

*Original Scientific Article***EVALUATING BIOSECURITY ON SELECTED COMMERCIAL PIG FARMS IN SERBIA**

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**ABSTRACT**

Biosecurity measures, coupled with effective on-farm management, encompass all aspects aimed at preventing the entry of pathogens into pig farms and their subsequent spread within the facility. This study assessed biosecurity practices on commercial pig farms in Serbia by surveying farm veterinarians/managers. To evaluate biosecurity on these farms, a Biocheck online survey (<https://biocheckgent.com>) was conducted across ten commercial pig farms in Northern Serbia, where the highest concentration of industrial pig production occurs. The average overall biosecurity score was  $65.56 \pm 11.65$ . External biosecurity scored higher ( $75.56 \pm 9.39$ ), whereas internal biosecurity scored lower ( $54.89 \pm 16.92$ ). Within external biosecurity, the weakest scores were observed in categories such as feed, water, and equipment supply ( $47 \pm 25.48$ ), showing considerable variation among farms, particularly in feed, water, equipment supply ( $54.22$ ), and farm location ( $57.65$ ). Regarding internal biosecurity, the lowest scores were noted during the farrowing and suckling period ( $37.22 \pm 15.08$ ) and the finishing unit ( $37.66 \pm 24.12$ ). This study reveals that biosecurity measures in commercial pig farms in Serbia are slightly below the global average. Given the predominance of extensive production systems in Serbia, urgent improvements in biosecurity practices on industrial farms are essential. Identification and implementation of appropriate biosecurity measures tailored to existing animal production systems are urgently needed.

**Key words:** biosecurity, assessment, pig, commercial (industrial) farms, Serbia

**INTRODUCTION**

Biosecurity has evolved into a key component of livestock production, notably in intensive pig industrial systems. The recognition of the significance of animal health and its correlation with biosecurity has surged in recent years, spurred by the emergence and re-emergence of numerous challenging-to-control diseases (1). Biosecurity is a basic measure aimed at preventing the spread of infectious diseases within the farm itself or between

farms (2). Moreover, they are regarded as the pivotal factors in lower disease incidence, higher productivity, and reduced use of antimicrobials (3, 4). Different infectious diseases in pigs such as porcine reproductive and respiratory syndrome and porcine epidemic diarrhea can be easily transmitted due to insufficient implementation of biosecurity measures (5). Keeping in mind that African swine fever (ASF) represents an increasing challenge, not only for developing countries (6) but also for European Union member countries (7), biosecurity should be set as a priority goal. In this way, potential economic damages might be significantly minimized. However, their implementation requires awareness campaigns, constant training of workers, but also investing significant efforts and financial resources (8).

For reaching improved production results, it is imperative to achieve lower risk of disease spread and lower antibiotic use (5, 9, 10, 11).

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Biosecurity assessment can be a useful tool for analyzing the current state on the farm (11). Today, there are various online tools for biosecurity assessment. One of the most commonly used is Biocheck. UGent™ risk-based scoring tool, which is available online and has been used previously to quantitatively and objectively assess the level of biosecurity in pig herds (12, 13) and broiler farms (14). Biosecurity measures and farm practices have to be periodically reviewed and improved.

Currently, Serbia has no national regulation on the application of biosecurity measures (15). Biosecurity is a part of various laws, regulations, and annual animal health protection measure programs. For example, in the latest Government Instruction for ASF, it is stated that commercial and family farms need to have officially written and implemented biosecurity plans for their production (15). For these reasons, some measures are mandatory by law and some are not. Typically, each segment of the pig industry in Serbia prescribes its biosecurity protocols and establishes its standards (16).

Pig production in Serbia plays a crucial role in animal husbandry (17), boasting the highest pig density among all Balkan countries, with a total population of 2.7 million pigs (18). Despite fluctuations over time, the estimated pig numbers are currently on a steady decline (19). In 2022, the total pig count was by 11.9% lower compared to the ten-year average from 2012 to 2021 (20).

About 44% of the pig population is raised on industrial-type commercial farms (15). The rest are kept in different production systems, such as backyard, free-range, and semi-free-range with very low biosecurity measures (15). Following the legislation, all farms in Serbia are divided into five categories: commercial pig farms (industrial pig production, officially recognized with a high level of biosecurity); family farms of type A (farms with more than 10 animals and high level of biosecurity measures implemented); family farm of type B (farm with more than 10 animals but insufficient, low level of biosecurity); and backyards, usually with few animals/pigs (less than 10) reared and kept mainly for self-consumption, with a low or total absence of any biosecurity measures (15). Free-range and semi-free-range rearing systems have no biosecurity measures. Backyard pig producers and smallholding farmers in Serbia have little information and knowledge in biosecurity which favors the spread of the ASF virus. In the currently prevailing smallholder and backyard farming systems, farm biosecurity is largely nonexistent (19).

