

# Scientists Identify Bacteria Linked to the Immune System Farm Effect

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October 28, 2026

## STORY AT-A-GLANCE

- › Children raised around farms have lower rates of asthma and allergic conditions, and research identifies specific bacteria that statistically account for much of this observed “farm effect”
- › Nine genera of gram-positive bacteria explained about two-thirds of the association between farm exposure and lower childhood asthma risk in this cross-sectional analysis, narrowing the effect from thousands of environmental microbes to a much smaller group
- › Farm bacteria are predicted to produce or process compounds that interact with receptors on human cells involved in immune responses, pointing to a possible route by which environmental microbes may influence immune function
- › You don’t need to live on a farm to support healthy microbial exposure; outdoor play, gardening and regular contact with soil, plants and pets help create a less sterile everyday environment
- › Supporting your microbiome with healthy carbohydrates and varied whole foods, while limiting ultraprocessed foods, antibacterial soap and unnecessary antibiotics, helps create an environment where beneficial microbes thrive

Children who grow up around farms are less prone to asthma, allergies and hay fever, and researchers have spent decades trying to explain why. The leading framework, an updated version of what was originally called the “hygiene hypothesis,” holds that regular

contact with diverse environmental microbes helps calibrate a child's developing immune system, reducing the likelihood it will overreact to harmless substances.

Epidemiological evidence has broadly supported that idea, but an important gap remained: no one had identified which specific microbes in the farm environment carried the protective association, or traced how they influenced human biology at the molecular level. A study published in the New England Journal of Medicine (NEJM) Evidence narrows much of that gap.<sup>1</sup>

An international research team moved beyond the general observation that farm exposure is beneficial. They traced a biological chain from barn air to specific bacteria, from those bacteria to the compounds they produce, and from those compounds to the receptors on human cells that recognize them. The result is one of the most detailed maps yet of the proposed biological pathway that may connect farm exposure to immune regulation.

This gives researchers concrete, testable targets for future research into whether that association can be reproduced outside farm settings.

## **Specific Barn Bacteria Account for Most of the Farm Effect**

For the featured NEJM Evidence study, researchers analyzed **bacterial exposure** among 1,018 schoolchildren in a cross-sectional analysis of two German populations.<sup>2,3</sup>

Researchers analyzed bacteria in mattress dust by examining their genetic material (specifically via 16S ribosomal ribonucleic acid gene sequencing), which allowed them to identify the different genera of bacteria present.

They then combined those results with computer-based analyses of bacterial metabolism and laboratory measurements of microbial compounds.

Instead of stopping at a simple comparison between farm and nonfarm children, the team examined how microorganisms related to one another and which groups tracked most closely with lower asthma risk. Researchers also analyzed fungi and

bacteriophages, which are viruses that infect bacteria, and tested their findings in independent populations.

- **Nine genera of gram-positive bacteria explained about two-thirds of the link —** Gram-positive is a classification based on cell wall structure, and it matters here because gram-positive and gram-negative bacteria are recognized by different arms of the innate immune system. That said, nine genera stood out from the enormous variety of microbes found in farm environments.

A combined score based on these bacteria explained two-thirds of the inverse association between farm exposure and asthma in a mediation analysis. In plain terms, these nine bacterial genera accounted for a large share of the statistical link between farm life and lower asthma risk. Importantly, this relationship remained independent of gram-negative farm-associated bacteria.

Fungi and bacteriophages appeared alongside the beneficial bacterial genera but didn't independently predict the protective association. The researchers did not test whether these organisms play a supporting ecological role — what the analysis showed is that they co-occurred with the beneficial bacteria without carrying the association themselves. That distinction gives researchers a much narrower target than the broad idea that exposure to any farm microbe is beneficial.

- **The bacteria were connected to specific metabolic pathways —** The researchers used genomic prediction tools (PICRUSt2) that match bacterial genes to known metabolic functions, allowing them to forecast what the identified bacteria were equipped to produce or process. That analysis revealed nine bacterial pathways whose enzymes were encoded by the bacterial genera linked to the farm effect.

Using mass spectrometry, a laboratory technique that identifies molecules by their chemical characteristics, researchers also detected corresponding metabolites in cowshed dust. Metabolites are small compounds created or processed during biological activity. Finding them in actual barn dust helped connect the bacterial genetic findings with substances children could encounter in the farm environment.

