

# Exposure to Forest Biodiversity Encourages Immune Regulation

**This study is the first clinical trial using a biodiversity intervention to improve levels of biomarkers involved in immune regulation. It shows that, for children in daycare, modifying the outdoor daycare environment and encouraging interaction with natural materials from forests can alter human microbiome diversity and enhance immune regulation, and may aid the development of immune tolerance.**

Compared to rural dwellers, individuals living in urban environments have a higher incidence of immune-mediated diseases like autoimmune, inflammatory, or allergic conditions. Rural environments often have greater diversity in lifeforms and habitats, whereas urban areas show reduced overall biodiversity yet higher levels of pathogens, pollutants, and manmade materials. These alterations in living environs have been found to correlate with changes in immune cell activation and gut microbiome composition that may help explain why certain patterns of immune intolerance have become relatively common. Most children in developed societies now live in urban areas with limited access to natural biodiversity.

Residential ground cover and vegetation are known to influence human gut microflora composition, and early life contact with animal, plant, and microbial diversity is associated with immune tolerance. Regular and sometimes intensive exposure to a wide spectrum of plants, microbes, animals, fungi, invertebrates, and other life forms in natural settings repeatedly exercises regulatory pathways of the immune system, moderating overall immune reactivity and promoting tolerance. Increased time spent outdoors may also improve physical activity and



elevate mood and feelings of vitality, and all of these benefits should be taken into account in urban planning.

In this study, 75 urban-living children aged 3-5 years and attending daycare during weekdays were assigned to three study groups according to the outdoor landscaping arrangements at their daycare centers:

Nature-oriented daycares provided children with daily visits to nearby forests; Intervention daycares were provided enriched outdoor space coverings of forest floor vegetation (mainly from heather, moss, and berry plants), peat blocks, sod, and planters; Standard daycares provided typical outdoor areas having little or no green space, and served as the control.

Children played in these outdoor areas for an average of 1.5 hours each weekday over a 28-day period, and had direct contact with the natural and/or manmade materials in the designated study spaces. Researchers sampled and analyzed the children's skin and gut microbiota, plasma cytokines, and regulatory T immune cell counts before and after the 28-day intervention. Environmental microbiota for the Standard and Intervention outdoors spaces were also sampled and analyzed.

**According to this research team: “Our conclusion is that letting urban children play in microbiologically diverse dirt and vegetation alters skin and gut microbiota, which is accompanied by parallel changes in the immune system within a relatively short period of 1 month.”**

## Clinical Summary

Comparing the skin and gut microbiota diversity and circulating immune factors among children provided exposure to Nature-oriented, Intervention, and Standard outdoor spaces at daycare over a 28-day period, major findings from this study included the following:

- After intervention, children in the Intervention group showed increases in gut diversity of members of the Ruminococcaceae family of bacteria, which includes numerous species that generate butyric acid, a gut-nourishing short-chain fatty acid. Prior to intervention, children in the Standard and Intervention groups showed comparable diversity in Ruminococcaceae, while after intervention, children in the Intervention group showed Ruminococcaceae diversity more comparable to that of children in the Nature-oriented group.
- After intervention, the IL-10:IL-17A ratio increased significantly only in children in the Intervention group. Interleukin-17 (IL-17) is a proinflammatory cytokine implicated in several autoimmune conditions, while interleukin-10 (IL-10) has more immunomodulatory and anti-inflammatory associations.



- Prior to the intervention, children in Nature-oriented daycares showed greater overall skin Proteobacterial diversity than those in Intervention and Standard groups. After the intervention, children in the Intervention group displayed greater overall skin Proteobacterial diversity than those in the Standard group, with the Intervention group's Proteobacterial diversity approaching that of the Nature-oriented group.
- Children in the Intervention and Nature-oriented groups showed modest increases in skin Gammaproteobacteria diversity, and this finding correlated significantly with increased plasma levels of transforming growth factor-beta1 (TGF-β1). Skin Gammaproteobacteria diversity decreased in children in the Standard group, who also displayed a reduction in TGF-β1 levels. TGF-β1 is involved in downregulating processes that encourage inflammation, especially in the intestines.
- Greater skin Gammaproteobacteria diversity was also significantly associated with lower plasma IL-17A levels, higher IL-10 levels, and a higher percentage of regulatory T cells. Regulatory T cells are critical for regulating immune activation and maintaining immune tolerance.
- Children in the Nature-oriented group showed greater gut microbiota abundance of the desirable butyrate-producer *Faecalibacterium prausnitzii*, which was also associated with increased abundance of its relative *Anaerostipes*, another butyrate-producer, of which at least one species has been linked with tolerance to milk and nut allergens.

The authors note that direct physical contact with forest floor vegetation and dirt was encouraged in this study, as previous research has found that touching green landscaping materials is an effective means of diversifying skin Proteobacteria.

## CONCLUSION

**Time spent in natural outdoors settings is a crucial immune-regulating experience for urban dwellers, and especially for children. Direct exposure to forest biomes—or even just forest floor vegetation and dirt—is an effective means of altering balance among circulating immune factors (interleukins, regulatory T cells, etc.) that are key to developing immune tolerance. Biodiversity intervention is of growing importance for the management of dysbiosis and immune imbalance.**

