

Organic agriculture through a One Health perspective: connecting soil, animal, human and environmental health

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Abstract. Organic agriculture is increasingly considered within broader sustainability and health frameworks because agricultural management simultaneously affects soil, plants, animals, ecosystems, food production, and human exposure pathways. This review critically examines organic agriculture through a One Health perspective, integrating evidence from agricultural, environmental, veterinary, microbiological, food-safety, and human-health research. Particular attention is given to soil health and the soil microbiome, environmental functioning, animal health and welfare, antimicrobial use and resistance, food safety and pathogen transmission, and human health implications. The available evidence indicates that organic management can support soil biological functioning, microbial diversity, nutrient cycling, biodiversity, and reduced exposure to certain synthetic pesticides. Organic livestock systems may also provide greater opportunities for species-specific behaviour and lower antimicrobial use. However, these characteristics do not consistently translate into superior outcomes across all health domains. Animal welfare remains strongly influenced by management quality; antimicrobial resistance can persist despite reduced antimicrobial use; and practices such as manure recycling, outdoor access, and crop-livestock integration may create additional pathogen-transmission pathways when inadequately managed. Evidence for human health is strongest for reduced exposure to some pesticides, whereas nutritional differences are generally modest and direct long-term clinical benefits remain insufficiently demonstrated. Overall, organic agriculture should be regarded as a management framework with the potential to contribute to One Health objectives rather than as an inherently healthier production system, with outcomes depending strongly on specific practices and environmental conditions.

Keywords: animal welfare, antimicrobial resistance, food safety, public health, soil microbiome, pesticide exposure.

Introduction. Agriculture is closely connected to human, animal, plant, and environmental health, as food production systems simultaneously influence ecosystems, biological communities, exposure pathways, and the health of farmed animals and people. These interconnections are consistent with the One Health approach, which recognises that human, animal, plant, and ecosystem health are closely linked and interdependent. Agroecosystems are therefore particularly relevant to One Health because they are highly managed socio-ecological systems in which food safety, zoonotic diseases, antimicrobial resistance, environmental contamination, biodiversity, and climate-related pressures intersect (Garbisu et al., 2026; van Bruggen et al., 2019; Zhang et al., 2024).

Organic agriculture provides a useful framework for examining these relationships because its principles extend beyond crop productivity to include ecological processes, biodiversity, soil biological activity, animal welfare, and the broader functioning of agroecosystems. Organic agriculture has been described as a holistic production system that seeks to sustain the health of soils, ecosystems, and people through ecological processes and locally adapted biological and agronomic practices (Ferreira et al., 2020). However, organic production should not be regarded as inherently superior to conventional agriculture across all health-related dimensions. Both organic and conventional systems encompass heterogeneous management practices, and their outcomes may vary according to environmental conditions,

crop or livestock species, production intensity, farm management, and regional context (Sanders et al., 2025).

Soil represents a particularly important interface between agriculture and One Health. Soil microbial communities contribute to nutrient cycling, organic matter transformations, soil structure, carbon dynamics, plant nutrition, and pathogen suppression. At the same time, soil can act as both a source and a reservoir of beneficial and pathogenic microorganisms that interact with plants, animals, and humans. Banerjee and van der Heijden (2023) identified more than 40 soil microbiome functions with direct or indirect relevance to soil, plant, animal, and human health, emphasising the importance of microbial diversity within the One Health framework. Agricultural management can substantially modify these communities, and comparative studies have reported differences in soil microbial diversity and composition between organic and conventional systems, although these responses remain strongly dependent on local environmental and management conditions (Huang et al., 2025; Lupatini et al., 2017).

The relevance of organic agriculture to One Health extends further to livestock production, antimicrobial resistance, food safety, and human exposure. Organic livestock standards can provide greater opportunities for species-specific behaviour and impose restrictions on routine antimicrobial use, but comparative evidence does not show consistently superior animal health or welfare outcomes. Management quality, housing, grazing, hygiene, and disease prevention remain major determinants of animal-health outcomes (Åkerfeldt et al., 2021; Wagner et al., 2026). Lower antimicrobial use may reduce selection pressure for resistance in some production systems, although antimicrobial resistance can persist and circulate through animals and environmental reservoirs. In addition, greater use of manure and closer integration between livestock and crop production may create interfaces through which microorganisms and pathogens move among animals, soil, irrigation water, crops, farm workers, and consumers (Alsanius et al., 2019). Human-health implications must therefore also be interpreted cautiously: organic production may reduce selected pesticide and antimicrobial exposure pathways, whereas evidence for substantial nutritional or direct long-term clinical advantages remains more limited and susceptible to confounding (Mie et al., 2017).

