

Mind your gut heroes: Microbiota in health and disease

1. Summary

The impact of gut microbes in health is perceived as one of the most exciting advancements in biomedicine in recent years. However, the complexity of this “long forgotten organ” sometimes lead to media confusion that directly influences public perception on microbiota research. This project aimed at providing long-lasting and accurate knowledge to the public on this topic.

1.1. Content and objectives

A recent scientific publication¹ showing how microbial network disturbances influence health required samples of patients diagnosed with Inflammatory Bowel Diseases (IBD) collected by gastroenterologists all around Switzerland. Our intention was to communicate to the public about the importance of microbial communities to be treated on an entire community rather than individual bacterial strains and to bring all parties of this study together (researchers, medical doctors and patients) to show the importance of collaborative work for a successful scientific output. This project aimed to increase public’s motivation to actively participate in research initiatives through the recognition of the importance of science for progress and to improve health. Additionally, we intended i) to expand the scientific knowledge of the public on understanding that healthy microbiota means healthy individuals, ii) to raise public awareness for antibiotic usage, and iii) to show our gratitude to every voluntary participant in the scientific study.

1.2. Scientific and social context

The rising access to unreliable information erodes the value that society gives to facts and cause the degradation of public trust in the integrity and validity of scientific research. This highlights the emerging needs of science education where the direct interaction between scientists with the public appear as an innovative and urgently needed approach to improve public trust in researchers and in the recognition of scientific discoveries for progress and health. This is especially true for young minds and this type of initiatives should be introduced in early stages of school training. Additionally, outreach initiatives that promote meaningful experiences with scientific content promote critical thinking that is a requisite to build the foundations for a better society. Here, we tackle those issues by giving special attention to microbiome related studies.

2. Description of the activities

We aimed to include and get the attention of both children and adults by adapting our communication material to each age group. Hands-on experiments, scientific games and inquiry based-methodologies helped children to get the basic concepts of microbiology and the role of antibiotics in our lives; concept-based flyers and an animated video showing the major findings regarding the microbiota in health and disease allowed to communicate detailed information to adults, including the patients who participated in these studies.

Specific Aim 1. Science education to young minds. To teach young participants about the interactions established between microorganisms and the human body we developed hands-on activities and games according to our initial plan shown in **Box 1**. Exceptionally, the “individual gut microbiome characterization” step (**Box 1**, highlighted in red) was not done due to concerns of data protection and ethical approval raised by one of the reviewers. As an alternative, and to show participants the incredible diversity of microbiota that live on our body, children cultured their own skin bacteria in plates containing different growing media (**Supplementary Figure 1**). All results can be accessed in the website of the project (<http://ginkgo-educa.com/microbiota/>) and each student could see own plates using an unique and untraceable code.

Mind your gut heroes: Microbiota in health and disease

We guided each session and directly interacted with the participants. We solely aimed at focusing on young patients that were admitted at *Inselspital* paediatric clinic but, unfortunately, due to the COVID-19 pandemic and consequent restrictive measures, we were unable to reach our target group and further organized workshops in other venues (for more information go to the section “2.2. COVID-19 pandemic and deviations from the project plan” of this report and consult Figure 1).

Box 1. Detailed description of activities. Deviations from the project plan are highlighted in red.

Specific Aim 1. Science education to young minds	Specific Aim 2. Science education to adults
<p>1. To contextualize the microorganisms within ecology and symbiotic relationships by</p> <ol style="list-style-type: none"> a) Elucidating the different types of symbiosis using superhero analogy. b) Observing bacteria that live in our mouth under the light microscope. c) Characterizing bacteria that live in our skin by culturing in LB medium. d) Culturing environmental samples collected from different sites of the classroom. <p>GOAL: To promote our understanding of what the microorganisms are, where they live and what type of dynamic interactions they can establish with other living organisms found in their vicinity (including humans).</p> <p>2. To demonstrate the importance of human gut microbiota, several experimental activities are planned which are</p> <ol style="list-style-type: none"> a) Digestive system simulation: To observe what happens to food in the different organs of the digestive system b) M&Ms in science: To demonstrate the number of bacteria in our gut in comparison with number of human cells by using M&Ms, the colorful button-shaped chocolates. c) The importance of antibiotics: To demonstrate how antibiotic intake shape our gut microbiota and their roles in health and disease using a board game developed by us. d) Individual gut microbiota characterization: To sequence children's gut bacteria and to disseminate the results to educators and parents. <p>GOAL: To teach the importance of gut microbiota and as well as the importance and consequences of antibiotic intake in the context of health and disease.</p>	<p>1. To distribute flyers and to show graphic animation that explain:</p> <ol style="list-style-type: none"> a) How specific microbial network disturbances can influence severity of inflammatory bowel diseases. b) How probiotics contribute to improve health of a patient with short bowel syndrome that leads to D-lactic acidosis. <p>GOALS: i) To explain in more details of my recent publications in the context of gut microbiota and to call public's attention to underline the importance of these studies for improving the public health in general. ii) To encourage interactions and communication between different stakeholders of this initiative: parent-child, researcher-medical and doctor-patient.</p> <p>2. To organize an exhibition with the drawings of participants (e.g. children) on different topics that they have learned mainly about:</p> <ol style="list-style-type: none"> a) What gut microbiota is, how they interact with each other or their host, and where their specific niche is. b) The digestive system and role of gut microbiota in it c) Gut microbiota in health and disease <p>GOAL: To reach a wider audience (in national level).</p>

