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Univerza v Mariboru

ANTAGONISTIC AND CLINICAL EFFECTS OF MULTI-STRAIN PROBIOTICS: EVIDENCE FROM OUR RESEARCH

University of Maribor, Faculty of Health Sciences, Slovenia

Full Prof. Dr. Sabina Fijan



PROF. Dr. SABINA FIJAN

CONTACT DATA

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AFFILIATION:
University of Maribor, Faculty of Health Sciences, Slovenia

TEACHING

- Employed at the University of Maribor, Slovenia since 1999
- teach subjects including: Microbiology | Biochemistry | Probiotics in Foods | Beneficial Microorganisms in Foods | Effects of Beneficial Microorganisms on Human Health
- My teaching and research are closely connected, with an emphasis on integrating fundamental microbiology with current developments in probiotics, nutrition and health.

ACADEMIC BACKGROUND

- I am a full professor of microbiology since May 2025.
- My earlier research focused on microbiology and hygiene, including the microbiological aspects of hospital textiles and infection-related environmental hygiene.
- I also completed a research mobility at Western Sydney University, Australia, further broadening my international academic and research experience.

RESULTS OF THE CLINICAL TRIAL PROURTI WITH OMNi-BiOTiC® Active

IN VITRO STUDIES OF ANTIMICROBIAL ACTIVITY OF PROBIOTICS

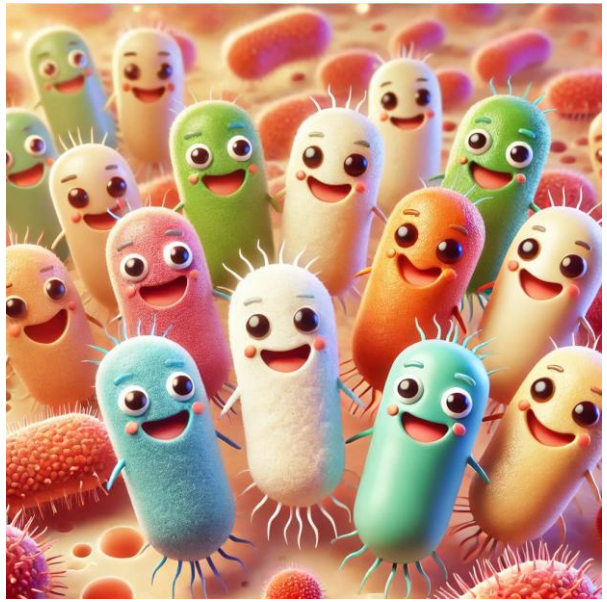
INTEGRATIVE REVIEW ON ANTAGONISTIC EFFECTS OF PROBIOTICS FOR WOUND INFECTIONS

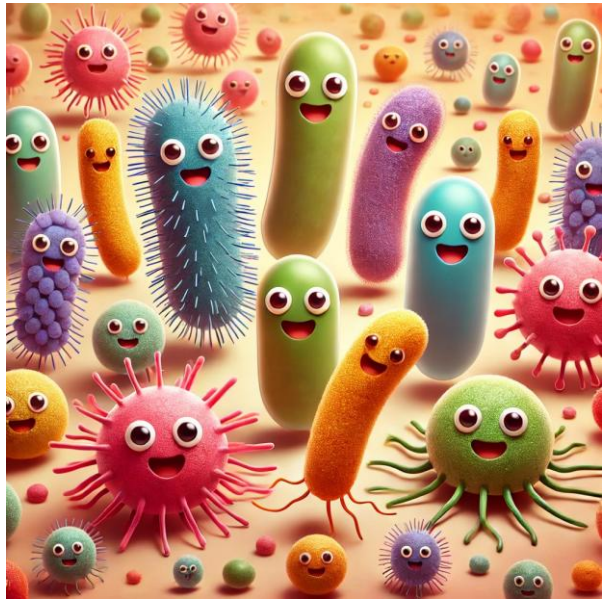
INTERNATIONAL SURVEY ON THE KNOWLEDGE OF PROBIOTICS AMONG HEALTH PROFESSIONALS

FINAL CONCLUSIONS

RESULTS OF THE CLINICAL TRIAL PROURTI WITH OMNi-BiOTiC® Active

URTI: Upper Respiratory Tract Infections







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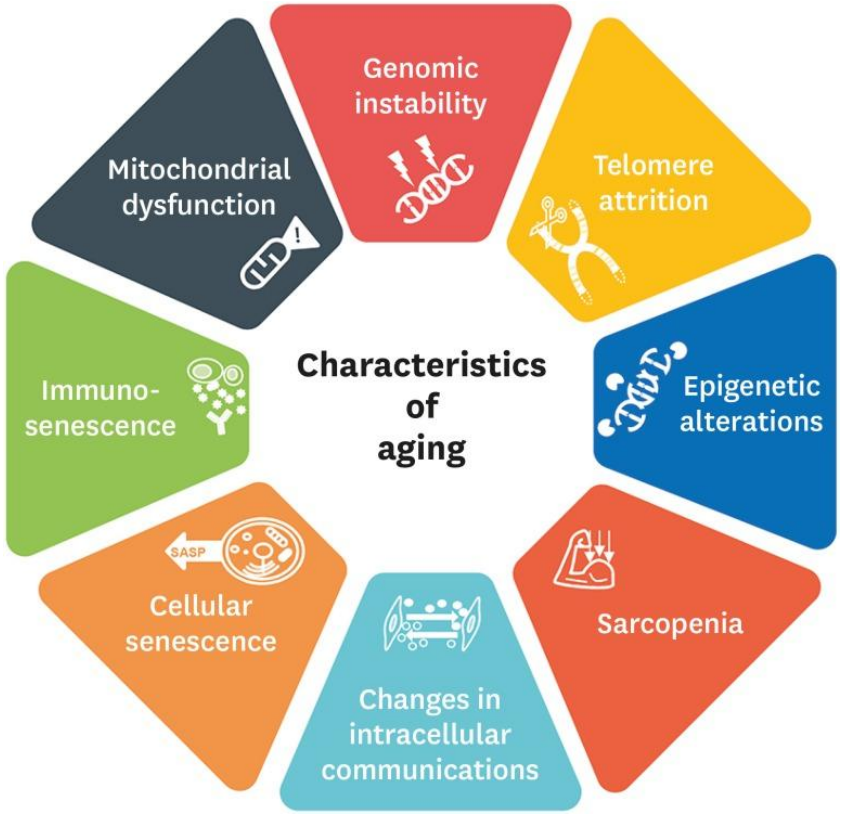
PROBIOTIC RESEARCH – CLINICAL STUDY

WHY FOCUS ON OLDER ADULTS

- The global population is ageing, and the number of people over 60 is increasing worldwide.
- As we age, our immune system changes and becomes less effective. This process, called **IMMUNOSENESCENCE**, makes us more susceptible to infections.
- Ageing is also associated with **INFLAMMAGING**, which means that the body has a low level of chronic inflammation.
- Respiratory infections are particularly important in older adults because they can lead to more severe illness, hospitalization and even death.
- Ageing also affects the gut microbiota, which may influence the gut microbiota–lung axis and the regulation of our immune system. This is where probiotics may have a role.



Oh, S. et al. (2025) Aging and the Immune System: the Impact of Immunosenescence on Viral Infection, Immunity and Vaccine Immunogenicity. Immune network, 19(6), e37.

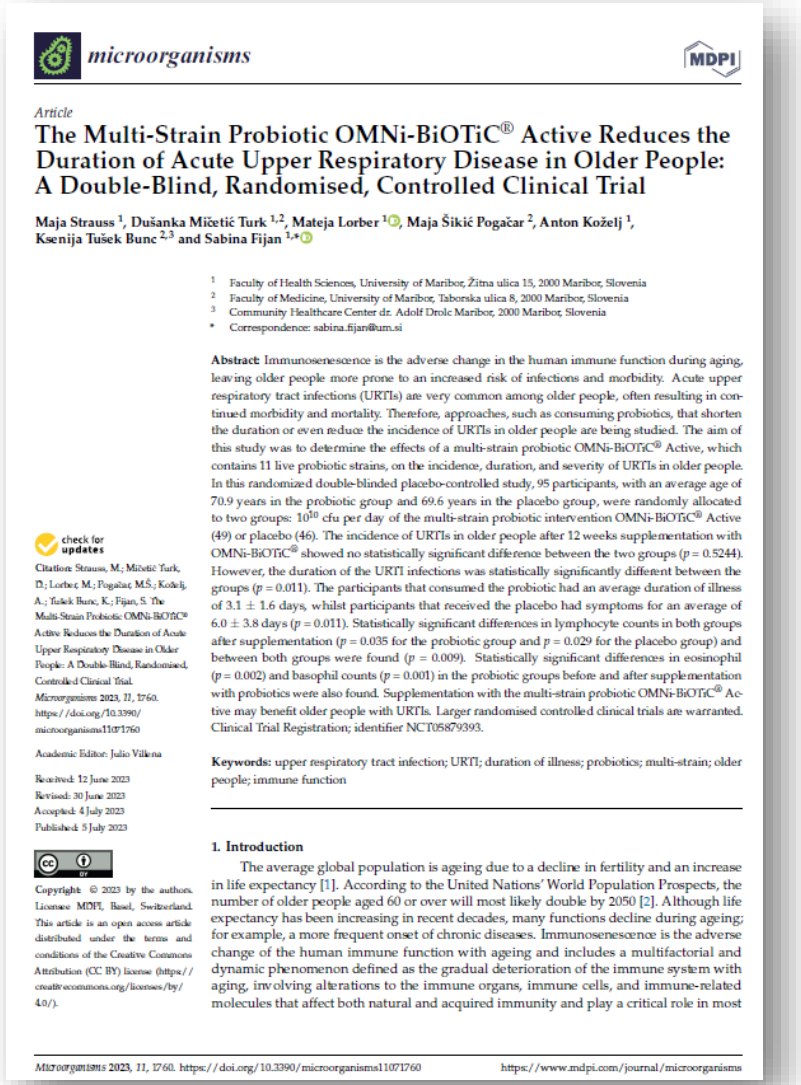
THE RATIONALE: Older adults are more vulnerable to respiratory infections because their ageing immune systems respond less effectively.

PROBIOTIC RESEARCH – CLINICAL STUDY

INTRODUCTION

1. **STUDY DESIGN**: Double-blind, randomized, placebo-controlled clinical trial.
2. **INTERVENTION:** 12 weeks of supplementation with the 11-strain probiotic OMNi-BiOTiC® Active versus placebo.
3. **OUTCOMES:** Incidence, duration, and severity of acute upper respiratory tract infections in older adults.





microorganisms

MDPI

Article

The Multi-Strain Probiotic OMNi-BiOTiC® Active Reduces the Duration of Acute Upper Respiratory Disease in Older People: A Double-Blind, Randomised, Controlled Clinical Trial

Maja Strauss [1], Dušanka Mičetić Turk [1,2], Mateja Lorber [1], Maja Šikić Pogačar [2], Anton Koželj [1], Ksenija Tušek Bunc [2,3] and Sabina Fijan [1,*]

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[2] Faculty of Medicine, University of Maribor, Taborska ulica 8, 2000 Maribor, Slovenia
[3] Community Healthcare Center dr. Adolf Drolc Maribor, 2000 Maribor, Slovenia
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Abstract: Immunosenescence is the adverse change in the human immune function during aging, leaving older people more prone to an increased risk of infections and morbidity. Acute upper respiratory tract infections (URTIs) are very common among older people, often resulting in continued morbidity and mortality. Therefore, approaches, such as consuming probiotics, that shorten the duration or even reduce the incidence of URTIs in older people are being studied. The aim of this study was to determine the effects of a multi-strain probiotic OMNi-BiOTiC® Active, which contains 11 live probiotic strains, on the incidence, duration, and severity of URTIs in older people. In this randomized double-blinded placebo-controlled study, 95 participants, with an average age of 70.9 years in the probiotic group and 69.6 years in the placebo group, were randomly allocated to two groups: 10^{10} cfu per day of the multi-strain probiotic intervention OMNi-BiOTiC® Active (49) or placebo (46). The incidence of URTIs in older people after 12 weeks supplementation with OMNi-BiOTiC® showed no statistically significant difference between the two groups ($p = 0.5244$). However, the duration of the URTI infections was statistically significantly different between the groups ($p = 0.011$). The participants that consumed the probiotic had an average duration of illness of 3.1 ± 1.6 days, whilst participants that received the placebo had symptoms for an average of 6.0 ± 3.8 days ($p = 0.011$). Statistically significant differences in lymphocyte counts in both groups after supplementation ($p = 0.035$ for the probiotic group and $p = 0.029$ for the placebo group) and between both groups were found ($p = 0.009$). Statistically significant differences in eosinophil ($p = 0.002$) and basophil counts ($p = 0.001$) in the probiotic groups before and after supplementation with probiotics were also found. Supplementation with the multi-strain probiotic OMNi-BiOTiC® Active may benefit older people with URTIs. Larger randomised controlled clinical trials are warranted. Clinical Trial Registration; identifier NCT05879393.