Against this background, organic agriculture is best evaluated not as an intrinsically healthier production system, but as a management framework capable of generating both synergies and trade-offs across interconnected health domains. This review critically examines organic agriculture through a One Health perspective, with particular emphasis on the pathways linking soil and environmental processes to animal health and welfare, antimicrobial resistance, food safety, and human health. It evaluates both potential benefits and risks, the extent to which reported outcomes depend on management and environmental context, and the principal knowledge gaps that currently limit integrated One Health assessment of organic production systems.

Literature Review Methodology. This study was conducted as a structured narrative review examining organic agriculture across interconnected One Health domains. Relevant peer-reviewed literature was initially identified using Consensus as a literature-discovery tool and subsequently verified against the original publications. Reference lists of key reviews were also examined to identify relevant primary studies. Search terms included combinations of organic agriculture, organic farming, One Health, soil health, soil microbiome, environmental health, animal health, animal welfare, antimicrobial use, antimicrobial resistance, food safety, pathogen transmission, pesticide exposure, and human health. Priority was given to systematic reviews, meta-analyses, recent review articles, and comparative or experimental studies directly addressing relationships between agricultural management and one or more One Health domains. Earlier publications were retained when they provided relevant primary evidence, particularly for antimicrobial resistance. Publications lacking a clear connection to organic agriculture or One Health, providing insufficient methodological information, or making broad health claims without adequate scientific support were excluded. Because the available

evidence varied substantially in study design, species, production system, geographical context, and measured outcomes, findings were synthesised qualitatively, with particular attention to conflicting results, trade-offs, and methodological limitations. Representative studies illustrating the diversity of evidence considered across the principal One Health domains are summarised in Table 1.

Table 1

Representative evidence on organic agriculture across selected One Health domains			
<i>Study</i>	<i>Domain</i>	<i>Main finding</i>	<i>Key limitation / implication</i>
Lupatini et al. (2017)	Soil microbiome	Greater microbial richness and diversity in the organic system studied	Local study; results should not be generalised to all systems
Wagner et al. (2026)	Animal welfare	Organic systems were better in 28% of comparisons, similar in 56%, and worse in 16%	Management may be more important than production system
Grobbe et al. (2022)	AMR	Lower <i>E. coli</i> resistance in organic poultry, particularly broilers	Effects differed among poultry systems
Hess et al. (2022)	AMR	High multidrug resistance persisted in organic laying hens despite minimal antimicrobial treatment	Reduced antimicrobial use does not eliminate established resistance
Alsanius et al. (2019)	Food Safety	Manure, water, animals and humans can act as microbial-transmission routes	Risk depends strongly on hygiene and management
Mie et al. (2017)	Human Health	Strongest evidence concerns reduced pesticide exposure	Direct long-term clinical benefits remain insufficiently demonstrated

Source: Author's synthesis based on the studies reviewed in this article.

Organic Agriculture within the One Health Framework. The relationship between organic agriculture and One Health is based on a shared systems perspective in which human, animal, plant, and environmental health are interdependent. Agriculture is particularly relevant to this approach because agroecosystems are highly managed socio-ecological systems in which food production, livestock, biological communities, environmental resources, and human activities interact (Papp, 2026abc). Garbisu et al. (2026) therefore identify agriculture as a key component of the One Health arena and propose agroecosystems as suitable settings for examining interactions among the four health domains.

Organic agriculture shows substantial conceptual overlap with this framework. The principles of the International Federation of Organic Agriculture Movements encompass health, ecology, fairness, and care, with the principle of health explicitly linking the health of soil, plants, animals, humans, and the planet. The principles of ecology and care further emphasise ecological cycles and precautionary management (Alsanius et al., 2019). Organic agriculture can therefore be considered not merely as the replacement of synthetic inputs, but as a production approach in which soil fertility, biodiversity, crop production, livestock management, and ecosystem functioning are interconnected.

Microorganisms provide an important biological link among these components. Van Bruggen et al. (2019) proposed that subsets of microbial communities cycle from the environment, particularly soil, through plants, animals, and humans and back into the environment, thereby connecting different dimensions of ecosystem health. Such connectivity, however, can generate both beneficial and adverse effects. In organic systems, the greater use of animal-derived fertilisers and closer crop–livestock interfaces may facilitate nutrient recycling but can also create pathways for *faecal* pathogens to move among animals, soil,

irrigation water, crops, workers, and consumers when hygiene and risk-management measures are insufficient (Alsanius et al., 2019).

A One Health evaluation of organic agriculture should therefore consider both ecological opportunities and potential health risks. The effects associated with organic management depend on the specific practices employed, local environmental conditions, species, production intensity, and farm management. The following sections consequently examine soil and environmental processes, animal health and welfare, antimicrobial resistance, food safety, and human health as interconnected components of the same agricultural system. The principal interactions among organic agricultural management and the interconnected One Health domains considered in this review are illustrated in Figure 1.