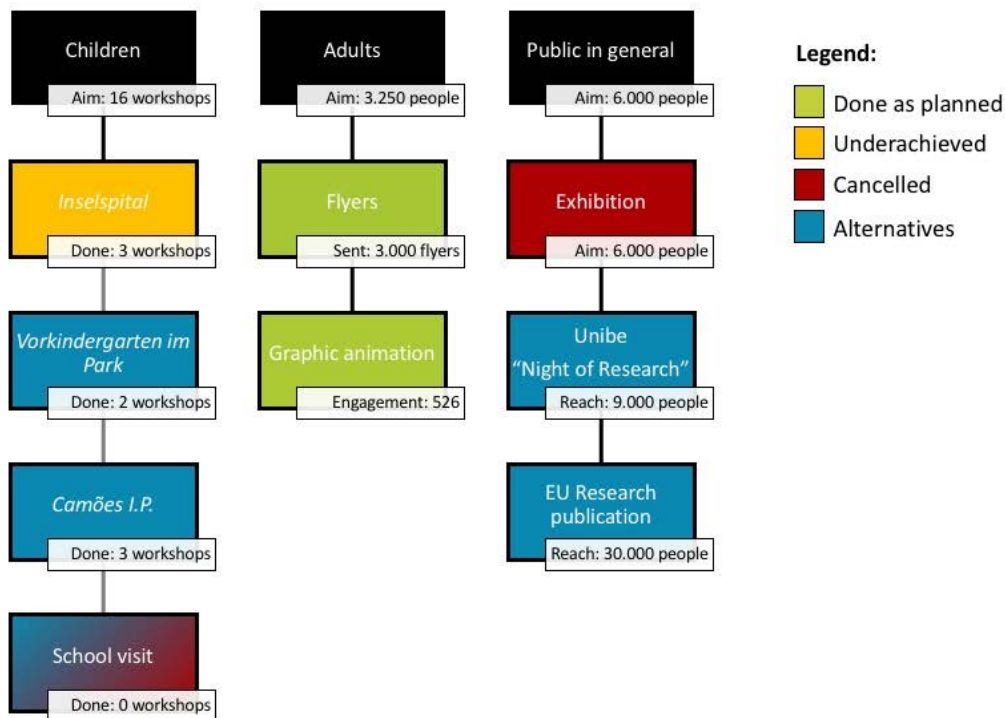


Figure 1. Deviations from the project plan. This outreach initiative was divided into two main categories based on participants' age: children and adults. Here, we included an extra division named “public in general”, for readability. We organized hands-on science workshops for children that were initially planned to materialize at *Inselspital* (aimed to teach 16 workshops to 160 participants). Due to the COVID-19 pandemic, we were only able to organize three workshops at *Inselspital*; we further taught two workshops at the

Mind your gut heroes: Microbiota in health and disease

Vorkindergarten im Park and three classes for the students at *Camões I.P.* that are learning Portuguese as heritage language in Switzerland. We also established a collaboration with the International School of Berne to organize a workshop and school visit to the laboratory of Prof. Dr. Andrew Macpherson that was also cancelled due to the pandemic restriction measures. The communication to adults specifically targeting IBD patients went as initially planned. Our scheduled exhibition that aimed at bringing attention to a wider public was also cancelled, but we submitted our project for communication at the University of Bern “Night of Research” that expects to welcome 9.000 participants in September 2022. Additionally, we also published an article about this project at the EU Research journal that has 30.000 active readers.