Keywords: upper respiratory tract infection; URTI; duration of illness; probiotics; multi-strain; older people; immune function

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Citation: Strauss, M.; Mičetić Turk, D.; Lorber, M.; Pogačar, M.Š.; Koželj, A.; Tušek Bunc, K.; Fijan, S. The Multi-Strain Probiotic OMNi-BiOTiC® Active Reduces the Duration of Acute Upper Respiratory Disease in Older People: A Double-Blind, Randomised, Controlled Clinical Trial. *Microorganisms* **2023**, *11*, 1760. https://doi.org/10.3390/microorganisms11071760

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1. Introduction

The average global population is ageing due to a decline in fertility and an increase in life expectancy [1]. According to the United Nations' World Population Prospects, the number of older people aged 60 or over will most likely double by 2050 [2]. Although life expectancy has been increasing in recent decades, many functions decline during ageing; for example, a more frequent onset of chronic diseases. Immunosenescence is the adverse change of the human immune function with ageing and includes a multifactorial and dynamic phenomenon defined as the gradual deterioration of the immune system with aging, involving alterations to the immune organs, immune cells, and immune-related molecules that affect both natural and acquired immunity and play a critical role in most

Microorganisms **2023**, *11*, 1760. https://doi.org/10.3390/microorganisms11071760 https://www.mdpi.com/journal/microorganisms

Fijan et al., (2023). The Multi-Strain Probiotic OMNi-BiOTiC® Active Reduces the Duration of Acute Upper Respiratory Disease in Older People: A Double-Blind, Randomised, Controlled Clinical Trial. Microorganisms, 11(7), 1760.

PROBIOTIC RESEARCH – CLINICAL STUDY

OMNi-BiOTiC® Active COMPOSITION

PLACEBO	PROBIOTIC
Rice starch, maltodextrin, plant proteins, potassium chloride, magnesium sulfate, and manganese sulfate.	Same composition as placebo plus 11 bacterial strains: *Bifidobacterium bifidum* W23 *Bifidobacterium breve* W25 *Bifidobacterium lactis* W51 *Bifidobacterium lactis* W52 *Bifidobacterium longum* W108 *Lactobacillus acidophilus* W37 *Levilactobacillus* brevis* W63 *Lacticaseibacillus* casei* W56 *Ligilactobacillus* salivarius* W24 *Lactococcus lactis* W19 *Lactococcus lactis* W58

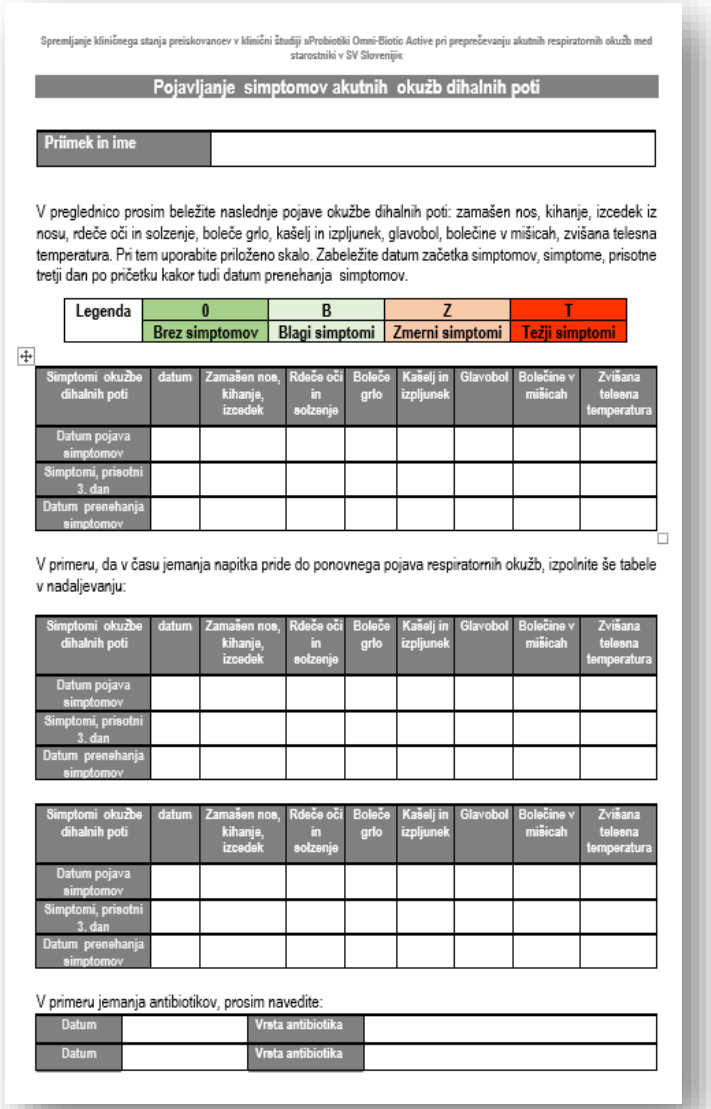


* New nomenclature of lactobacilli according to **Zheng** et al., (2020). A taxonomic note on the genus Lactobacillus: Description of 23 novel genera, emended description of the genus Lactobacillus Beijerinck 1901, and union of Lactobacillaceae and Leuconostocaceae. Int. J. Syst. Evol. Microbiol, 70, 2782–285.

PROBIOTIC RESEARCH – CLINICAL STUDY

STUDY DESIGN

- **PARTICIPANTS**: Adults aged >65 years were included in the study.
- **INTERVENTION**: Participants consumed a probiotic or placebo drink twice daily, in the morning and evening, for 12 weeks.
- **CLINICAL MONITORING**: Participants recorded episodes of acute upper respiratory tract symptoms in a symptom diary throughout the intervention period.
- **BLOOD SAMPLING**: Blood samples were collected at baseline and after 12 weeks for laboratory analysis.
- **QUESTIONNAIRES:** Sociodemographic data were collected, together with the Mini Nutritional Assessment (MNA) to assess nutritional status and risk of malnutrition, the EQ-5D-5L to assess health-related quality of life, and the SF-36 to evaluate general physical and mental health.



Spremljanje kliničnega stanja preiskovancev v klinični študiji »Probiotiki Omni-Biotic Active pri preprečevanju akutnih respiratornih okužb med starostniki v SV Sloveniji«

Pojavljanje simptomov akutnih okužb dihalnih poti

Priimek in ime	

V preglednico prosim beležite naslednje pojave okužbe dihalnih poti: zamašen nos, kihanje, izcedek iz nosu, rdeče oči in solzenje, boleče grlo, kašelj in izpljunek, glavobol, bolečine v mišicah, zvišana telesna temperatura. Pri tem uporabite priloženo skalo. Zabeležite datum začetka simptomov, simptome, prisotne tretji dan po pričetku kakor tudi datum prenehanja simptomov.

Legenda	0	B	Z	T
	Brez simptomov	Blagi simptomi	Zmerni simptomi	Težji simptomi

Simptomi okužbe dihalnih poti	datum	Zamašen nos, kihanje, izcedek	Rdeče oči in solzenje	Boleče grlo	Kašelj in izpljunek	Glavobol	Bolečine v mišicah	Zvišana telesna temperatura
Datum pojava simptomov								
Simptomi, prisotni 3. dan								
Datum prenehanja simptomov								

V primeru, da v času jemanja napitka pride do ponovnega pojava respiratornih okužb, izpolnite še tabele v nadaljevanju:

Simptomi okužbe dihalnih poti	datum	Zamašen nos, kihanje, izcedek	Rdeče oči in solzenje	Boleče grlo	Kašelj in izpljunek	Glavobol	Bolečine v mišicah	Zvišana telesna temperatura
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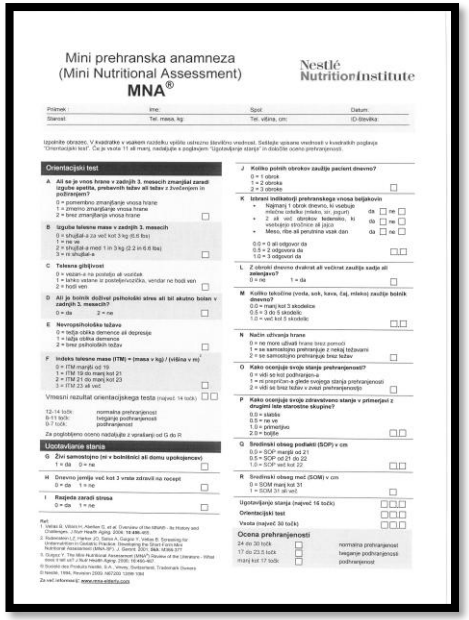
Simptomi okužbe dihalnih poti	datum	Zamašen nos, kihanje, izcedek	Rdeče oči in solzenje	Boleče grlo	Kašelj in izpljunek	Glavobol	Bolečine v mišicah	Zvišana telesna temperatura
Datum pojava simptomov								
Simptomi, prisotni 3. dan								
Datum prenehanja simptomov								

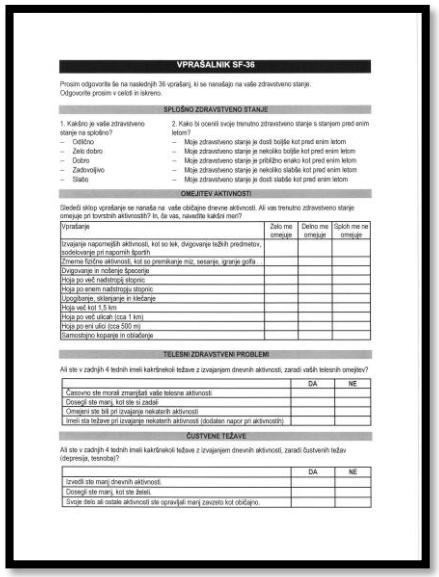
V primeru jemanja antibiotikov, prosim navedite:

Datum		Vrsta antibiotika	
Datum		Vrsta antibiotika	



Mini prehranska anamneza
(Mini Nutritional Assessment)
MNA®

Nestlé Nutrition Institute

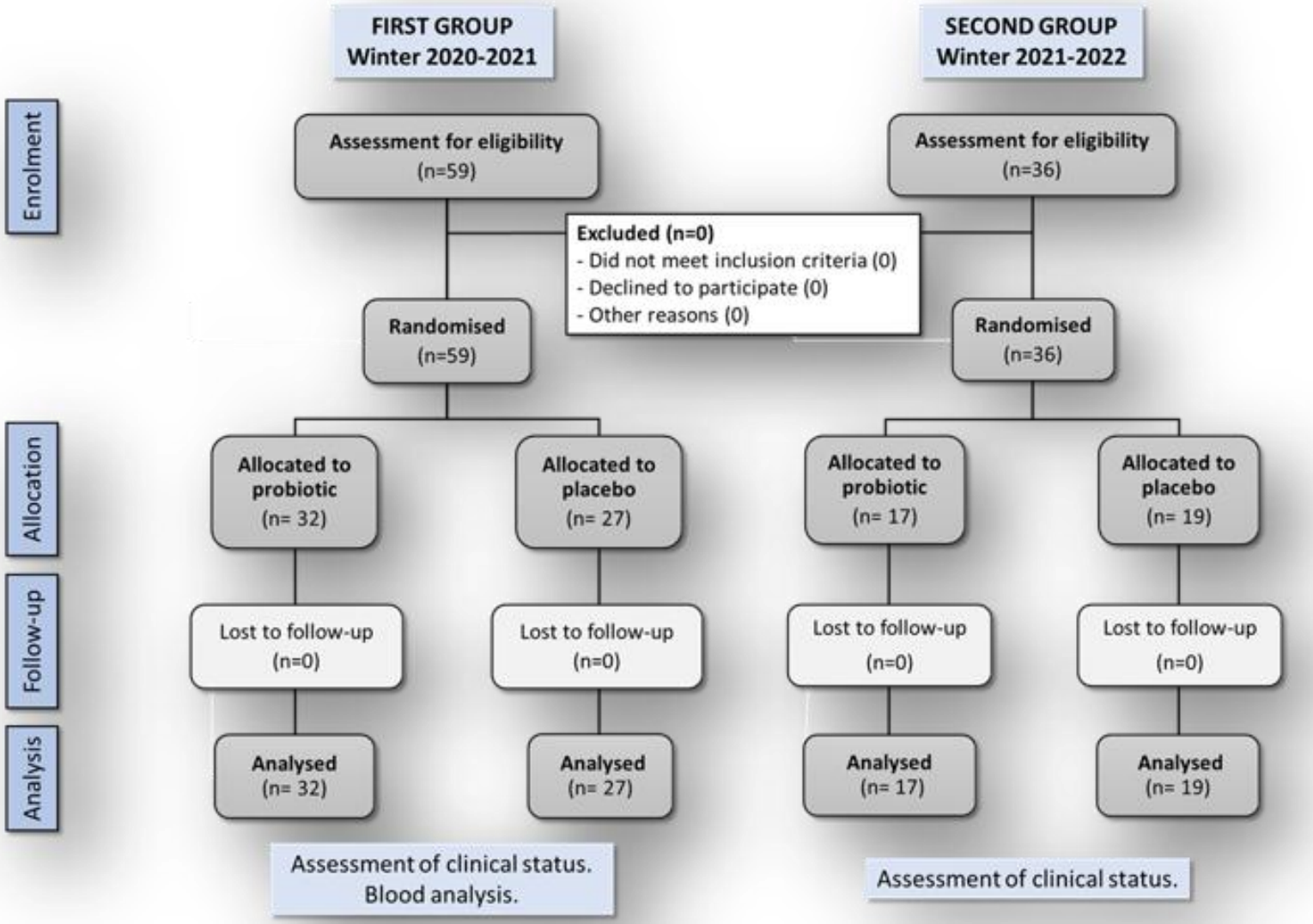


VPRAŠALNIK SF-36

PROBIOTIC RESEARCH – CLINICAL STUDY

PARTICIPANT FLOW

- The study included 95 participants, recruited in two winter cohorts:
  - 2020–2021 and
  - 2021–2022.
- Participants were randomly assigned to receive either the probiotic (n=49) or placebo (n=46).
- All randomized participants completed the study and were included in the final analysis.
- Blood analyses were performed in a subset of participants at baseline and after 12 weeks to assess changes in selected laboratory parameters.