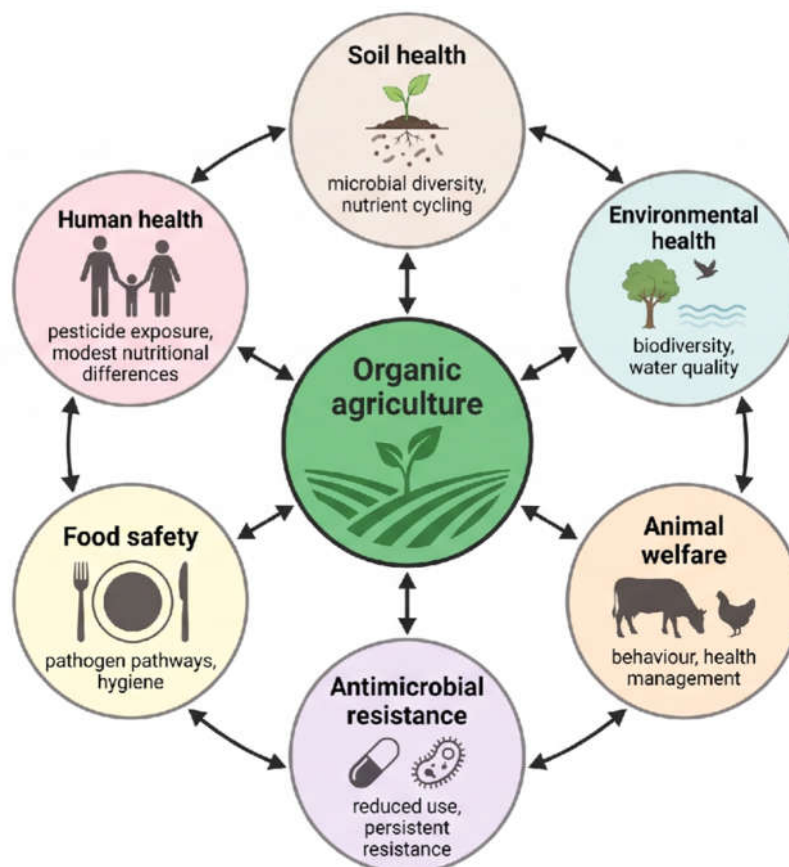


Figure 1. Conceptual One Health framework of organic agriculture, showing the interactions among soil health, environmental functioning, animal health and welfare, food safety, antimicrobial resistance, and human health. Source: Created by the author with BioRender, based on the conceptual synthesis of van Bruggen et al. (2019), Alsanius et al. (2019), Banerjee and van der Heijden (2023), and Garbisu et al. (2026).

Soil Health and the Soil Microbiome as a Foundation of One Health. Soil health provides a biological foundation for linking agricultural management with plant, animal, environmental, and human health. It has been defined as the continued capacity of soil to function as a living ecosystem that sustains plants, animals, and humans. Soil health integrates physical, chemical, and biological properties, with soil organic matter and soil biota contributing to nutrient cycling, carbon dynamics, crop productivity, and the limitation of some pathogens (Montgomery et al., 2024).

The soil microbiome is central to these functions. Diverse microbial communities regulate the transformation and availability of carbon, nitrogen, phosphorus, and other nutrients, contribute to organic matter dynamics and soil aggregation, and influence plant

nutrition and pathogen suppression. Their relevance extends beyond crop production because soil acts as both a source and a reservoir of beneficial microorganisms, pathogens, and antimicrobial resistance determinants. Banerjee and van der Heijden (2023) identified more than 40 soil microbiome functions with direct or indirect implications for soil, plant, animal, and human health, highlighting soil as an important interface within One Health.

Agricultural management can substantially modify these microbial communities. Lupatini et al. (2017) reported greater taxonomic and phylogenetic richness, diversity, and heterogeneity in organically managed soils than in the conventional system examined, together with enrichment of microbial taxa associated with suppression of plant-parasitic nematodes and soil-borne fungi. However, the study was based on a single sampling period and a local experimental site, and the authors explicitly cautioned against generalising the findings across ecosystems without confirmation from long-term studies under contrasting environmental and management conditions.

Recent evidence further illustrates the importance of context. Huang et al. (2025) reported higher soil organic carbon and fertility and differences in microbial community composition in the organically managed sites examined, including greater abundance of some bacterial functional groups involved in carbon and nitrogen cycling. However, the comparison involved organic orange fields and conventionally managed coffee and maize fields, meaning that differences in crop type and vegetation accompanied differences in management system. The observed microbial patterns should therefore not be attributed exclusively to organic management. The study also found lower abundance of symbiotic fungi under organic management and no significant differences in saprotrophic or pathogenic fungal groups, illustrating that microbial responses are not uniformly beneficial.

Evidence reviewed by Tahat et al. (2020) similarly indicates that organic management may enhance microbial activity, nutrient mineralisation, microbial abundance, and enzyme activity in some systems. These effects, however, are better interpreted as responses to specific practices, including organic amendments, crop rotation, diversification, and reduced reliance on some synthetic inputs, rather than as inherent consequences of organic certification (Mihelič et al., 2024).