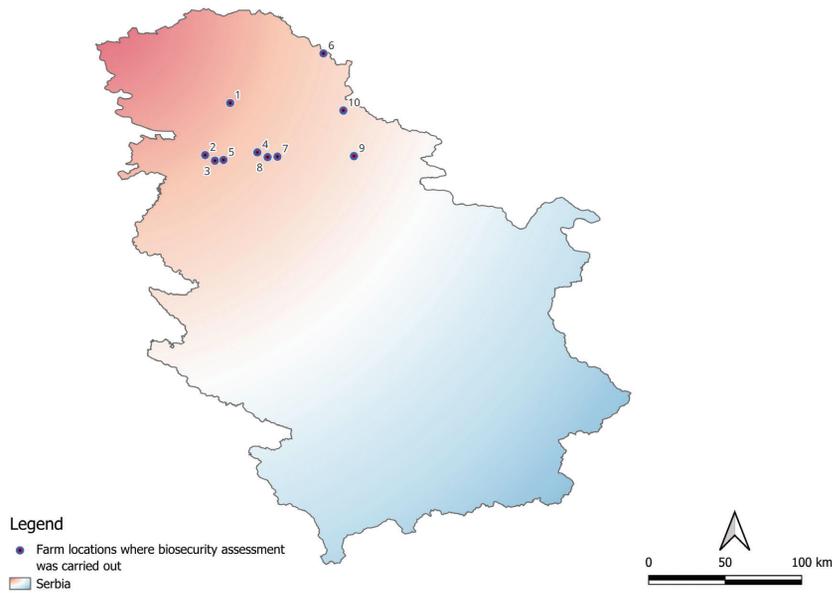
Pig producers in Serbia primarily prioritize curative health management through medication or

vaccination, often neglecting preventive measures and management. This approach leaves commercial pig farms vulnerable to disease outbreaks, impacting both animal health and economic sustainability. Previous assessments have indicated a concerning lack of biosecurity measures in backyard holdings (21), highlighting the need for comprehensive evaluation and enhancement of biosecurity practices across all types of pig production systems in Serbia. The current study hypothesized that the average biosecurity scores in Serbia are lower relative to those in more developed countries due to variations in resources, management practices, and biosecurity standards. The level of biosecurity in pig farms in Serbia has been scarcely assessed or remains largely unexplored. Given the limited scientific data available on biosecurity measures, specifically in commercial pig farms in Serbia, this study aimed to fill this gap by identifying current deficiencies, proposing improvements, and ultimately promoting more effective disease prevention strategies within the industry.

## MATERIAL AND METHODS

To assess biosecurity in commercial (industrial) farms, the risk-based Biocheck. UGent survey (<http://www.biocheck.ugent.be/>) was conducted in the ten commercial pig farms located in the Northern part of Serbia where industrial pig production is mostly localized and the highest density of pig production may be found. The Vojvodina province in north of Serbia was selected for conducting the current study because it has the densest pig population according to the Statistical Office of the Republic of Serbia (22) (Fig. 1).

The survey was conducted between January and March 2023. The participating farmers were briefed on the study's goals and procedures before filling the questionnaire. Each farmer provided written informed consent for data collection, sharing, and publication. The study adhered to animal welfare guidelines as stipulated by the Law on Protection of Animal Welfare from the Ministry of Agriculture and Environmental Protection of the Republic of Serbia and Directive 2010/63/EU. No ethical approval from the Ministry's Ethical Committee was necessary. Data were gathered from 10 farrow-to-finish commercial pig farms, labeled Farms 1 through 10 (see Fig. 1). Each farm had between 550 and 2200 sows on average, and the participating farms had been in operation for an average of 18 years.



**Figure 1.** Farm locations where biosecurity assessment was carried out

Assessment of biosecurity measures was carried out using the questionnaire Biocheck.UGent survey. The checklists for the indoor pigs comprised 109 questions divided into 12 categories. External and internal biosecurity was assessed within 12 categories: purchase of breeding pigs, piglets, and semen; transport of animals, removal of carcasses and manure; feed, water, and equipment supply; visitors and farmworkers; vermin and bird control; location of the farm; disease management; farrowing and suckling period; nursery unit; finishing unit; measures between compartments, working lines and use of equipment; cleaning and disinfection. The interviewee was usually a veterinarian or farm manager.