PROBIOTIC RESEARCH – CLINICAL STUDY

RESULTS – INFECTION INCIDENCE AND DURATION

- **INFECTION INCIDENCE:** No statistically significant difference was observed between the probiotic and placebo groups.
- **DURATION Of INFECTION:** The probiotic group experienced a significantly shorter duration of infection compared with placebo (3.1 vs. 6.0 days; p = 0.011), representing an approximately 48% reduction in duration.

Variables of URTI Events	Probiotic Group (n = 49)		Placebo Group (n = 46)		p-Value
Total number of URTI events, number (%)	15	30.61%	17	36.96%	$p = 0.524$ *
Number of participants with URTI events	15	30.61%	14	30.43%	
0 URTI events per participant, number (%)	34	69.39%	32	69.57%	
1 URTI event, number of participants (%)	15	30.61%	12	26.09%	
2 URTI events, number of participants (%)	0	0%	1	2.17%	
3 URTI events, number of participants (%)	0	0%	1	2.17%	
Duration of URTI episodes, mean (SD)	3.1	(1.6)	6.0	(3.8)	$p = 0.011$ **

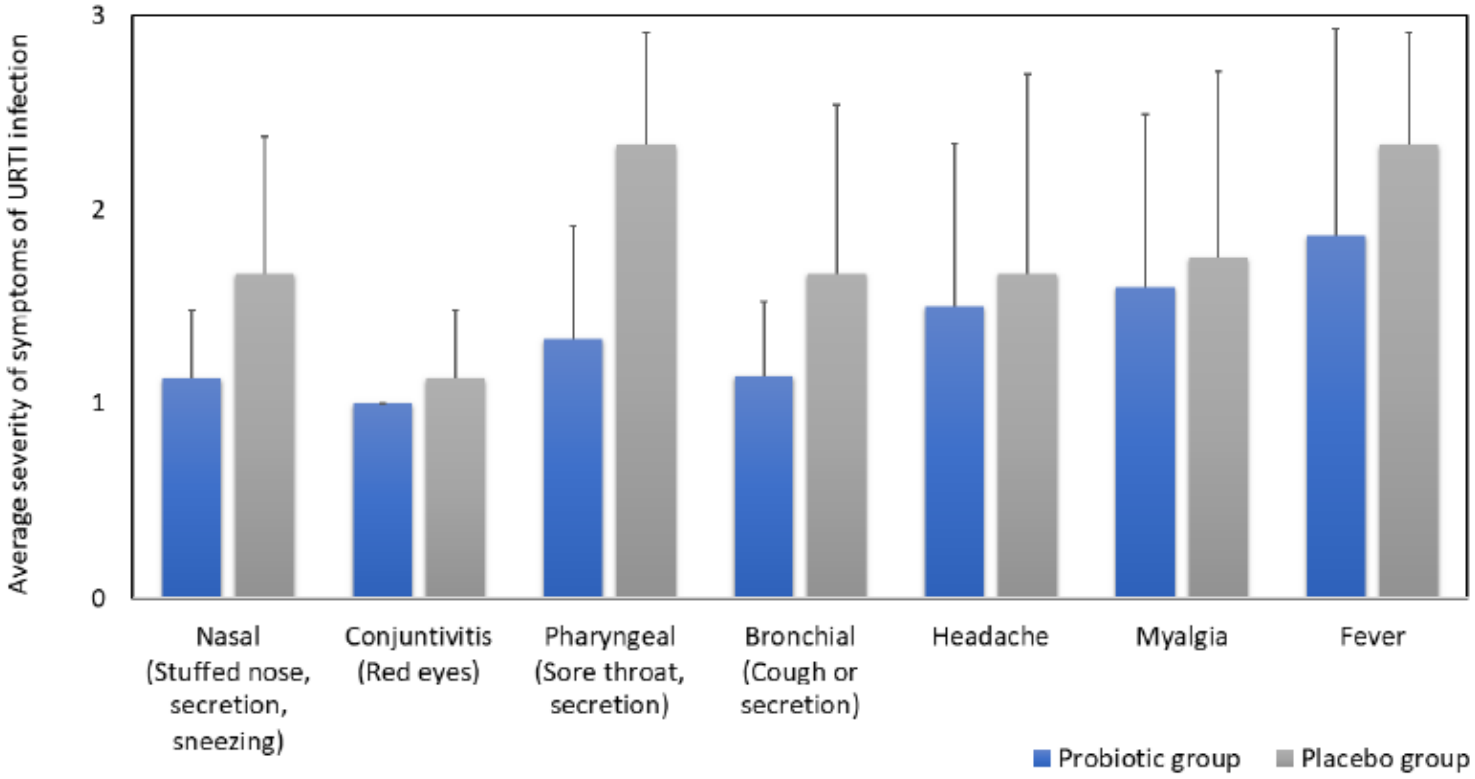
* Fisher's exact test, ** Mann–Whitney U test, SD—standard deviation, URTI—upper respiratory tract infection.

KEY FINDING: Probiotic intake significantly reduced the duration of infection by almost 50% 3.1 days vs. 6.0 days | p = 0.011

PROBIOTIC RESEARCH – CLINICAL STUDY

RESULTS – SYMPTOM SEVERITY

- **SYMPTOM SEVERITY:** A consistent trend toward lower symptom severity was observed in the probiotic group across all assessed symptoms, including nasal symptoms, conjunctivitis, pharyngeal and bronchial symptoms, headache, myalgia and fever.
- Although these differences did not reach statistical significance, all symptoms showed lower mean severity in the probiotic group.





KEY FINDING: Probiotic intake reduced symptom severity

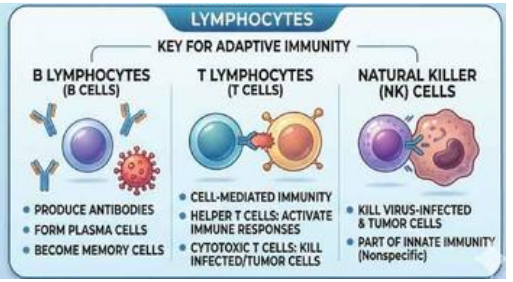
PROBIOTIC RESEARCH – CLINICAL STUDY

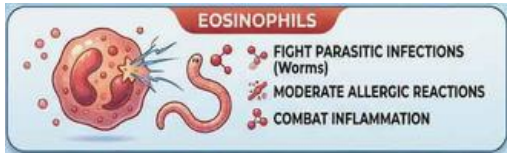
RESULTS – CHANGES IN IMMUNE CELLS AND IMMUNE-RELATED MOLECULES

- Probiotic supplementation was associated with STATISTICALLY SIGNIFICANT changes in LYMPHOCYTE, EOSINOPHIL and BASOPHIL counts. These changes suggest that the probiotic may have modulated specific components of the immune response during the 12-week intervention.

Blood Assessment		Probiotic Group (N = 32)				p Value #	Placebo Group (N = 27)				p Value #
Parameter	Unit	Baseline		12 Weeks			Baseline		12 Weeks		
		Mean		SD			Mean		SD		
Leukocytes	10^9/L	6.2	1.5	6.0	1.4	0.169	6.8	1.6	7.0	2.1	0.329
Neutrophils segm.	10^9/L	3.3	1.1	3.3	1.1	0.889	3.8	1.2	3.8	1.5	1.000
Lymphocytes	10^9/L	2.2	0.8	1.9	0.6	**0.035** *	2.2	0.6	2.6	1.0	**0.029** *
Monocytes	10^9/L	0.54	0.14	0.50	0.15	0.113	0.55	0.14	0.57	0.16	0.227
Eosinophils	10^9/L	0.25	0.15	0.16	0.08	**0.002** *	0.20	0.11	0.19	0.12	0.852
Basophils	10^9/L	0.06	0.05	0.02	0.04	**0.001** *	0.04	0.05	0.03	0.04	0.327
IgA	g/L	2.6	1.2	2.4	1.0	0.267	2.0	0.8	2.1	1.0	0.344

paired t-test (* $p < 0.05$); SD—standard deviation.







KEY FINDING: Together with the significant reduction in URTI duration, the findings are consistent with a potential immunomodulatory effect of the multi-strain probiotic.

PROBIOTIC RESEARCH – CLINICAL STUDY

DISCUSSION – WHY THESE FINDINGS MATTER

- Shortening the duration of respiratory infections may be beneficial for older adults, even if probiotics do not reduce the number of infections.
- Probiotics may influence the gut microbiota and the immune system, which could help explain the observed effects.
- Older adults could consider starting probiotic supplementation before the winter season. As immune-related effects may take around one month to develop, supplementation should ideally begin before the period when respiratory infections become more common.
- Further studies are needed to determine which probiotic strains or combinations are most effective, and how long they should be taken.

KEY MESSAGE: In older adults, supporting a faster recovery may be an important complementary goal alongside preventing infection.



microorganisms

MDPI

Article

The Multi-Strain Probiotic OMNi-BiOTiC® Active Reduces the Duration of Acute Upper Respiratory Disease in Older People: A Double-Blind, Randomised, Controlled Clinical Trial

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Keywords: upper respiratory tract infection; URTI; duration of illness; probiotics; multi-strain; older people; immune function

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Citation: Strauss, M.; Mičetić Turk, D.; Lorber, M.; Pogačar, M.Š.; Koželj, A.; Tušek Bunc, K.; Fijan, S. The Multi-Strain Probiotic OMNi-BiOTiC® Active Reduces the Duration of Acute Upper Respiratory Disease in Older People: A Double-Blind, Randomised, Controlled Clinical Trial. *Microorganisms* **2023**, *11*, 1760. https://doi.org/10.3390/microorganisms11071760

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1. Introduction

The average global population is ageing due to a decline in fertility and an increase in life expectancy [1]. According to the United Nations' World Population Prospects, the number of older people aged 60 or over will most likely double by 2050 [2]. Although life expectancy has been increasing in recent decades, many functions decline during ageing; for example, a more frequent onset of chronic diseases. Immunosenescence is the adverse change of the human immune function with ageing and includes a multifactorial and dynamic phenomenon defined as the gradual deterioration of the immune system with aging, involving alterations to the immune organs, immune cells, and immune-related molecules that affect both natural and acquired immunity and play a critical role in most

PROBIOTIC RESEARCH – CLINICAL STUDY





VABILO

Vljudno Vas vabimo na učno delavnico »**Zdrav življenjski slog in preprečevanje okužb zgornjih dihal pri starejših**«, ki bo potekala v soboto, dne **09.04.2022** s **pričetkom ob 09.00** uri v Predavalnici številka 2 (I. nadstropje) na **Fakulteti za zdravstvene vede Univerze v Mariboru, Žitna ulica 15, Maribor.**

09.00-09.10 **Uvodni pozdrav**

09.10-09.30 **Zdrav življenjski slog in preprečevanje okužb zgornjih dihal**
Viš predav. mag. Maja Strauss

09.30-09.50 **Gibanje za izboljšanje počutja in zdravja**
Izr. prof. dr. Jadranka Stričević

09.50-10.10 **Zdrava prehrana v starosti, na kaj moramo biti pozorni?**
Predav. Ksenija Ekart

10.10-10.30 **Kaj so probiotiki in drugi koristni mikroorganizmi in kakšna je njihova vloga v našem telesu**
Izr. prof. dr. Sabina Fijan

10.30 **Diskusija in zaključek srečanja**

Po izvedbi delavnice boste udeleženci imeli možnost, da vam **brezplačno izmerimo krvni sladkor in holesterol v krvi**. Vljudno vas prosimo, če se lahko kot udeleženci klinične študije udeležite dogodka, ki predstavlja drug del raziskave in je za vrednotenje rezultatov izjemnega pomena.

Svojo prisotnost sporočite na telefonsko številko: **02 300-47-00, najkasneje do torka 05.04.2022**. Na tel. smo dosegljivi v soboto od 08-12.00h in med tednom 07.00-19.00h.

Za udeležbo na delavnici se Vam vnaprej zahvaljujemo in Vas lepo pozdravljamo!