From a One Health perspective, the importance of soil lies in these interconnected pathways. Changes in soil biodiversity and microbial functioning can influence plant productivity and food production, while soil microorganisms, pathogens, and resistance determinants may move between environmental reservoirs, livestock, crops, and humans. Soil health should therefore be considered not only an agronomic objective but also a component of wider strategies addressing food safety, animal health, antimicrobial resistance, and human exposure.

Environmental Health and Ecosystem Functioning. Environmental health is an integral component of One Health because agricultural production both depends on and modifies ecosystem processes that ultimately affect plant, animal, and human health. Relevant dimensions include biodiversity, water quality, nutrient cycling, greenhouse gas emissions, energy use, and land occupation; consequently, the environmental performance of a farming system cannot be assessed through a single indicator (Garbisu et al., 2026).

Organic management frequently incorporates practices such as crop diversification, rotations, organic amendments, biological pest control, and restrictions on certain synthetic inputs. These practices can support habitat heterogeneity, soil biological functioning, and biodiversity, although their effects depend strongly on local management and environmental conditions. Van Bruggen et al. (2019) similarly emphasise that diversification of plant communities and reduced pesticide and nutrient pressure can contribute to microbial diversity and ecosystem resilience. Such environmental effects are relevant to One Health because changes in biodiversity and ecosystem functioning may influence pathogen dynamics, food production, livestock exposure, and human contact with environmental hazards.

Nutrient and water management represent another important interface. Organic systems rely more strongly on biological nutrient cycling and organic nutrient sources, and some

comparisons reviewed by Tahat et al. (2020) reported improved nutrient mineralisation, microbial activity, and lower groundwater nitrate concentrations under organic management. These outcomes are not automatic, however, because excessive or poorly timed nutrient applications can generate environmental losses regardless of whether the nutrient source is organic or synthetic. Similarly, practices that maintain soil organic matter and biological functioning may contribute to carbon storage and resilience (Shi et al., 2024), but overall environmental performance must also consider productivity, greenhouse gas emissions, nutrient losses, and resource use (Krause et al., 2024). Environmental benefits should therefore be attributed to specific management practices and evaluated together with their possible trade-offs rather than assumed from organic certification alone (Raveloaritiana & Wanger, 2026).

Animal Health and Welfare in Organic Livestock Systems. Animal health and welfare represent a central interface between organic agriculture and One Health. Welfare is multidimensional, encompassing physical health and biological functioning, opportunities to express species-specific behaviour, and affective state. Organic livestock standards are designed to support these dimensions through requirements concerning housing, feeding, outdoor access, preventive health management, and husbandry. However, higher production standards do not necessarily translate into consistently superior welfare outcomes under commercial conditions (Chincarini et al., 2022).

The most comprehensive recent evidence supports this distinction. Wagner et al. (2026) systematically reviewed 86 peer-reviewed comparative studies published between 1990 and 2023, comprising 623 organic–conventional comparisons across major livestock species in Europe and North America. Organic systems showed advantages in 28% of comparisons, no clear difference in 56%, and disadvantages in 16%. Most studies focused on animal-health indicators and particularly on dairy cattle, while behavioural and affective-state measures were much less represented. The authors concluded that management factors can be more influential than production system alone and recommended greater use of standardised animal-based welfare indicators.

These conclusions are consistent with the systematic mapping by Åkerfeldt et al. (2021), which included 166 peer-reviewed publications covering cattle, sheep, pigs, laying hens, and broilers. The review found no strong evidence that animal welfare was consistently inferior or distinctly superior in organic production. Organic standards may provide greater opportunities for species-specific behaviour, but important health challenges remain, including mastitis and lameness in dairy cattle, parasitic disease and lamb mortality in sheep, piglet mortality and leg disorders in pigs, and feather pecking, parasitism, and dermatitis-related problems in poultry.

Outdoor access illustrates an important welfare trade-off. Pasture and outdoor environments can facilitate grazing, rooting, locomotion, and other species-specific behaviours, but they may also increase exposure to parasites and environmental pathogens. Wagner et al. (2026) therefore emphasise that the welfare benefits associated with more natural living conditions depend on effective preventive health and pasture management. Organic systems should consequently be viewed as creating opportunities for high welfare rather than guaranteeing it.

From a One Health perspective, this distinction is important because animal welfare is closely connected to antimicrobial use, pathogen circulation, environmental exposure, and food safety. Disease prevention can reduce the need for antimicrobial treatment, whereas outdoor access, housing conditions, and manure management can modify contact with parasites and microorganisms. Assessment of organic livestock systems should therefore combine production standards with direct animal-based health and welfare outcomes.