- **Farm bacteria were predicted to produce or process compounds that human cells recognize** — Corresponding metabolites were also detected in cowshed dust, including kynurenine, a metabolite of the amino acid tryptophan involved in immune tolerance; xanthine, a purine compound involved in cellular energy metabolism; and two omega-3 fatty acids, alpha-linolenic acid and stearidonic acid.

Some of these compounds interact with two receptors on human airway and immune cells — AhR and PPAR $\gamma$  — that appear to help regulate whether inflammatory responses escalate or stand down. These receptors function as molecular sensors: when particular compounds bind to them, they shift the balance of activity inside the cell.

This finding matters because the study didn't identify bacteria and then simply assumed they affected immunity. It connected bacterial groups with their metabolic machinery, detected relevant metabolites in cowshed dust and identified human receptors capable of recognizing those compounds. That gives researchers several measurable steps along the biological pathway rather than one unexplained association.

- **Children's genes interacted with the bacterial exposure-asthma relationship** — Researchers looked for small differences in the children's genes (single nucleotide polymorphisms) that affect how the AhR and PPAR $\gamma$  receptors work. These genetic variants interacted with the combined bacterial score in relation to asthma. That finding suggests the farm effect isn't simply about how many bacteria a child encounters.

The response may also depend on how bacterial metabolites interact with biological receptors in the child. This helps explain why the same environmental exposure doesn't necessarily produce an identical response in every person and gives researchers a more personalized framework for studying environmental influences on immune function.

- **The researchers replicated their results using independent populations, including the PASTURE birth-cohort populations in France and Finland** — This is an important strength because a finding that appears in separate groups is harder to dismiss as something unique to one sample. Their analysis therefore connected environmental exposure, specific bacteria, bacterial metabolism and human genetics across multiple populations.

The work still doesn't prove that deliberately exposing children to these bacteria will prevent asthma, and the researchers didn't test a bacterial treatment. Instead, it identifies specific components of the farm environment for laboratory researchers to investigate next.

But the biology the study maps out doesn't depend on waiting for a bacterial treatment. The same receptor families — AhR and PPAR $\gamma$  — that respond to farm-derived microbial compounds are also reported to respond to metabolites produced by a healthy gut microbiome, though this study did not examine diet, gut bacteria, or asthma outcomes. That overlap is a reasonable prompt to look at the everyday choices that shape your own microbial environment, wherever you live.

## **Support a Healthy Microbiome No Matter Where You Live**

Not everyone gets to grow up on a farm or spend childhood surrounded by the rich mix of microbes found in rural environments. The farm-effect research shows why those environmental exposures matter, but you still have practical ways to support a diverse, resilient microbiome wherever you live. The place to start is your gut and the everyday choices that determine which microbes have the opportunity to thrive.

1. **Feed beneficial gut bacteria with healthy carbohydrates** — Your gut bacteria depend on carbohydrates that survive digestion in the upper gut and reach the colon intact. If your digestion is healthy, focus on whole fruits, root vegetables and other minimally processed carbohydrate sources. Aim for around 250 grams of healthy carbohydrates each day so your cells have enough fuel to produce energy efficiently.

If you have a damaged gut and struggle with bloating or irregular bowel habits when consuming fiber, start slowly with easier-to-digest foods such as fruit and white rice, then gradually expand the variety of foods as you tolerate them. As your gut recovers, beneficial bacteria produce short-chain fatty acids such as [butyrate](#), which help maintain the intestinal barrier and support a healthier gut environment.

Butyrate has also been reported to act on PPAR $\gamma$  — one of the same receptor families highlighted in the featured farm-exposure research. That is a shared receptor target, not a demonstrated equivalence: The study examined inhaled farm-derived compounds rather than dietary butyrate, and it did not test whether feeding gut bacteria changes asthma risk. The goal is to create conditions where beneficial bacteria thrive rather than forcing large amounts of fiber into a gut that isn't ready for it.

- 2. Increase the variety of whole foods you eat** — You don't need access to a farm to expose your gut to a broader range of foods and the compounds they contain. Instead of eating the same few foods every week, challenge yourself to gradually increase variety while paying attention to how your digestion responds.