Opombe:

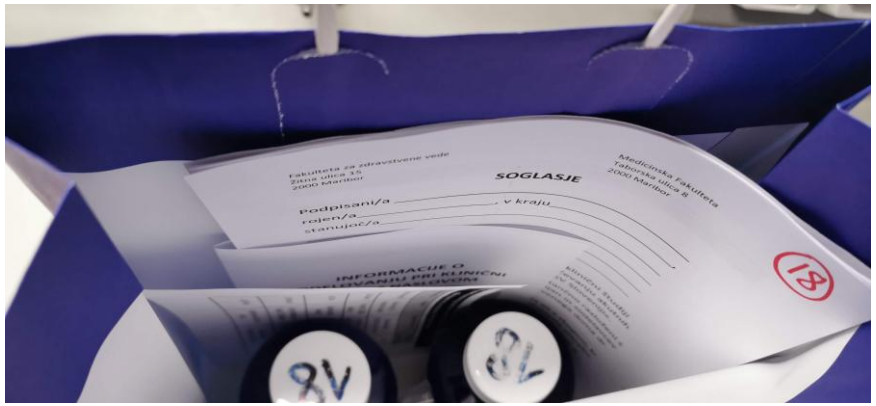
- *V javnih zavodih je zaradi preprečevanje okužbe s virusom SARS-CoV-2, še vedno obvezna uporaba zaščitnih mask. Prav tako bomo skušali vzdrževati medosebno razdaljo.*
- *Parkirišče je zagotovljeno.*

A seminar with some of our participants on health promotion and probiotics was conducted in the frame of the doctoral thesis of my student (Assist. Prof. Dr. Maja Strauss; Doctor of Nursing at the Faculty of Health Sciences).

PROBIOTIC RESEARCH – CLINICAL STUDY





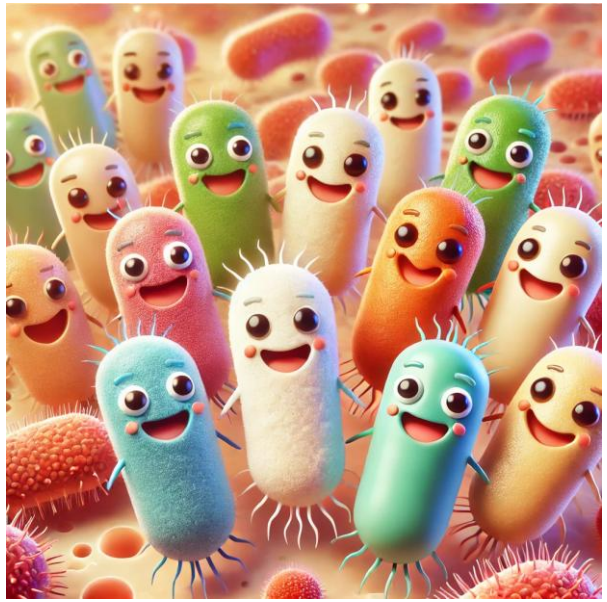


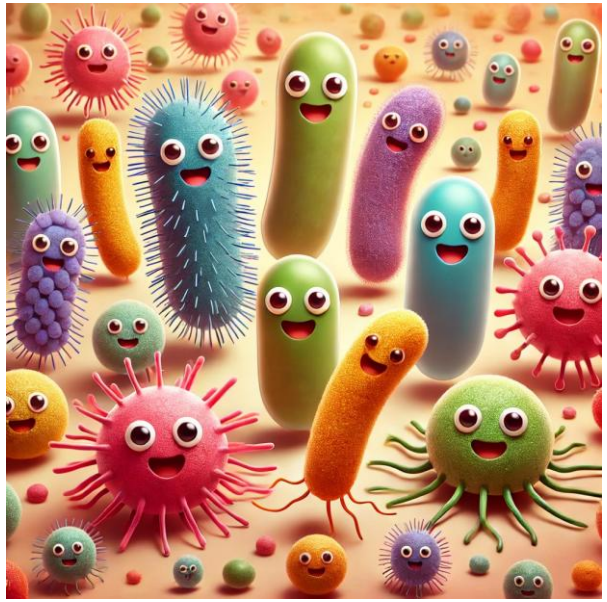




A few moments from our project activities

IN VITRO STUDIES OF ANTIMICROBIAL ACTIVITY OF PROBIOTICS







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IN VITRO PROBIOTIC RESEARCH – THE FIRST STEP

International Journal of *Environmental Research and Public Health*

MDPI

Article

Study of the In Vitro Antagonistic Activity of Various Single-Strain and Multi-Strain Probiotics against *Escherichia coli*

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Abstract: *Escherichia coli* is an important commensal of our gut, however, many pathogenic strains exist, causing various severe infections in the gut or beyond. Due to several antibiotic resistance patterns of *E. coli*, research of alternative treatments or adjuvant therapy is important. One of these is the use of probiotics as antagonistic agents against *E. coli*. Most published studies investigate only one strain of *E. coli* and single-strain probiotics. The objectives of this study were to evaluate the antagonistic activity of selected single-strain and multi-strain probiotic supplements against selected clinical *E. coli* pathotypes using the in vitro agar spot test and the co-culturing method. Molecular methods were used to determine the presence of the genus lactobacilli and bifidobacteria as well as certain selected strains in the probiotic supplements. The agar-spot test showed that the multi-strain probiotics were more effective than the single-strain probiotics. On the other hand, the co-culturing method showed the opposite result, indicating that results are importantly influenced by the chosen method. The most effective single-strain probiotics against *E. coli* strains were *Bifidobacterium animalis* subsp. *lactis* BB-12 and *Lactobacillus reuteri* DSM 17938. The most effective multi-strain probiotics contained lactobacilli, bifidobacteria and enterococci strains, thus proving that most effective probiotics against *E. coli* strains are the lactic acid bacteria and bifidobacteria. The overall results from both in vitro tests reveal that all selected probiotics exhibited an antagonistic activity against all *E. coli* strains. From a public health perspective probiotics have thus proved to be successful in inhibiting the growth of *E. coli* and could therefore be used as adjuvant therapy or alternative therapy in *E. coli* infections.

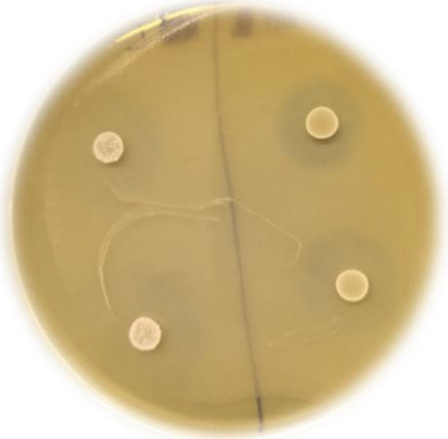
Keywords: probiotic; *Escherichia coli*; antagonistic effect

1. Introduction

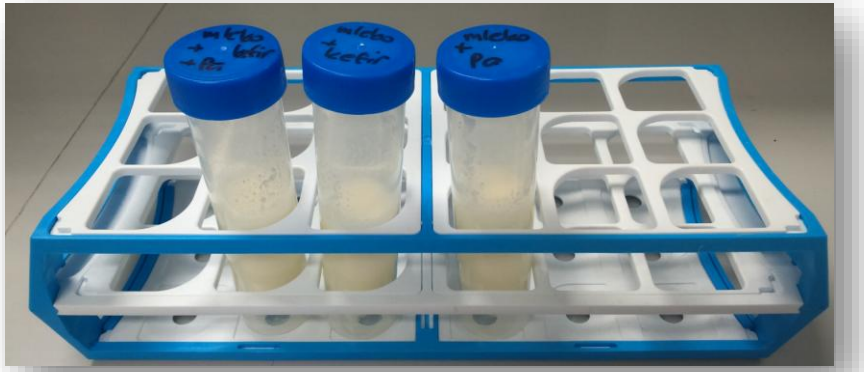
Escherichia coli is facultative anaerobe that is generally considered a commensal inhabitant or resident bacteria in lower numbers of the gastrointestinal tract of humans and warm-blooded animals as well as cold-blooded animals [1,2]. It is also one of the bacteria that colonizes the infant gut and aids in establishing an anaerobic environment which enables a shift to the colonisation of obligate anaerobes, of which bifidobacteria are the largest group in the infant microbiome [3,4]. In order to become a resident of the human gastrointestinal tract *E. coli* must evade host defenses, survive acidity in the stomach, acquire nutrients for survival, compete with other microorganisms and adhere to the gut epithelium by entering the mucus layer. Certain strains of *E. coli*, however, are some of the important causes of healthcare-associated infections and carry several virulent factors and can easily gain resistance to antibiotics, which include resistance caused by extended-spectrum

IN VITRO PROBIOTIC RESEARCH – NUMBER 1

In this **in vitro** study, we evaluated the antagonistic effect of single-strain and multi-strain probiotics (MSP1 – OMNi-BiOTiC Metabolic) against different **clinical pathogenic strains of *Escherichia coli*** using the AGAR SPOT TEST and CO-CULTURE METHOD.



AGAR SPOT TEST



CO-CULTURE METHOD

MSP1

3×10^9 cfu/3 g



Ligilactobacillus salivarius W57
Lacticaseibacillus rhamnosus W71
Lactobacillus acidophilus W22
Enterococcus lactis W54
Lacticaseibacillus paracasei W56
Lactococcus lactis subsp. lactis W58
Lactiplantibacillus plantarum W62

IN VITRO PROBIOTIC RESEARCH – THE FIRST STEP

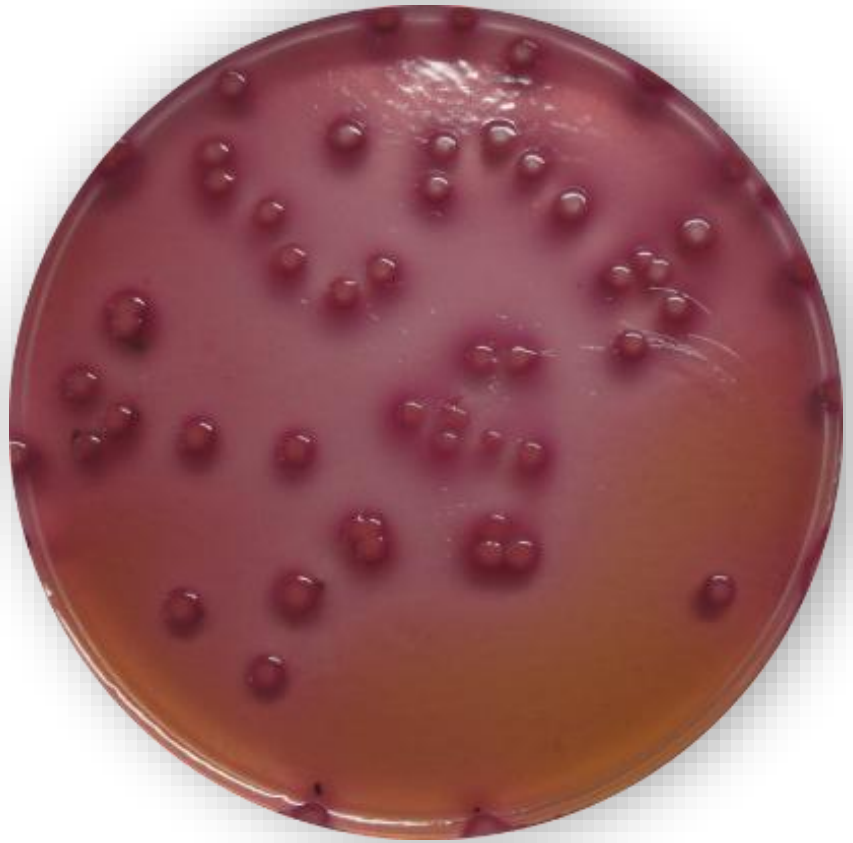
IN VITRO PROBIOTIC RESEARCH – NUMBER 1

Pathogenic *Escherichia coli* clinical isolates:

- EAEC – enteroaggregative *E. coli* (EAEC1, EAEC2, EAEC3),
- EPEC – enteropathogenic *E. coli* (EPEC1 and EPEC2),
- ETEC – enterotoxigenic *E. coli* (ETEC1),
- ESBL-positive *E. coli* – extended-spectrum β-lactamase (ESBL1),

Commensal *Escherichia coli* strains:

- *E. coli* K12 DSM 1562
- *E. coli* Nissle 1917



***E. coli* colonies on VRBG agar**
Photo: S. Fijan

Fijan et al., (2018). Fijan, S., Šulc, D., & Steyer, A. (2018). Study of the In Vitro Antagonistic Activity of Various Single-Strain and Multi-Strain Probiotics against Escherichia coli. International journal of environmental research and public health, 15(7), 1539.

IN VITRO PROBIOTIC RESEARCH – THE FIRST STEP

IN VITRO PROBIOTIC RESEARCH – NUMBER 1

- MULTI-STRAIN PROBIOTICS were more effective in the AGAR SPOT TEST, whereas SINGLE-STRAIN PROBIOTICS showed a better effect in the CO-CULTURE METHOD, demonstrating the important influence of the selected method.
- All tested probiotics inhibited *Escherichia coli* growth to some degree, supporting their potential as an adjunctive or alternative therapy for *Escherichia coli* infections.

Table 4. Antagonistic effect of probiotics against selected strains of *E. coli* using the agar spot test.