Antimicrobial Use and Antimicrobial Resistance. Antimicrobial resistance (AMR) represents a direct One Health connection between livestock production, food, humans, and the environment. Antimicrobial use exerts selection pressure that can favour resistant bacteria,

but resistance may persist after treatment has ceased and circulate through animal populations and environmental reservoirs (Pandey et al., 2024). Reducing unnecessary antimicrobial use is therefore an important component of AMR control, but cannot by itself eliminate resistance.

Organic livestock production is relevant to this relationship because antimicrobial use is subject to specific restrictions. Under Regulation (EU) 2018/848, Annex II, Part II, points 1.5.1.3 and 1.5.2.1–1.5.2.5, chemically synthesised allopathic veterinary medicinal products, including antibiotics, may not be used preventively in organic livestock. However, animals that become sick or injured must be treated without delay, and antibiotics may be used when necessary under veterinary responsibility. The regulation also imposes restrictions on repeated treatment and requires a withdrawal period twice that normally prescribed, with a minimum of 48 h. These provisions aim to reduce unnecessary antimicrobial exposure without withholding necessary treatment from diseased animals.

Comparative poultry studies indicate that organic production can be associated with lower AMR when antimicrobial-use patterns differ substantially between systems. In Germany, Grobbel et al. (2022) found lower resistance in *Escherichia coli* of organic origin; among broilers, 70.1% of isolates from organic farms were susceptible to all tested antimicrobials compared with 13.3% from conventional farms, and resistance to three or more antimicrobial classes was substantially more frequent in conventional production. Earlier, Luangtongkum et al. (2006) reported fluoroquinolone resistance in fewer than 2% of *Campylobacter* isolates from organic poultry, compared with approximately 46% from conventional broilers and 67% from conventional turkeys. Nevertheless, tetracycline resistance remained common in organic poultry despite the absence of tetracycline use, illustrating that reduced antimicrobial exposure does not necessarily eliminate established resistance.

This limitation is reinforced by Hess et al. (2022), who examined 209 *E. coli* isolates from 18 organic laying-hen flocks. Of these isolates, 95.70% were multidrug resistant and 36.84% met the study definition of extensively drug-resistant, although antimicrobial treatment had not been used in all but two flocks. Resistance also increased with flock age, supporting the relevance of environmental reservoirs and repeated exposure to resistant bacteria in the persistence of AMR. Conversely, Sjöström et al. (2020) found generally low and largely similar resistance patterns in *E. coli* from calves in 30 organic and 30 conventional Swedish dairy herds, with no clear association between antimicrobial use and resistance. The authors attributed the limited difference partly to good animal health and low antimicrobial use in both production systems.

Taken together, these studies indicate that restrictions on antimicrobial use may reduce selection pressure and can be associated with lower resistance in some organic livestock populations, but the effect is strongly context-dependent. Species, bacterial taxa, historical antimicrobial exposure, husbandry conditions, and environmental reservoirs all influence observed resistance patterns. From a One Health perspective, antimicrobial stewardship in organic agriculture should therefore combine prudent drug use with disease prevention, animal welfare, biosecurity, environmental hygiene, manure management, and surveillance of resistant bacteria and resistance determinants (Pinto Jimenez et al., 2023).

Food Safety and Pathogen Transmission. Food safety represents an important One Health interface because microorganisms can move among livestock, soil, water, crops, wildlife, farm workers, food products, and consumers. This is particularly relevant for fruits and vegetables consumed raw or minimally processed, where no subsequent processing step may eliminate microbial hazards. In organic production, greater use of manure and compost and closer integration of livestock and crop production may increase some contact interfaces between these compartments. Alsanius et al. (2019) identified four major routes of microbial transmission in fruit and vegetable production: soil and soil-fertility management, irrigation water, livestock and wildlife, and humans involved in production and harvesting.

Animal-derived fertilisers represent one important pathway. Enteric pathogens can persist in manure and agricultural soils and may subsequently reach crops through soil contact, splash, runoff, or other environmental routes. *Escherichia coli*, *Salmonella spp.*, and *Listeria*

monocytogenes have been reported in association with organic manures, while G. Jiang et al. (2024) emphasise that manure application can introduce human pathogens into farmland soils and potentially contribute to direct or food-chain exposure. However, pathogen detection in soil does not necessarily imply crop contamination or human disease, since actual risk depends on survival, transfer, environmental conditions, and subsequent exposure. Appropriate treatment of animal-derived fertilisers is therefore essential. Thermophilic composting can reach temperatures above 60 °C and reduce the survival of many non-thermophilic microorganisms, whereas inadequate composting or storage may compromise hygienic quality (Alsanius et al., 2019).

Irrigation water, livestock, wildlife, and human activity provide additional transmission pathways. Water quality can be affected by runoff, animal access, storage conditions, and microbial growth within irrigation infrastructure. Similarly, grazing animals and wildlife may introduce faecal microorganisms into crop-production areas, while manual harvesting and inadequate worker hygiene can contribute to cross-contamination. These hazards are not exclusive to organic production, but their interaction is particularly relevant when ecological diversification, animal integration, and fresh-produce production occur within the same farming system (Alsanius et al., 2019).