Each category was evaluated on a scale from 0 (indicating no biosecurity measures on the farm) to 100 (reflecting full implementation of biosecurity measures). Overall biosecurity was determined by averaging scores from external and internal biosecurity assessments. For this investigation, mean scores across biosecurity categories were presented, and computed from final scores obtained for each farm.

Differences between biosecurity scores of Farms 1 to 10 and global scores (WS) sourced from the Biocheck.UGent online survey database was analyzed using independent samples t-tests for overall, external, and internal biosecurity scores across the 12 categories. Statistical significance

was set at an alpha level of 0.05. Data analysis was conducted using Graph Pad Prism v 9.4.1 software.

## RESULTS

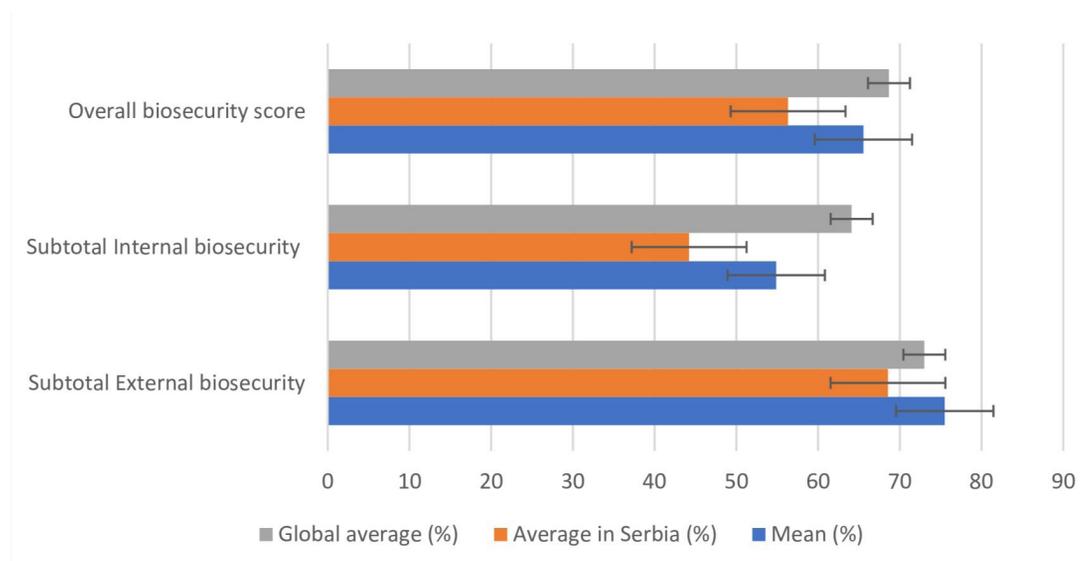
The results of the biosecurity assessment are presented in Table 1. The average overall biosecurity score was  $65.56 \pm 11.65$  (Fig. 2).

External biosecurity scores averaged  $75.56 \pm 9.39$ , while internal biosecurity scores averaged  $54.89 \pm 16.92$ . The variation in total external biosecurity scores among the participating farms was within an acceptable range (CV external=12.43%), whereas internal biosecurity scores exhibited greater variability (CV internal=30.83%). Scores for different categories varied across farms. For external biosecurity, the lowest scores were recorded for feed, water, and equipment supply, with an average of  $47.00 \pm 25.48$ . Notable variations were observed in certain external biosecurity categories, such as feed, water, and equipment supply (54.22) and farm location (57.65). In terms of internal biosecurity, the farrowing and suckling period had the lowest average score ( $37.22 \pm 15.08$ ), closely followed by the finishing unit ( $37.66 \pm 24.12$ ). High variation was also noted within internal biosecurity categories, including disease management (47.42), the farrowing and suckling period (40.52), and the finishing unit (64.05).