E. coli Strain	Mean Inhibition Zone Diameter * (mm ± SD)								
	SSP1	SSP2	SSP3	SSP4	SSP5	MSP1	MSP2	MSP3	MSP4
EAEC1	2.50 ± 0.71	3.00 ± 0.71	9.67 ± 3.51	1.50 ± 0.58	1.00 ± 0.50	12.00 ± 2.00	4.00 ± 0.57	8.67 ± 1.50	5.00 ± 0.82
EAEC2	1.00 ± 0.50	1.50 ± 0.41	4.00 ± 0.53	1.50 ± 0.71	1.00 ± 0.63	8.00 ± 0.82	5.50 ± 1.93	9.00 ± 1.00	5.50 ± 0.71
EAEC3	2.00 ± 0.82	2.50 ± 0.41	5.00 ± 0.53	1.00 ± 0.66	1.00 ± 0.44	7.00 ± 1.50	6.50 ± 2.14	5.50 ± 0.71	7.50 ± 0.58
EPEC1	4.50 ± 0.71	3.50 ± 0.50	5.00 ± 0.50	1.00 ± 0.53	1.00 ± 0.41	10.33 ± 1.15	5.50 ± 1.87	3.50 ± 0.71	5.00 ± 0.50
EPEC2	3.50 ± 0.71	2.67 ± 0.47	6.5 ± 0.71	2.00 ± 0.30	1.00 ± 0.63	4.5 ± 0.71	3.17 ± 0.48	4.0 ± 1.41	5.50 ± 0.72
ETEC	2.00 ± 0.57	3.00 ± 0.82	9.00 ± 2.65	1.00 ± 0.20	2.00 ± 0.82	5.00 ± 1.41	3.50 ± 1.04	3.5 ± 0.71	5.50 ± 0.71
ESBL	5.00 ± 0.50	4.00 ± 1.00	5.0 ± 1.00	1.00 ± 0.35	3.00 ± 1.00	3.50 ± 0.71	5.50 ± 1.80	2.00 ± 0.50	5.50 ± 1.00
Ec K12	0.00 ± 0.00	1.67 ± 0.47	9.00 ± 1.41	2.50 ± 0.71	1.00 ± 0.63	6.00 ± 1.41	4.50 ± 1.18	2.00 ± 0.50	9.5 ± 0.71
Mean	2.05	2.73	6.64	1.44	1.38	7.04	4.77	4.77	6.12

* mean of three separate trials in mm, measured from the outer edge of the colony to the edge of the clear zone.

Table 5. Antagonistic effect of probiotics against selected strains of *E. coli* using the co-culturing method.

E. coli Strain	Average Log Step Reduction of cfu/mL of *E. coli* Strains after Three Day Co-Culturing in Milk with Probiotics *							
	SSP1	SSP2	SSP3	SSP4	MSP1	MSP2	MSP3	MSP4
EAEC1	1.87	1.08	0.63	1.27	0.23	0.22	0.34	1.02
EPEC1	2.23	1.40	2.20	1.39	0.79	0.09	0.33	0.05
ETEC	1.73	1.78	2.13	0.55	1.03	1.24	1.00	1.25
ESBL	1.00	1.64	1.53	0.39	0.24	0.62	0.40	1.35
Ec K12	1.97	1.12	0.95	0.40	1.37	1.30	0.30	0.68
mean	1.76	1.40	1.49	0.73	0.73	0.69	0.47	0.87

* average log step reduction.

Fijan et al., (2018). Fijan, S., Šulc, D., & Steyer, A. (2018). Study of the In Vitro Antagonistic Activity of Various Single-Strain and Multi-Strain Probiotics against Escherichia coli. International journal of environmental research and public health, 15(7), 1539.

IN VITRO PROBIOTIC RESEARCH – THE FIRST STEP



microorganisms MDPI

Article

The Antimicrobial Effect of Various Single-Strain and Multi-Strain Probiotics, Dietary Supplements or Other Beneficial Microbes against Common Clinical Wound Pathogens

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Abstract: The skin is the largest organ in the human body and is colonized by a diverse microbiota that works in harmony to protect the skin. However, when skin damage occurs, the skin microbiota is also disrupted, and pathogens can invade the wound and cause infection. Probiotics or other beneficial microbes and their metabolites are one possible alternative treatment for combating skin pathogens via their antimicrobial effectiveness. The objective of our study was to evaluate the antimicrobial effect of seven multi-strain dietary supplements and eleven single-strain microbes that contain probiotics against 15 clinical wound pathogens using the agar spot assay, co-culturing assay, and agar well diffusion assay. We also conducted genera-specific and species-specific molecular methods to detect the DNA in the dietary supplements and single-strain beneficial microbes. We found that the multi-strain dietary supplements exhibited a statistically significant higher antagonistic effect against the challenge wound pathogens than the single-strain microbes and that lactobacilli-containing dietary supplements and single-strain microbes were significantly more efficient than the selected propionibacteria and bacilli. Differences in results between methods were also observed, possibly due to different mechanisms of action. Individual pathogens were susceptible to different dietary supplements or single-strain microbes. Perhaps an individual approach such as a 'probiogram' could be a possibility in the future as a method to find the most efficient targeted probiotic strains, cell-free supernatants, or neutralized cell-free supernatants that have the highest antagonistic effect against individual clinical wound pathogens.

Keywords: probiotics; beneficial microbes; wound pathogens; skin pathogens; agar spot; co-culturing; agar well diffusion; molecular methods; PCR

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Citation: Fijan, S.; Kocbek, P.; Steyer, A.; Vodičar, P.M.; Strauss, M. The Antimicrobial Effect of Various Single-Strain and Multi-Strain Probiotics, Dietary Supplements or Other Beneficial Microbes against Common Clinical Wound Pathogens. *Microorganisms* **2022**, *10*, 2518. https://doi.org/10.3390/microorganisms10122518

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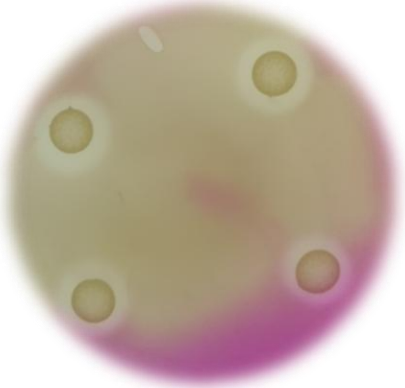
1. Introduction

The skin is the largest organ in the human body and is colonized by diverse microbiota. Most of these microbes are harmless or even beneficial and serve as physical barriers, protecting our bodies from potential assaults by foreign organisms or toxic substances. The skin, therefore, prevents disruption of this balance caused by the invasion of pathogens due to skin damage because of illness, surgery, and burns [1,2]. Skin damage can be caused by a variety of different reasons such as trauma (including cuts, abrasions, chemical burns, fire burns, cold, heat, radiation, and surgery), or as a consequence of underlying illnesses such as diabetes [3]. The most common wound pathogens include biofilm-forming bacteria such as *Staphylococcus aureus*, *Pseudomonas aeruginosa*, *Enterococcus faecalis*, *Acinetobacter baumannii*, *Escherichia coli*, *Klebsiella pneumoniae*, *Enterobacter* spp., *Bacteroides* spp., *Peptostreptococcus* spp. [4–7]. Especially chronic wounds are a prominent health concern as they represent an

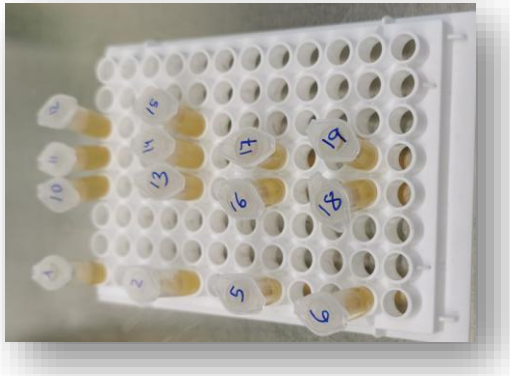
Fijan, et al. The Antimicrobial Effect of Various Single-Strain and Multi-Strain Probiotics, Dietary Supplements or Other Beneficial Microbes against Common Clinical Wound Pathogens. Microorganisms 2022, 10, 2518.

IN VITRO PROBIOTIC RESEARCH – NUMBER 2

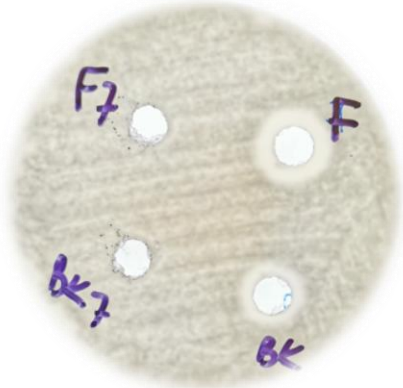
In this second ***in vitro*** study, we evaluated the antimicrobial efficacy of seven multi-strain and eleven single-strain probiotics against 15 clinical WOUND ISOLATES using three methods (AGAR SPOT TEST, CO-CULTURE and AGAR DIFFUSION TEST).



AGAR SPOT TEST



CO-CULTURE METHOD



AGAR DIFFUSION TEST



MS1 – OMNi-BiOTiC® Hetox



MS2 – OMNi-BiOTiC® Stress Repair



MS3 – OMNi-BiOTiC® 6



MS4 – OMNi-BiOTiC® Flora+



MS5 – OMNi-BiOTiC® Activ

IN VITRO PROBIOTIC RESEARCH – THE FIRST STEP

IN VITRO PROBIOTIC RESEARCH – NUMBER 2

The clinical isolates were obtained from patients with different types of wound and healthcare-associated infections, including:

- Leg ulcer infections
- Diabetic ulcer infections
- Inguinal infections following cardiac intervention
- Gastrostomy-site infections
- Central venous catheter-associated infections
- Sternal wound infections
- Surgical wound infections, including wound dehiscence
- Pressure ulcer (bedsore) infections
- Perianal infection.

Fijan, et al. The Antimicrobial Effect of Various Single-Strain and Multi-Strain Probiotics, Dietary Supplements or Other Beneficial Microbes against Common Clinical Wound Pathogens. Microorganisms 2022, 10, 2518.

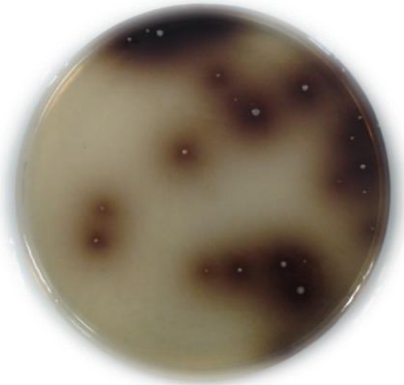
Table 3. Clinical pathogenic isolates and their origin.

Label	Pathogen	Origin
1	*Staphylococcus aureus*	Patient with leg ulcer infection
2		Patient with diabetic ulcer infection
3	*Pseudomonas aeruginosa*	Patient with inguinal infection after cardio intervention
4		Patient with gastrostomy site infection
5	*Enterococcus faecalis*	Patient with infection at central venous catheterization
6		Patient with sternal wound infection
7	*Escherichia coli*	Patient with surgical wound infection and dehiscence
8		Patient with surgical wound infection
9	*Klebsiella pneumoniae*	Patient with sternal wound infection
10		Patient with surgical wound infection
11	*Enterobacter* spp.	Patient with leg ulcer infection
12		Patient with inguinal infection after cardio intervention
13	*Acinetobacter* spp.	Patient with bedsore (pressure ulcer) infection
14	*Bacteroides* spp.	Patient with perianal infection
15		Patient with bedsore (pressure ulcer) infection



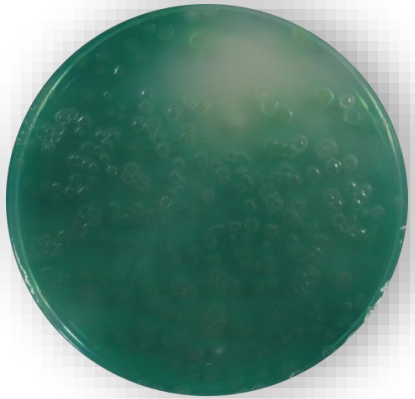
Staphylococcus aureus on Baird-Parker agar

Photo: S. Fijan



Enterococcus faecium on kanamycin-esculin azide agar

Photo: S. Fijan



Pseudomonas aeruginosa on cetrimide agar

Photo: S. Fijan

IN VITRO PROBIOTIC RESEARCH – THE FIRST STEP

IN VITRO PROBIOTIC RESEARCH – NUMBER 2

We found that multi-strain preparations, particularly those containing lactobacilli, were statistically significantly more effective than single-strain probiotics, and that efficacy strongly depended on the method and pathogen species. The results support the potential development of a "PROBIOGRAM" for individually tailored selection of effective probiotic strains or their metabolites for treating wound infections.