Soil microbial diversity may also influence pathogen establishment. G. Jiang et al. (2024) describe mechanisms including competition for nutrients and space, predation, antimicrobial interactions, and dilution effects that may increase resistance of diverse soil communities to pathogen invasion. Such ecological processes may contribute to pathogen suppression but cannot replace direct food-safety measures. Overall, the relevant One Health objective is therefore not to avoid nutrient recycling or ecological integration, but to combine them with effective manure treatment, water-quality management, worker hygiene, and risk-based pathogen control throughout the production chain. The principal pathogen-transmission pathways and corresponding intervention points relevant to organic agricultural systems are summarised in Figure 2.

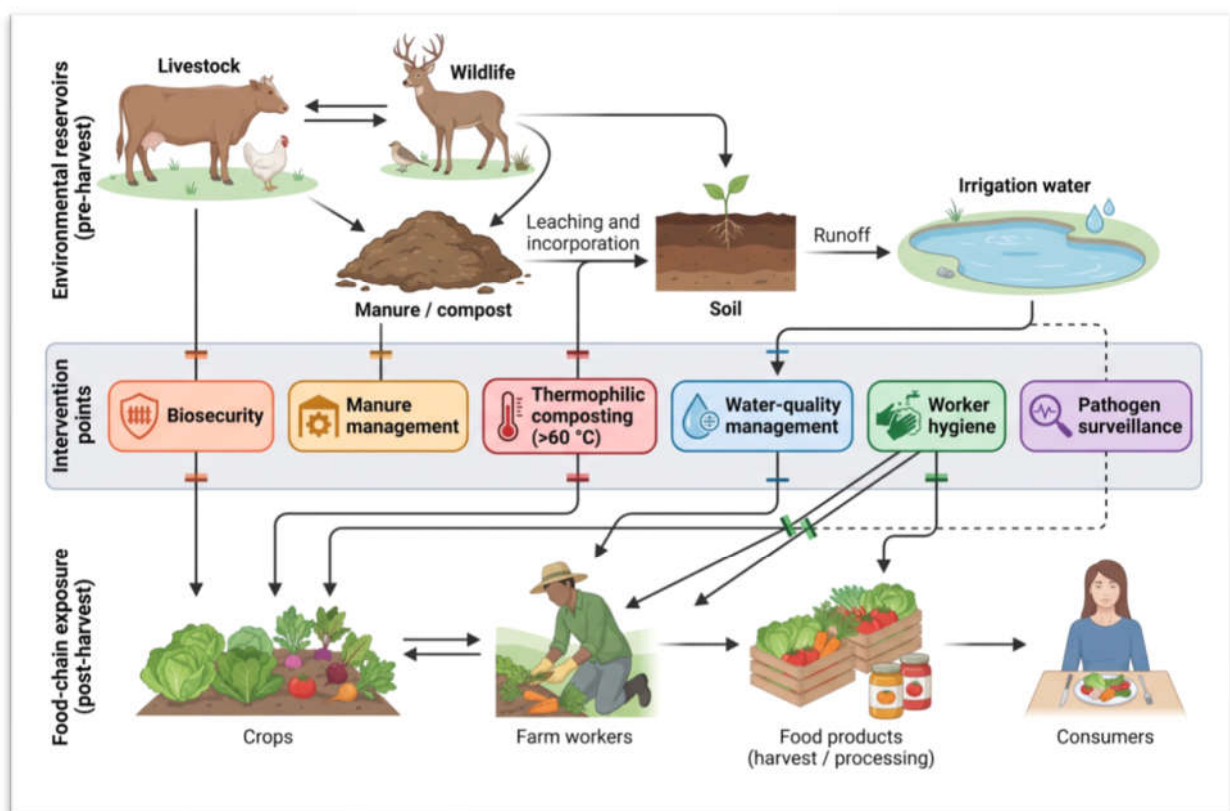


Figure 2. Main pathogen-transmission pathways and intervention points in organic agricultural systems from a One Health perspective. Source: Created by the author with BioRender, based on Alsanius et al. (2019) and G. Jiang et al. (2024).

Human Health Implications. Human health represents a downstream component of the agricultural One Health continuum, but the strength of evidence differs substantially among exposure pathways and health outcomes. In organic agriculture, the clearest differences concern exposure to certain pesticides, whereas evidence for substantial nutritional or direct long-term clinical benefits remains less conclusive (B. Jiang et al., 2024).

Reduced pesticide exposure is one of the best-documented differences associated with organic food consumption. Organic production restricts the use of many synthetic pesticides, and dietary residues represent an important source of pesticide exposure in the general population. Intervention studies reviewed by Mie et al. (2017) reported marked reductions in urinary pesticide metabolites after approximately one week of predominantly organic food consumption, while observational studies similarly associated more frequent organic-food consumption with lower urinary metabolite concentrations. More recent assessments also indicate substantially lower pesticide use and dietary pesticide risks in organic production (Benbrook et al., 2021). These findings demonstrate a difference in exposure, but reduced exposure should not automatically be interpreted as a demonstrated reduction in disease incidence.