Whole fruits, root vegetables, herbs and other minimally processed foods each provide different carbohydrates and compounds for your microbial ecosystem. If you tolerate [fermented foods](#), options such as traditionally fermented vegetables and grass fed dairy like yogurt can also support microbial variety and bacterial metabolites. Build diversity gradually. More isn't automatically better if your gut is damaged and you're still working to tolerate fiber.

- 3. Eliminate foods that undermine your gut environment** — One of the simplest ways to change what reaches your gut is to remove ultraprocessed foods, packaged snacks, fast food and seed oils high in [linoleic acid](#), or LA. I recommend keeping LA below 5 grams per day, with 2 grams as the ideal target. Avoid nuts and seeds as well because they're concentrated sources of LA.

Replace industrial fats with grass fed butter, ghee or tallow. This step also reduces your reliance on highly processed foods that provide little of the carbohydrate diversity you want your beneficial gut bacteria to receive.

- 4. Avoid wiping out microbes unnecessarily** — Modern life encourages you to treat bacteria as something that should constantly be eliminated, but the farm-effect study paints a much more nuanced picture. Specific environmental bacteria were associated with much of the protective farm effect identified by the researchers.<sup>4</sup> At home, ordinary natural soap is sufficient for routine handwashing; you don't need antibacterial soap for everyday use.

Take the same measured approach to [antibiotics](#). Use them when they're truly necessary rather than treating every illness as a reason to eliminate bacteria indiscriminately. Choosing organic, grass fed meat when available is one way to limit dietary exposure to antibiotic residues, though the featured NEJM Evidence study did not examine dietary antibiotic exposure.

Think of microbial exposure as an ecosystem question: the goal isn't to eliminate bacteria but to maintain conditions where beneficial species have an advantage.

- 5. Make your everyday environment less sterile and more natural** — If you're raising children in a city or suburb, you don't need a barn in the backyard to give them regular contact with the natural world. Outdoor play, gardening, time in parks and ordinary contact with soil, pets, and plants provide opportunities to interact with a less sanitized environment.

The research doesn't establish these activities as substitutes for farm exposure, but it reinforces an important principle — environmental microbial exposure interacts with human biology in measurable ways.

Pair that outdoor exposure with the foundations that support your own cellular energy: adequate food, appropriate carbohydrates, regular movement and natural daylight. Your microbiome and immune system don't exist in isolation. Supporting

the environment inside your body while allowing normal contact with the environment outside it gives you a practical strategy regardless of where you call home.

## **FAQs About the Immune System Farm Effect**

**Q: What is the "farm effect"?**

**A:** The farm effect refers to the lower rates of asthma and allergic conditions observed among children raised in farm environments. Research suggests that regular exposure to a rich variety of environmental microbes helps shape how the developing immune system responds to its surroundings.

**Q: Which bacteria were linked to the farm effect?**

**A:** Researchers identified nine genera of gram-positive bacteria that accounted for about two-thirds of the association between farm exposure and lower asthma risk. Other microbes, including fungi and viruses that infect bacteria, were present but didn't account for the protective association.

**Q: How do these farm bacteria interact with the immune system?**

**A:** The bacteria are predicted to produce or process compounds, several of which were detected in cowshed dust, that interact with AhR and PPAR $\gamma$ , two receptors on human cells involved in immune responses. Researchers also found that genetic differences affecting these receptors influenced how bacterial exposure related to asthma.

**Q: Do you need to live on a farm to support healthy microbial exposure?**

**A:** No. If you live in a city or suburb, ordinary outdoor activities such as gardening, spending time in parks and contact with soil, pets and plants provide opportunities to interact with a less sanitized environment. The study didn't establish these activities as substitutes for farm exposure.

**Q: What everyday steps support a healthier microbiome?**

**A:** Focus on minimally processed carbohydrates you tolerate, gradually increase whole-food variety and avoid ultraprocessed foods and seed oils. Ordinary natural soap rather than antibacterial soap, antibiotics only when truly necessary, and regular contact with natural outdoor environments also help you avoid unnecessarily disrupting microbial exposure.

*This article is for informational purposes only and does not constitute medical advice. Consult a qualified health care provider before making changes to your health regimen.*

## Sources and References

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- <sup>1, 2, 4</sup> [NEJM Evidence July 28, 2026](#)
- <sup>3</sup> [LMU Hospital July 28, 2026](#)