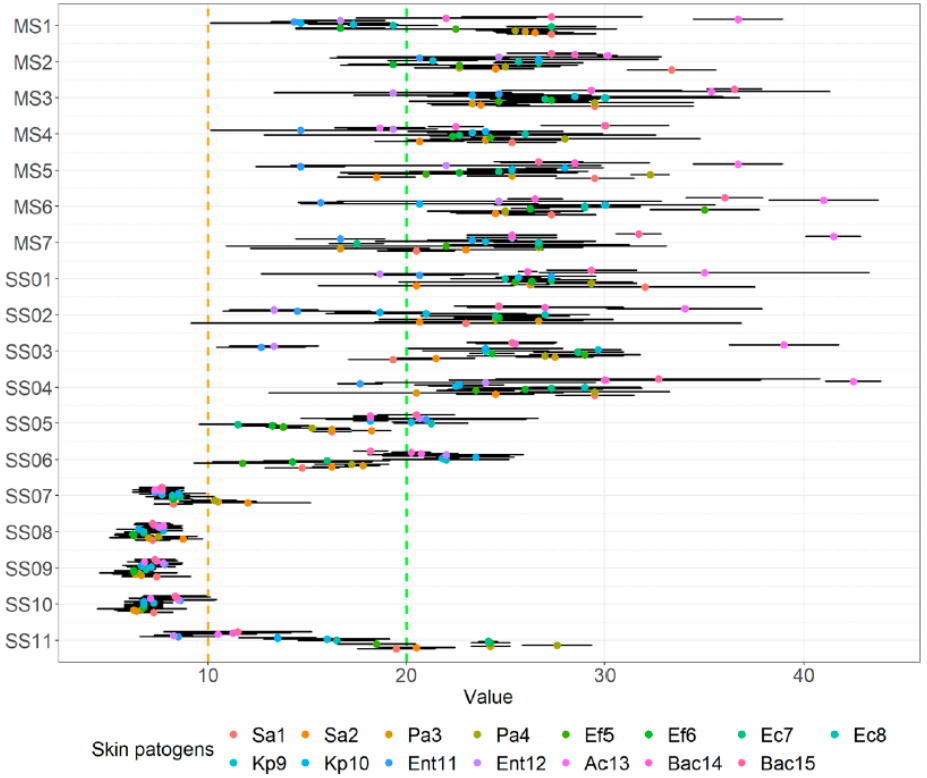


Figure 2. Means of inhibition zone together with 95% CI of various probiotics and other beneficial microbes against clinical skin pathogens using the agar spot assay.

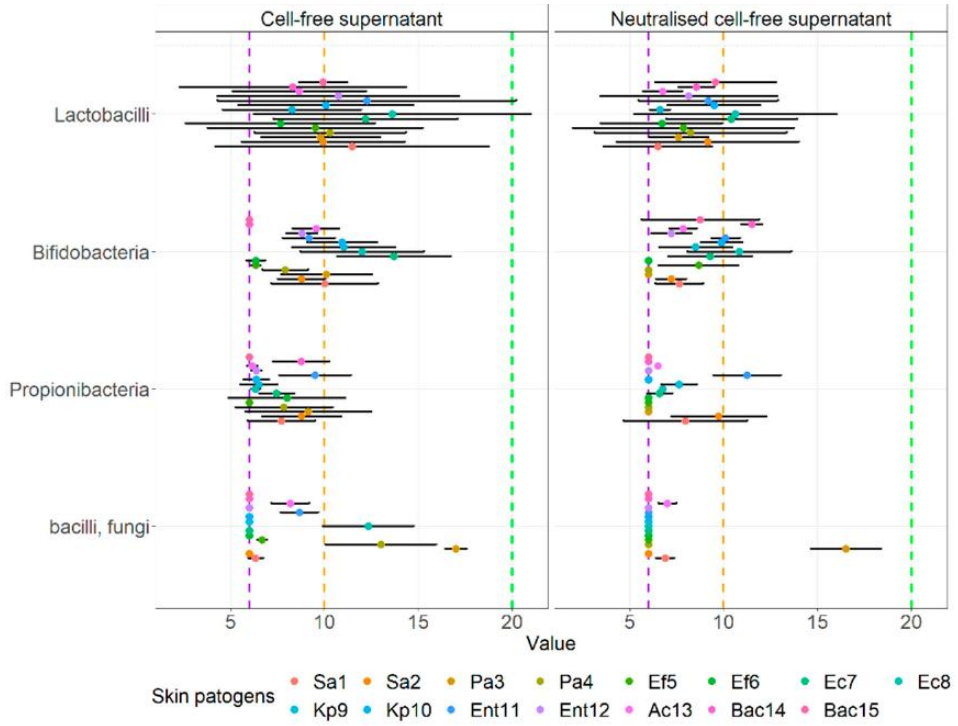
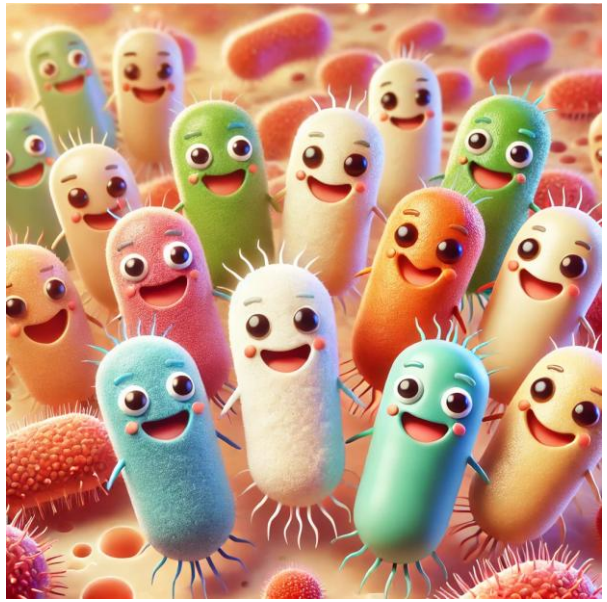
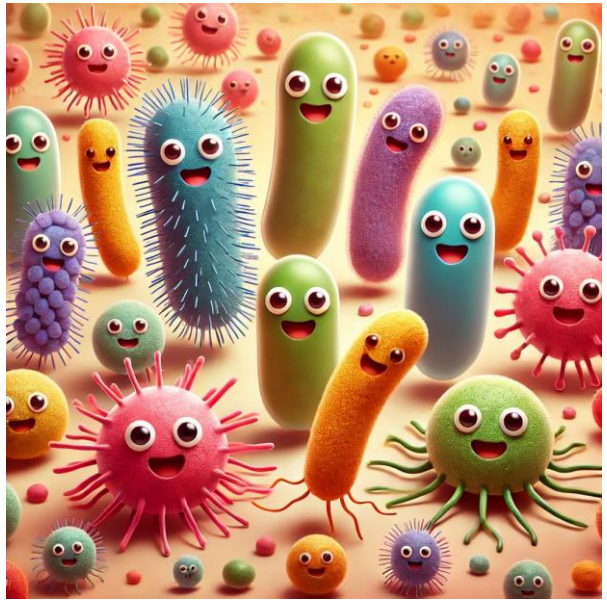


Figure 7. Means of inhibition zone together with 95% CI of cell-free supernatants of probiotics and other beneficial microbes, divided into groups according to main species, against clinical skin pathogens using the agar well diffusion assay.

INTEGRATIVE REVIEW ON ANTAGONISTIC EFFECTS OF PROBIOTICS FOR WOUND INFECTIONS







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REVIEW ARTICLES – BUILDING BLOCKS OF KNOWLEDGE FOR THE GENERAL PUBLIC

Hindawi
BioMed Research International
Volume 2019, Article ID 7585486, 21 pages
https://doi.org/10.1155/2019/7585486

Review Article

Efficacy of Using Probiotics with Antagonistic Activity against Pathogens of Wound Infections: An Integrative Review of Literature

Sabina Fijan,[1] Anita Frauwallner,[2] Tomaž Langerholc,[3] Bojan Krebs,[4] Jessica A. ter Haar (née Younes),[5] Adolf Heschl,[2] Dušanka Mičetić Turk,[1,6] and Irena Rogelj[7]

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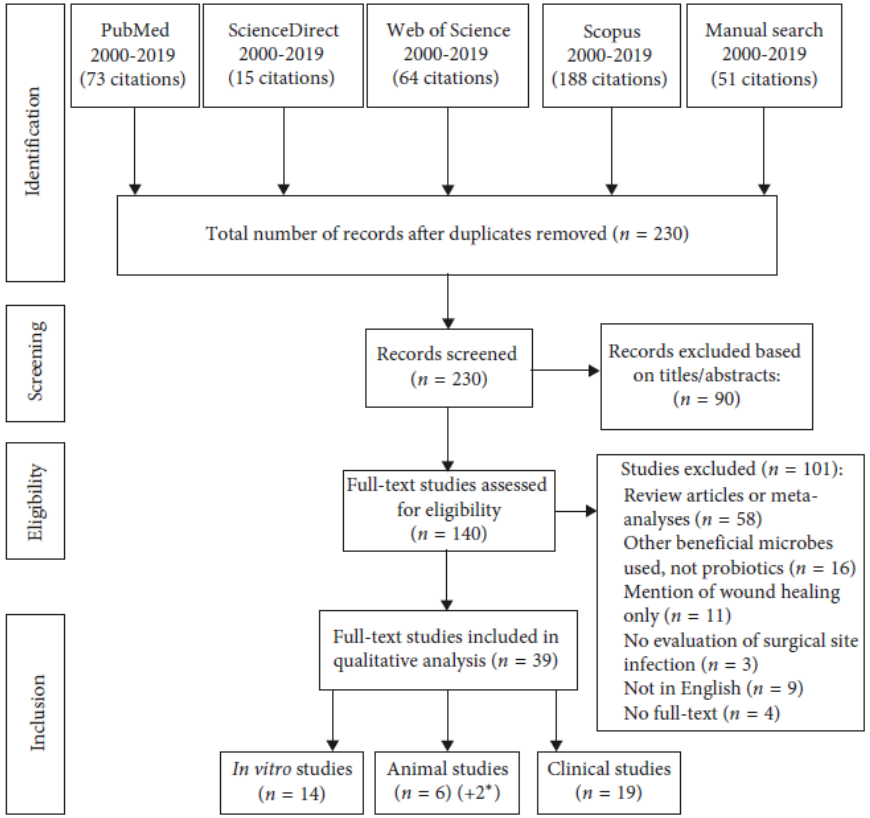
The skin and its microbiota serve as physical barriers to prevent invasion of pathogens. Skin damage can be a consequence of illness, surgery, and burns. The most effective wound management strategy is to prevent infections, promote healing, and prevent excess scarring. It is well established that probiotics can aid in skin healing by stimulating the production of immune cells, and they also exhibit antagonistic effects against pathogens via competitive exclusion of pathogens. Our aim was to conduct a review of recent literature on the efficacy of using probiotics against pathogens that cause wound infections. In this integrative review, we searched through the literature published in the international following databases: PubMed, ScienceDirect, Web of Science, and Scopus using the search terms "probiotic" AND "wound infection." During a comprehensive review and critique of the selected research, fourteen *in vitro* studies, 8 animal studies, and 19 clinical studies were found. Two of these *in vitro* studies also included animal studies, yielding a total of 39 articles for inclusion in the review. The most commonly used probiotics for all studies were well-known strains of the species *Lactobacillus plantarum*, *Lactobacillus casei*, *Lactobacillus acidophilus*, and *Lactobacillus rhamnosus*. All *in vitro* studies showed successful inhibition of chosen skin or wound pathogens by the selected probiotics. Within the animal studies on mice, rats, and rabbits, probiotics showed strong opportunities for counteracting wound infections. Most clinical studies showed slight or statistically significant lower incidence of surgical site infections, foot ulcer infection, or burn infections for patients using probiotics. Several of these studies also indicated a statistically significant wound healing effect for the probiotic groups. This review indicates that exogenous and oral application of probiotics has shown reduction in wound infections, especially when used as an adjuvant to antibiotic therapy, and therefore the potential use of probiotics in this field remains worthy of further studies, perhaps focused more on typical skin inhabitants as next-generation probiotics with high potential.

INTEGRATIVE REVIEW

In this research, we analysed studies on the antagonistic effect of probiotics against pathogens of wound infections and included thirty-nine *in vitro*, *in vivo* and clinical studies.



REVIEW ARTICLES – BUILDING BLOCKS OF KNOWLEDGE FOR THE GENERAL PUBLIC

INTEGRATIVE REVIEW

The studies predominantly reported positive effects of strains of *Lactiplantibacillus plantarum* and *Lacticaseibacillus rhamnosus* in reducing infections and accelerating healing. The results indicate that certain probiotic strains have potential as an adjunctive therapy, particularly in combination with antibiotics.

Table 4: CASP quality assessment checklist of included clinical trials using the CASP checklist for randomised controlled trials.