**Table 1.** The biosecurity scores in ten pig farms for the various categories of internal and external biosecurity

External biosecurity	WS <sup>1</sup>	Mean	SD	Median	Min	Max	CV (%)	<i>p</i> -value
<b>Purchase of breeding pigs, piglets, and semen</b>	89.00	90.00	9.55	92	70	100	10.61	0.78230
<b>Transport of animals, removal of carcasses and manure</b>	75.55	71.66	16.45	72	43	95	22.85	0.53720
<b>Feed, water, and equipment supply</b>	49.33	47.00	25.48	40	17	100	54.22	0.79900
<b>Visitors and farm workers</b>	71.33	90.11	9.57	94	71	100	10.62	0.00010
<b>Vermin and bird control</b>	73.44	78.89	19.69	90	30	100	24.96	0.46380
<b>Location of farm</b>	65.11	64.44	37.15	80	10	100	57.65	0.96020
<b>External biosecurity score</b>	73.00	75.56	9.39	77	59	90	12.43	0.47040
<b>Internal biosecurity</b>								
<b>Disease management</b>	72.11	57.78	27.40	60	20	100	47.42	0.16610
<b>Farrowing and suckling period</b>	59.44	37.22	15.08	43	14	64	40.52	0.00070
<b>Nursery unit</b>	67.22	57.00	27.19	50	21	100	47.70	0.30470
<b>Finishing unit</b>	73.88	37.66	24.12	36	7	100	64.05	0.00080
<b>Measures between compartments, working lines, and use of equipment</b>	53.00	61.22	15.37	57	43	93	25.11	0.16570
<b>Cleaning and disinfection</b>	67.66	62.56	18.86	60	30	88	30.14	0.48860
<b>Internal biosecurity score</b>	64.11	54.89	16.92	46	36	84	30.83	0.16180
<b>Overall biosecurity score</b>	68.67	65.56	11.65	63	48	85	17.78	0.48760

Legend: The shade of green represents a high level of implementation, yellow indicates a medium level, and red signifies a low level. WS- world score

**Figure 2.** Scores for assessed biosecurity

## DISCUSSION

The present study showed a slightly lower level of biosecurity measures in commercial pig farms in Serbia compared with the global average. Having in mind the different pig production systems in Serbia, there is an urgent need to improve biosecurity in industrial farms. In an investigation conducted in Slovenia, similar scores were obtained: the highest total biosecurity score was determined on commercial farms with  $64.59 \pm 16.47$ , followed by non-commercial farms with  $55.73 \pm 10.67$  and outdoor farms with  $48.47 \pm 8.20$  (23).

Serbia as a Western Balkan country, has a variable pig farming system characterized by a domination of traditional family farms, smallholdings, backyard production, semi-free and free-range system (15). Currently, traditional farming systems in Serbia represent a cultural identity and traditional heritage (19).

Previous studies on backyard pig farms in Serbia during ASF outbreaks revealed that the average score for external biosecurity was 20.2. This score reflected deficiencies in areas such as animal transport, carcass management, and manure disposal, which had an average score of 8.1. For internal biosecurity, the average score was 30.2, with the lowest score (0) observed in cleaning and disinfection practices (24). For these reasons, the biosecurity measures that could be implemented in existing animal production systems in Serbia need to be urgently identified. The external biosecurity score may be improved to a certain extent, however the internal biosecurity score may not be easily affected because it mostly depends on the farm owners and managers behavior. Internal biosecurity measures are closely linked to the farm management and the daily practices of farm workers such as hygiene protocols, operational procedures, cleaning, and disinfection practices. Enhancing the internal biosecurity level often entails straightforward interventions on the herd such as implementing strict hygiene protocols and ensuring proper operational procedures which could significantly contribute to reducing antimicrobial use. In this research, the lowest percentage score related to external biosecurity was obtained for feed, water, and equipment supply. In this regard, it is important to note that the control of incoming materials and equipment needs to be significantly improved to prevent the possible entry of diseases. Strict control and disinfection of vehicles should be applied and disinfection points for incoming materials should be organized and strictly used.

A recent report has shown a medium level of implementation for hygiene locks and disinfection baths at the entrance of farms in Serbia (25). It was observed that the change of fluid in disinfection baths (26) and cleaning and disinfection measures for the newly introduced materials (16, 25) is insufficient or inappropriate. This should be taken into account when proposing measures for improvement.

The average score for the subcategories visitors and workers is significantly higher ( $p=0.0001$ ) compared to the world score. This could be attributable to the implementation of strict biosecurity measures on commercial farms in Serbia with consideration of the African Swine Fever outbreak in 2019 (6).

A research conducted in Argentina identified specific routes that posed the highest risk for disease introduction: introduction of replacement animals, vehicles transporting feed or animals, and visitors (26). Another study emphasized the importance of personnel training in achieving avoidance for contact with external pig herds and enhancing farm entry protocols (27). Additionally, the same study highlighted the biosecurity weaknesses such as sharing trucks with other farmers and inadequate fencing (27).

