhiv2016;86: 499-513.

33. Sayers RG, Sayers GP, MeeJF, Good M, BerminghamML, GrantJ, Dillon PG. Implementing biosecurity measures on dairy farms in Ireland. The Veterinary Journal 2013; 197: 259-267.

34. Rushton J. The economics of animal health and production. 1st ed. Oxfordshire, UK: CAB International; 2009.

35. Thiermann AE. Globalization, international trade and animal health: the new roles of OIE. Preventive Veterinary Medicine 2005; 67: 101-108.