Differences in food composition are generally more modest. Organic fruits and vegetables have been reported to contain somewhat higher concentrations of phenolic compounds, whereas vitamin and mineral concentrations are generally similar between organic and conventional crops. Lower cadmium concentrations have also been reported in organic cereals, although long-term comparative evidence remains limited. Organic dairy products, and possibly meat, generally contain higher proportions of omega-3 fatty acids, largely reflecting differences in feeding practices. However, the nutritional significance of these compositional differences is considered relatively small, and they do not provide sufficient evidence for clinically meaningful superiority of organic foods (Mie et al., 2017).

Evidence for direct health effects of organic-food consumption is more uncertain. Observational studies have reported associations with outcomes including lower risks of overweight, obesity, and some allergic diseases, but organic-food consumers also tend to have healthier dietary and lifestyle patterns. Residual confounding therefore makes causal interpretation difficult. Long-term dietary intervention studies are lacking, while available clinical studies have generally involved small populations and short follow-up periods. Consequently, current evidence supports reduced exposure to some pesticides more strongly than it supports substantial direct improvements in long-term human health attributable specifically to organic-food consumption (Mie et al., 2017; Vigar et al., 2020).

From a One Health perspective, this distinction is essential. Agricultural practices can modify human exposure through pesticide residues, antimicrobial resistance, foodborne pathogens, and food composition, but evidence of altered exposure or intermediate biological effects should not be equated with evidence of clinical benefit. Human-health claims concerning organic agriculture should therefore remain proportional to the strength of the available evidence.

Trade-offs and Limitations of Organic Agriculture from a One Health Perspective. A One Health assessment of organic agriculture requires the simultaneous consideration of benefits and risks across interconnected health domains. Practices that benefit one component of the system may create pressures in another, and their effects frequently depend on the way they are implemented (Breure et al., 2024). Organic agriculture should therefore be evaluated as a heterogeneous management framework rather than as a uniform set of health outcomes.

Livestock production illustrates this complexity particularly well. Greater access to pasture and outdoor environments can provide opportunities for species-specific behaviour while simultaneously increasing exposure to parasites and other environmental hazards (Wagner et al., 2026). Similarly, restrictions on antimicrobial use may reduce selection pressure for resistance, but AMR can persist even where antimicrobial use is low (Hess et al., 2022; Sjöström et al., 2020), and necessary treatment of clinically ill animals remains essential for animal welfare. The relevant objective is therefore to combine antimicrobial stewardship with

preventive health management rather than to minimise treatment irrespective of animal-health needs.

Nutrient recycling creates a comparable trade-off between environmental and microbiological objectives. Manure and compost can return nutrients and organic matter to agricultural soils, but inadequately treated animal-derived materials may also introduce enteric pathogens into soil–crop systems. Effective hygienisation and management are therefore required to obtain the ecological benefits of nutrient recycling without increasing food-safety risks (Alsanius et al., 2019). More broadly, differences in exposure or environmental performance should not automatically be translated into equivalent health benefits; for example, lower exposure to some pesticide residues is better established than direct long-term clinical advantages of organic-food consumption (Mie et al., 2017).

Productivity represents an additional systems-level consideration. Reviews and long-term comparisons have commonly reported organic crop yields approximately 10–25% below those of intensive conventional systems, although the magnitude of the gap varies substantially among crops, environments, and management strategies and may decrease over time or with diversification practices (Rempelos et al., 2021). Productivity must therefore be considered alongside environmental, animal-health, food-safety, and human-health outcomes when evaluating the overall performance of production systems.

Finally, both “organic” and “conventional” agriculture encompass substantial internal variation. Farms differ in climate, soil, crop and animal species, stocking density, housing, grazing, nutrient management, disease prevention, and farmer expertise, while conventional systems may also incorporate practices commonly associated with organic or agroecological management. This heterogeneity limits broad production-system comparisons and supports greater emphasis on measurable One Health outcomes and specific management practices when assessing agricultural health impacts. The principal potential benefits, limitations, and broader One Health implications identified across the health domains considered in this review are summarised in Table 2.