Lower scores were registered for the farm location which is difficult to influence, the transport of animals, and the removal of carcasses and manure. In smallholder pig farms in North East India, 15% of the respondents reported the use of safe manure and carcass disposal measures (28). This is particularly significant in the light of the ASF epidemic. According to Davies et al. (29), the manure represents a powerful source of ASF transmission because the virus can remain infectious for nearly 4 (urine) or 3 (feces) days at 37 °C. The animal transport poses a significant risk for ASF transmission (30). Additionally, the porcine epidemic diarrhea virus (PEDV) can be easily transmitted via the feces, vehicles, farm workers, and feed (31).

Disinfection of vehicles for animal, products, raw materials, and animal waste transport is regulated in Serbia by a rulebook. All vehicles must be disinfected before loading which is validated by a veterinary certificate (32).

The procedure for removal of animal carcasses is regulated by a separate rulebook which states that animal carcasses can be removed in rendering plants, pits, animal cemeteries, or other suitable places, with exception when incineration is used. Compliance with these regulations is necessary to improve biosecurity standards for animal carcass removal (33).

Concerning internal biosecurity, the lowest scores were obtained for the farrowing and suckling period and finishing unit. Strict biosecurity measures in the farrowing house can prevent the spread of contagious infections including influenza and PRRS (1, 34). Internal biosecurity practices during the pre-weaning period are critical for prevention and transmission of swine influenza in farms within an endemic region. The internal biosecurity measures include regular observation of the healthy pigs in all age categories, including the sick animals (35).

An investigation carried out in Serbia (36) showed that low internal biosecurity was the factor that favored the maintenance of influenza on a commercial farrow-to-wean pig farm. Another investigation has observed gaps in hand washing stations and/or hand disinfection equipment between compartments/units, reporting that only 5% of the pig farms in Serbia use this type of equipment (25). In this context, enhancing internal biosecurity is crucial, particularly within farrowing, suckling, and finishing units. Research by Bernaerd et al. (35) highlighted the risks related to animal movements on the farms, noting that they may vary depending on the week of the batch, the day of the week, and the specific unit involved.

The risks associated with the introduction and spread of diseases are far more substantial in large herds (37).

The application of biosecurity measures can be a challenge in different extensive pig systems in Serbia (19). The unsuitable housing facilities and poor conditions makes the application of biosecurity measures practically unfeasible. The commercial farms aim is to protect the herds and prevent the occurrence or outbreak of diseases which requires adherence to strict biosecurity protocols. However, in some cases, despite all undertaken measures, failures occur that lead to disease outbreaks, which was the case in some commercial farms in Serbia in connection with the occurrence of ASF (38).

Various extensive pig production systems are traditionally practiced in rural areas, villages, and forests, often situated near riverbanks in Serbia. Backyard holdings are also commonly located in proximity to commercial farms (19). Traditional pig production systems in this context can be categorized into indoor and outdoor housing, although clear distinction between extensive indoor and outdoor units can be challenging. In traditional backyard setups, pigs are not confined to specific units at all times, and complete fencing is often lacking (19). Manure disposal tends to be inadequately managed, and workers may also keep pigs in their own homes.

The low levels of biosecurity or the absence of external biosecurity measures in swine farms pose significant risks for transmitting various pathogens. These include diseases caused by opportunistic microorganisms as well as notifiable diseases, which can have substantial negative impacts on the country's economy.

According to previous investigations traditional and smallholder farms with a low level of biosecurity measures are recognized as one of the main obstacles in preventing ASF spread and transmission (21).

## CONCLUSION

The study found that biosecurity measures in commercial industrial pig farms in Serbia generally exceed those in small-scale, semi-extensive, and extensive pig production units, but identified gaps in implementation. Despite achieving a slightly lower total biosecurity percentage compared to the world average, improvements are needed, especially in external biosecurity measures including feed, water, and equipment supply. Enhanced efforts are recommended to meet global standards in internal biosecurity, particularly during the farrowing and suckling period, and in the finishing unit. These findings underscore the need for heightened biosecurity measures in Serbia to mitigate disease risks, and to increase the awareness in farmers and veterinarians by training programs and campaigns.

## CONFLICT OF INTEREST

The authors declare that they have no known conflict of interest in the conduction of the current study.

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## AUTHORS' CONTRIBUTION

BK and JM contributed to the conception and design of the study. BK, BS, BM, MN and JM performed the farm visits and collected all data. BK, NJ, and JPR organized the database. BK and JM wrote the manuscript. BS, NJ, and JPR contributed to manuscript revision, reading, and adjustments. All authors approved the submitted version.

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