First author, year	Section A						Section B		Section C		
	1	2	3	4	5	6	7	8	9	10	11
Rayes, 2002 [82]	Yes	Yes	Yes	Yes	Yes	No	Small	Partial	Yes	Yes	Yes
Kanazawa, 2005 [83]	Yes	Yes	cannot tell	cannot tell	Yes	Yes	Some	Partial	Yes	Yes	Yes
Rayes, 2005 [84]	Yes	Yes	Yes	Yes	Yes	Yes	Small	Partial	Yes	Yes	Yes
Sugawara 2006 [56]	Yes	Yes	Yes	cannot tell	Yes	NA*	NA*	Partial	Yes	No	Yes
Rayes, 2007 [85]	Yes	Yes	Yes	Yes	Yes	Yes	Small	Partial	Yes	Yes	Yes
Peral, 2009 [22]	Yes	cannot tell	Yes	cannot tell	Yes	cannot tell	Large	Partial	Yes	Yes	Yes
Peral, 2010 [86]	Yes	No	Yes	No	No	NA*	NA*	Partial	Yes	No	Yes
Liu, 2011 [87]	Yes	Yes	Yes	Yes	Yes	Yes	Some	Precise	Yes	Yes	Yes
Usami, 2011 [88]	Yes	Yes	Yes	cannot tell	Yes	Yes	Small	Not precise	Yes	Yes	Yes
Zhang, 2012 [89]	Yes	Yes	cannot tell	Yes	Yes	Yes	Some	Precise	Yes	Yes	Yes
Zhang, 2013 [90]	Yes	cannot tell	Yes	cannot tell	Yes	Yes	Some	Partial	Yes	Yes	Yes
Sadahiro, 2014 [57]	Yes	Yes	Yes	cannot tell	Yes	Yes	Some	Precise	Yes	Yes	Yes
Aisu, 2015 [91]	Yes	No	cannot tell	No	Yes	Yes	Some	Precise	Yes	Yes	Yes
Kotzampassi, 2015 [58]	Yes	Yes	Yes	Yes	Yes	Yes	Some	Precise	Yes	Yes	Yes
Mayes, 2015 [92]	Yes	Yes	Yes	cannot tell	Yes	Yes	Some	Precise	Yes	Yes	Yes
El-Ghazely, 2016 [93]	Yes	Yes	Yes	Yes	Yes	Yes	Some	Precise	Yes	Yes	Yes
Kotmatsu, 2016 [94]	Yes	Yes	Yes	No	No	Yes	Some	Precise	Yes	Yes	Yes
Yang, 2016 [95]	Yes	Yes	Yes	Yes	Yes	Yes	Small	Precise	Yes	Yes	Yes

1. Does the trial address a clearly focused issue? 2. Was the assignment of patients to treatments randomized? 3. Were all the patients who entered the trial properly accounted for at its conclusion? Were patients, health workers and study personnel "blind" to treatment? 5. Were the groups similar at the start of the trial? 6. Aside from the experimental intervention, where the groups treated equally? 7. How large was the treatment effect? 8. How precise was the estimate of the treatment effect? 9. Can the results be applied to local population, or in your context? 10. Were all clinically important outcomes considered? 11. Are the benefits worth the harms and costs? *NA-not applicable, because was no control group.

Table 5: CASP quality assessment checklist of included case study using the CASP checklist for appraising a case-controlled study.

First author, year	Section A							Section B			Section C	
	1	2	3	4	5	6a	6b	7	8	9	10	11
Thomson, 2012 [55]	Yes	Yes	Yes	No	cannot tell	No	cannot tell	Small	Mostly	Yes	Yes	Yes

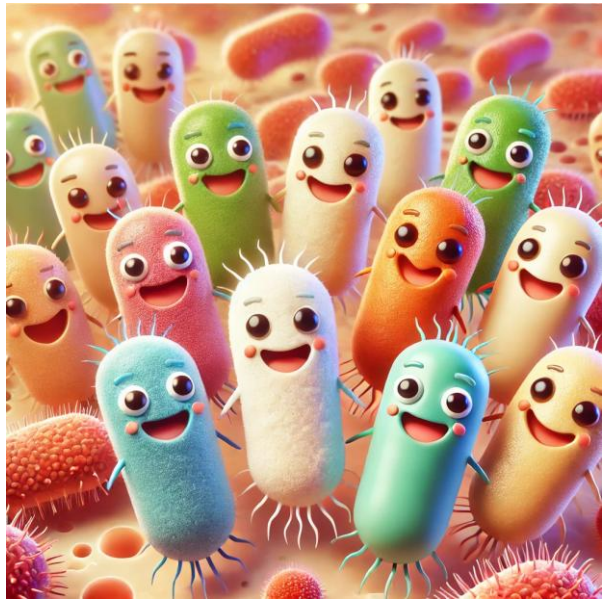
1. Did the study address a clearly focused issue? 2. Did the authors use an appropriate method to answer their question? 3. Were the cases recruited in an acceptable way? 4. Were the controls selected in an acceptable way? 5. Was the exposure accurately measured to minimise bias? 6a. Aside from the experimental intervention, where the groups treated equally? 6b. Have the authors taken account of the potential confounding factors in the design and/or in their anaylsis? 7. How large was the treatment effect? 8. How precise was the estimate of the treatment effect? 9. Do you believe the results? 10. Can the results be applied to local population? 11. Do the results of this study fit with other available information?

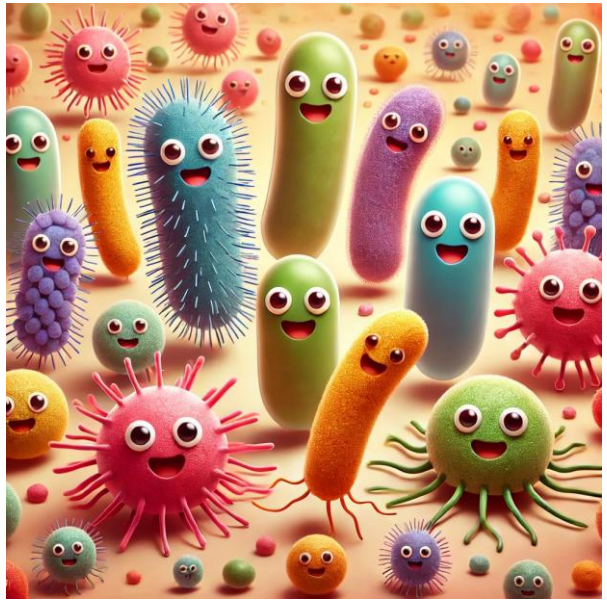
Table 6: Most commonly used probiotic species in the investigated studies against wound pathogens.

Probiotic species	Study type		
	In vitro References	Animal References	Clinical study References
Lactobacillus plantarum	[61]#, [64, 67, 71, 74, 75]	[61]#, [76, 78–80]	[22, 58, 82, 84–87, 90]
Lactobacillus casei	[64, 71, 73]		[55, 56, 83, 88–90, 94]
Lactobacillus acidophilus	[70, 71, 73, 75]		[58, 87, 95]
Lactobacillus rhamnosus	[66, 69, 70, 73]		[90, 92]
Lactobacillus fermentum	[63, 65]	[77]	[93]
Bifidobacterium breve			[56, 83, 88, 94]
Bifidobacterium longum	[71]		[87, 88, 95]
Lactobacillus reuteri	[64, 66, 72]		
Bifidobacterium lactis	[71]		[58, 90]
Bifidobacterium longum	[71]		[87, 88, 95]
			[57]
Bifidobacterium bifidum	[75]		[93]
Lactobacillus delbrueckii	[71]		[84, 85]
Pediococcus pentosaceus			[84, 85]
Leuconostoc mesenteroides			
Propionibacterium acnes	[68]#	[68]#	
Lactobacillus brevis	[71]		[90]
Lactobacillus paracasei			[84, 85]
Saccharomyces boulardii			[58]
Bifidobacterium animalis	[71]		
Lactobacillus salivarius	[71]		
Bacillus coagulans	[75]		
Bacillus mesentericus			[91]
Clostridium butyricum			[91]

#Study includes *in vitro* and animal model studies.

INTERNATIONAL SURVEY ON THE KNOWLEDGE OF PROBIOTICS AMONG HEALTH PROFESSIONALS







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SURVEY ON PROBIOTIC KNOWLEDGE AMONG HEALTH PROFESSIONALS

International Journal of Environmental Research and Public Health

MDPI

Article

Health Professionals' Knowledge of Probiotics: An International Survey

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Abstract: The objective of this study was to survey health professionals to investigate their knowledge of probiotics. An online survey was conducted to gather data on the knowledge of health professionals. The online survey was distributed via email and social media platforms using snowball sampling. A total of 1066 health professionals (859; 80.6% female) from 30 countries responded to the survey. Most of the respondents evaluated their knowledge of probiotics as medium (36.4%) or good (36.2%). Only 8.9% of the respondents rated it as excellent. No statistical difference in knowledge was found between male and female health professionals. Over 80% of pharmacists, allied health professionals, medical doctors and dentists, and other health professionals knew the correct definition of probiotics as "live microorganisms that, when administered in adequate amounts, confer a health benefit on the host", whereas three quarters of registered nurses and midwives and less than two thirds of psychologists identified the correct definition. Statistically, more female than male health professionals knew the correct definition of probiotics. The most frequently recognized species of bacteria containing probiotic strains were *Lactobacillus acidophilus* (92%), *Bifidobacterium bifidum* (82%), and *Lactobacillus rhamnosus* (62%). The opinions on when it is best to take probiotics were different ($\chi^2 = 28.375$; $p < 0.001$), with 90.2% of respondents identifying that probiotics have beneficial effects if taken during antibiotic therapy, 83.5% for diarrhea, 70.6% for constipation, 63.3% before traveling abroad, and 60.4% for treating allergies. Almost 79% of health professionals involved in this study have advised their patients to use probiotics and 57.5% of the respondents wanted to learn more about probiotics. All things considered, health professionals have a medium level of knowledge of probiotics, which could be improved by the implementation of targeted learning programs. As probiotics have many beneficial effects in a wide range of health areas, health professionals need to adopt the use of probiotics in clinical practice.

Keywords: probiotics; knowledge; health professionals

SURVEY ON PROBIOTIC KNOWLEDGE

- In 2018, we conducted an international survey of probiotic knowledge among 1,066 healthcare professionals from 30 countries.
- Most rated their knowledge as MODERATE to GOOD, while only 8.9% rated it as VERY GOOD.

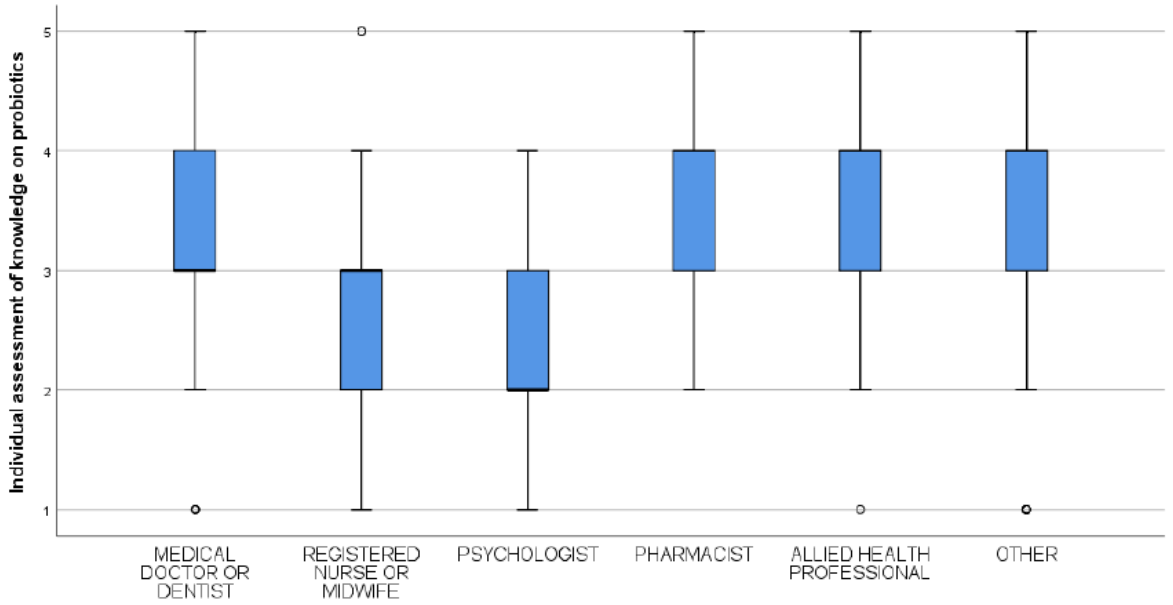
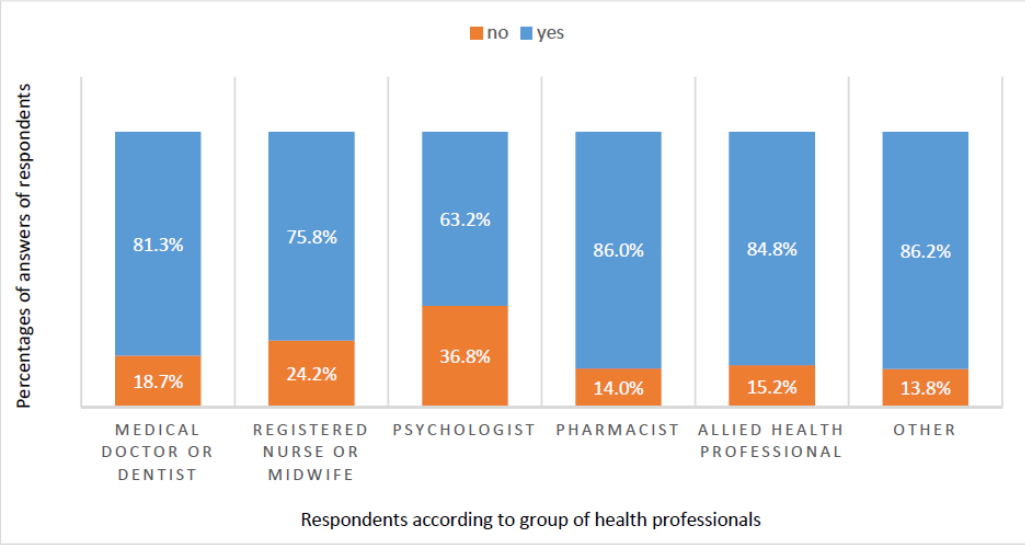


Figure 1. Self-evaluation of knowledge about probiotics by profession (1: No knowledge; 2: Little knowledge; 3: Medium knowledge; 4: Good knowledge; and 5: Very good knowledge). The boxplots show the quartiles for each group of healthcare professionals.