Table 2

Main One Health implications of organic agriculture across the health domains considered in this review

<i>Domain</i>	<i>Potential benefits</i>	<i>Main limitation / risks</i>	<i>Overall interpretation</i>
Soil and environment	Improved soil biological activity, microbial diversity, nutrient cycling and biodiversity in some systems	Effects are context-dependent and not uniformly beneficial	Outcomes depend mainly on specific management practices and local conditions
Animal health and welfare	Greater opportunities for species-specific behaviour and outdoor access	Parasites, environmental pathogens and variable health outcomes	Organic standards can support high welfare but do not guarantee it
Antimicrobial resistance	Reduced antimicrobial use may decrease selection pressure	Resistant bacteria can persist despite low antimicrobial use	Stewardship must be combined with prevention, biosecurity and surveillance
Food safety	Nutrient recycling and crop–livestock integration	Manure, water, wildlife and workers may create pathogen-transmission pathways	Ecological integration requires effective hygiene and risk management

Human health	Lower exposure to some pesticide residues	Nutritional differences are generally modest; direct clinical benefits remain uncertain	Evidence is stronger for reduced exposure than for long-term health benefits
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Source: Author's synthesis based on the literature reviewed in this article.

Future Perspectives. Future research on organic agriculture within a One Health framework should move beyond isolated comparisons of individual outcomes toward integrated and longitudinal assessment of agroecosystems. Soil and microbial processes, livestock health, antimicrobial use, pathogen circulation, environmental conditions, food safety, and human exposure are interconnected, yet they are still frequently investigated separately. Monitoring frameworks capable of evaluating several of these domains simultaneously would provide a stronger basis for identifying both synergies and unintended consequences of agricultural management (Burke & Risius, 2026).

Agricultural One Health Living Labs provide one possible framework for this approach. Garbisu et al. (2026) propose agroecosystems as suitable real-world settings because they bring together farmers, livestock, crops, soils, and wider ecosystem components. Such initiatives could integrate expertise from veterinary medicine, agronomy, soil science, public health, and other relevant disciplines while evaluating management interventions under operational farm conditions. Their value would lie in assessing whether improvements in one health domain are accompanied by benefits or trade-offs elsewhere in the system.

Future monitoring should also place greater emphasis on measurable biological outcomes. Soil assessment could combine conventional indicators with microbial diversity and function, pathogen surveillance, and antimicrobial resistance determinants. In livestock systems, standardised animal-based indicators should complement compliance with management standards, allowing welfare to be assessed through actual animal health, behaviour, and affective state rather than production-system classification alone (Wagner et al., 2026). Similarly, AMR and food-safety research would benefit from coordinated surveillance across animals, manure, soil, water, crops, and food products (Delpy et al., 2024). Improved molecular and computational detection approaches may further strengthen the identification of human pathogens and their transmission pathways within farmland environments (G. Jiang et al., 2024).

Human-health research remains particularly limited by the difficulty of distinguishing effects of production system from dietary and lifestyle characteristics. Long-term intervention studies comparing organic and conventional diets are scarce, whereas observational studies remain susceptible to exposure misclassification and residual confounding (Mie et al., 2017). Future research should therefore combine more precise exposure assessment with longer follow-up and, where possible, objective biomarkers. Importantly, reductions in pesticide or other environmental exposures should continue to be distinguished from demonstrated changes in long-term clinical outcomes.

Ultimately, future research should identify which management practices produce reproducible One Health benefits and under which conditions. Practices that improve animal welfare, antimicrobial stewardship, soil functioning, food safety, or environmental performance may be transferable beyond certified organic agriculture, while practices associated with unintended risks should be modified accordingly. The most informative future comparisons will therefore be those based on measurable outcomes across interconnected health domains rather than on production labels alone.

Conclusions. Organic agriculture provides a useful framework for examining agricultural production through a One Health perspective because management decisions simultaneously affect soil, ecosystems, crops, livestock, food production, and human exposure pathways. Evidence reviewed across these domains indicates several potential advantages, including support for soil biological functioning and biodiversity, reduced exposure to some synthetic

pesticides, greater opportunities for species-specific animal behaviour, and reduced antimicrobial use in some livestock systems. However, these characteristics do not consistently result in superior health outcomes.

The same ecological connections that generate potential benefits may also create trade-offs. Outdoor access can improve behavioural opportunities while increasing exposure to parasites or environmental pathogens; reduced antimicrobial use can lower selection pressure without eliminating antimicrobial resistance; and manure recycling can support soil fertility while creating pathogen-transmission pathways if inadequately managed. Human-health evidence is similarly differentiated: reduced exposure to certain pesticide residues is comparatively well supported, whereas nutritional differences are generally modest and substantial direct long-term clinical benefits of organic-food consumption remain insufficiently demonstrated.

Organic agriculture should therefore not be regarded as inherently healthier than conventional agriculture. Its contribution to One Health depends on the specific practices implemented, the environmental and production context, and the effectiveness of animal-health, antimicrobial-stewardship, food-safety, and environmental-management measures. Future evaluation should consequently prioritise measurable outcomes across interconnected health domains rather than certification status alone.

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Author Contributions. Robert R. Papp conceptualised the review, conducted the literature search and final literature selection, critically evaluated and interpreted the scientific evidence, verified the sources and references, and reviewed and approved the final manuscript.

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Data Availability. No new datasets were generated or analysed in this study. All information discussed in this review was derived from the published literature cited in the manuscript.

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