SURVEY ON PROBIOTIC KNOWLEDGE AMONG HEALTH PROFESSIONALS

SURVEY ON PROBIOTIC KNOWLEDGE

- PHARMACISTS and PHYSICIANS showed the HIGHEST level of correct knowledge of the probiotic DEFINITION, while PSYCHOLOGISTS showed the lowest.
- Almost 80% of participants already recommend probiotics in practice, while more than half would like additional education, indicating a need for targeted educational programs to improve the use of probiotics in clinical practice.



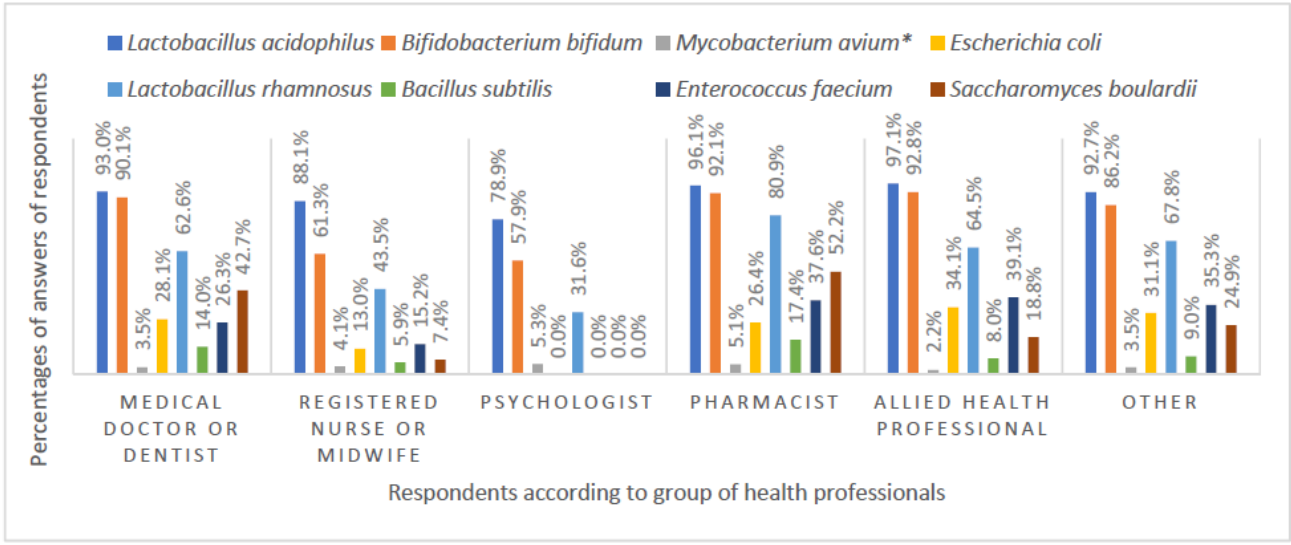
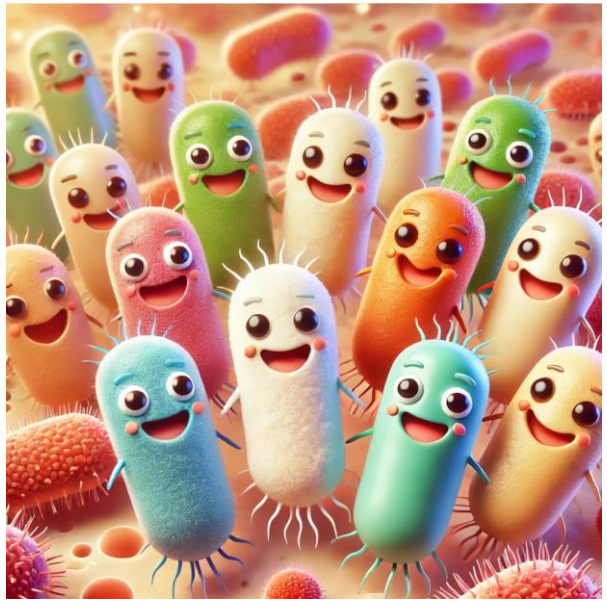
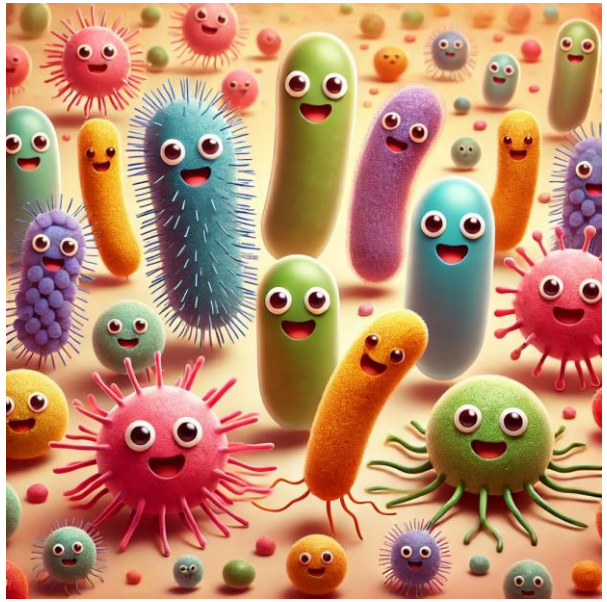


Figure 2. Knowledge of the correct definition of probiotics among different health profession groups. Blue proportions show the percentage of health professionals that chose the correct definition in each group.

FINAL CONCLUSIONS







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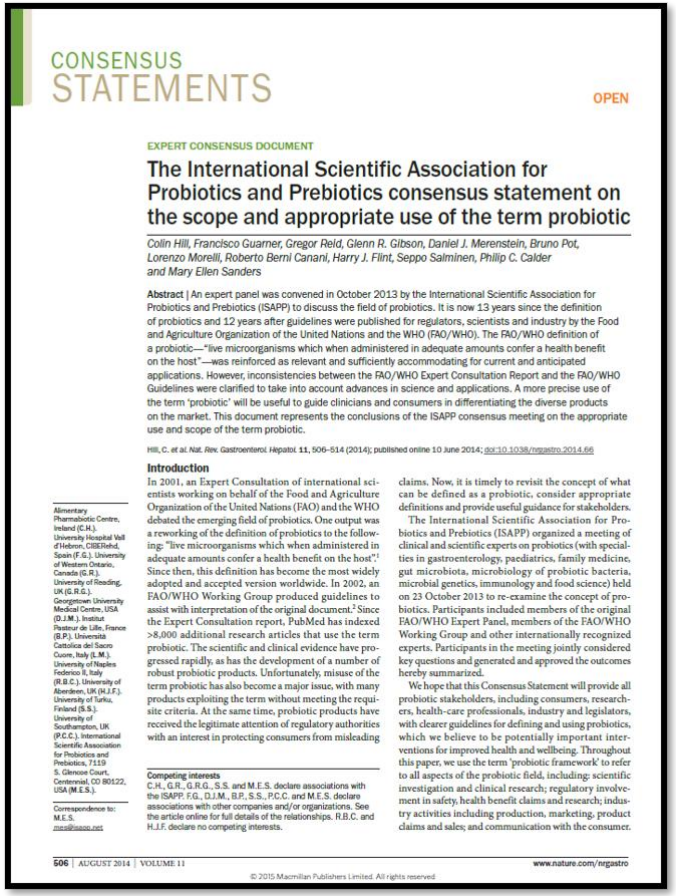
FINAL TAKE-HOME MESSAGES

- In our research, we found that multi-strain probiotics can show strong antagonistic activity — but multi-strain does not automatically mean superior efficacy.
- In older adults, OMNi-BiOTiC® Active significantly shortened the duration of acute respiratory infections, while incidence was not reduced.
- Antagonistic activity observed *in vitro* identifies promising candidates but does not replace clinical evidence.
- Probiotic effects are strain-, formulation-, population- and outcome-specific.

The KEY QUESTION is not simply:

“Do probiotics work?“ but

“Which probiotic, for whom, for which outcome?”



CONSENSUS STATEMENTS

OPEN

EXPERT CONSENSUS DOCUMENT

The International Scientific Association for Probiotics and Prebiotics consensus statement on the scope and appropriate use of the term probiotic

Colin Hill, Francisco Guarner, Gregor Reid, Glenn R. Gibson, Daniel J. Merenstein, Bruno Pot, Lorenzo Morelli, Roberto Berni Canani, Harry J. Flint, Seppo Salminen, Philip C. Calder and Mary Ellen Sanders

Abstract | An expert panel was convened in October 2013 by the International Scientific Association for Probiotics and Prebiotics (ISAPP) to discuss the field of probiotics. It is now 13 years since the definition of probiotics and 12 years after guidelines were published for regulators, scientists and industry by the Food and Agriculture Organization of the United Nations and the WHO (FAO/WHO). The FAO/WHO definition of a probiotic—“live microorganisms which when administered in adequate amounts confer a health benefit on the host”—was reinforced as relevant and sufficiently accommodating for current and anticipated applications. However, inconsistencies between the FAO/WHO Expert Consultation Report and the FAO/WHO Guidelines were clarified to take into account advances in science and applications. A more precise use of the term ‘probiotic’ will be useful to guide clinicians and consumers in differentiating the diverse products on the market. This document represents the conclusions of the ISAPP consensus meeting on the appropriate use and scope of the term probiotic.

Hill, C. et al. Nat. Rev. Gastroenterol. Hepatol. 11, 506–514 (2014); published online 10 June 2014; doi:10.1038/nrgastro.2014.66

Introduction

In 2001, an Expert Consultation of international scientists working on behalf of the Food and Agriculture Organization of the United Nations (FAO) and the WHO debated the emerging field of probiotics. One output was a reworking of the definition of probiotics to the following: “live microorganisms which when administered in adequate amounts confer a health benefit on the host”.[1] Since then, this definition has become the most widely adopted and accepted version worldwide. In 2002, an FAO/WHO Working Group produced guidelines to assist with interpretation of the original document.[2] Since the Expert Consultation report, PubMed has indexed >8,000 additional research articles that use the term probiotic. The scientific and clinical evidence have progressed rapidly, as has the development of a number of robust probiotic products. Unfortunately, misuse of the term probiotic has also become a major issue, with many products exploiting the term without meeting the requisite criteria. At the same time, probiotic products have received the legitimate attention of regulatory authorities with an interest in protecting consumers from misleading claims. Now, it is timely to revisit the concept of what can be defined as a probiotic, consider appropriate definitions and provide useful guidance for stakeholders.

The International Scientific Association for Probiotics and Prebiotics (ISAPP) organized a meeting of clinical and scientific experts on probiotics (with specialties in gastroenterology, paediatrics, family medicine, gut microbiota, microbiology of probiotic bacteria, microbial genetics, immunology and food science) held on 23 October 2013 to re-examine the concept of probiotics. Participants included members of the original FAO/WHO Expert Panel, members of the FAO/WHO Working Group and other internationally recognized experts. Participants in the meeting jointly considered key questions and generated and approved the outcomes hereby summarized.

We hope that this Consensus Statement will provide all probiotic stakeholders, including consumers, researchers, health-care professionals, industry and legislators, with clearer guidelines for defining and using probiotics, which we believe to be potentially important interventions for improved health and wellbeing. Throughout this paper, we use the term ‘probiotic framework’ to refer to all aspects of the probiotic field, including: scientific investigation and clinical research; regulatory involvement in safety, health benefit claims and research; industry activities including production, marketing, product claims and sales; and communication with the consumer.

Competing interests

C.H., G.R., G.R.G., S.S. and M.E.S. declare associations with the ISAPP. F.G., D.J.M., B.P., S.S., P.C.C. and M.E.S. declare associations with other companies and/or organizations. See the article online for full details of the relationships. R.B.C. and H.J.F. declare no competing interests.

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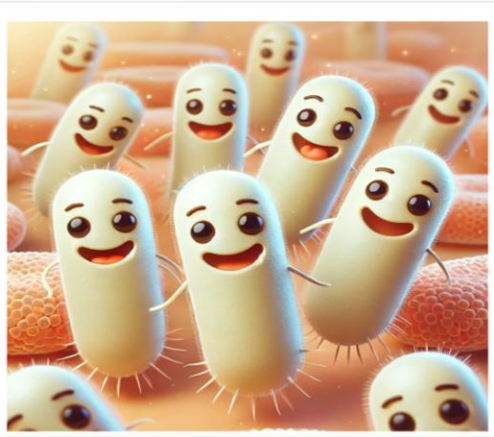
“Probiotics are live microorganisms that, when administered in adequate amounts, confer a health benefit to the host.“

World Health Organization

Food and Agriculture Organization of the United Nations

International Scientific Association for Probiotics and Prebiotics







THANK YOU FOR YOUR ATTENTION



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