Specific Aim 2. Science education to adults. Knowledge is acquired through the discussion and combination of different ideas and perspectives. That can only be achieved by promoting communication between the diverse social players (such as public, researchers and medical doctors) and in between different age groups. This outreach initiative also aimed at providing the right environment for these types of interactions to occur.

As stated in the previous section, we developed several fun hands-on experimentation activities for children to teach about the relationships established between microbiota and health (**Box 1**). Although our methodology proved to be successful², parents generally find it difficult to discuss with their children about the subjects they learn in science-related activities. This is mostly due to the lack of information specifically designed for parents or many false information that can be extracted from mass and social media. This part of the project aimed at fostering this interaction by designing flyers (that we provided to parents) containing detailed information about how microbial network disturbances influence severity of inflammatory disease conditions¹ (**Supplementary Figure 2**). When possible, parents were also welcomed to attend the workshop. This allowed to teach adults about the basis of healthy gut microbiota and how important they are, not at the individual level but as a community. For more details about activities see **Box 1**.

Given that most of my recent studies¹ were only possible due to the existence of the Swiss Inflammatory Bowel Disease Cohort (SIBDC)³ assembled over 10 years and collaborative effort of all medical doctors and patients, we aimed at bringing the contributors together in this part of the initiative. SIBDC biobank includes many different patients’ samples including biopsies and serum samples from teaching hospitals, community hospitals and office practices in Switzerland. 3.000 voluntary IBD patients have donated their samples and around 250 Swiss gastroenterologists have been taking care of these patients. These two parties are the critical players of this successful biobank that served more than 150 scientific and medical publications. Therefore, we sent to both groups the printed versions of the flyers (in French or German depending on the canton, **Supplementary Figure 2**), and made our graphic animation available for the wider public at the *Inselspital* website (<https://www.darmzentrum-bern.ch/de/research-education/research-ibd.html>). Both flyers and video are also accessible through the website of the project (<http://ginkgo-educa.com/microbiota/>) and were promoted on the social media.

Flyers and video comprised information about how the study was performed, who was involved, what we learned and what we can do as a next step. Additionally, these also served as a message to show our gratitude to the medical community and public for their contribution into the scientific discoveries. In our initial plan, we aimed at communicating the scientific discoveries described in two manuscripts^{1,4}, however, due to concerns brought up by one of the reviewers concerning budget allocation we decided to focus on only one of the manuscripts and information on how the introduction of probiotics contributed to improve health of a patient with short bowel syndrome⁷ was not included (**Box 1**, highlighted in red).

Of note, we also aimed at exhibiting children’s work that described different aspects of microorganisms’ life, ecology and importance for health at the different public places of the hospital. This closing initiative that aspired at reaching wider public communities and at stimulating discussions between different social elements had to be cancelled due to the COVID-19 pandemic (**Box 1**, highlighted in red). Alternatively, we applied to present the current outreach initiative at the University of Bern “Night of Research” including our material designed for the workshops to children, as well as the flyers and graphic animation intended to reach adult public (**Figure 1**).

As initially stated in our project, at the end of the funding period all material designed for this initiative was made available at <http://ginkgo-educa.com/microbiota/>.

Mind your gut heroes: Microbiota in health and disease

2.1 Implementation

The project was divided into two work packages, which are the education to young minds (*Specific Aim 1*) and to adults (*Specific Aim 2*). These packages were run in parallel without interfering with each other and in such a way to achieve desired impact in timely manner. Details on the proposed schedule, milestones and objectives are highlighted in **Figure 2**; deviations to the original plan can be seen in **Figure 3**.

One of the main objectives of this outreach initiative was to bring science to children admitted at the *Inselspital* paediatric clinic. Originally, we planned on running our workshops at the school in the premises of the hospital that children attend while recovering. In practice, it was important to guarantee that our activities would not interfere with the normal routine of the school and therefore decided (together with Livia Salis-Wiget, head of teaching unit) to run our workshops on weekends, outside the umbrella of the school. Consequently, and in order to assure that we would have participants, it was important to coordinate synergies and to establish a relationship based on trust with the workers that take care of those patients in all units – the nurses. This key step delayed the launch of our workshop but proved to be crucial for the success of the sessions we were able to teach at the *Inselspital* (**Figure 3**).

2.2. COVID-19 pandemic and deviations from the project plan

Communication to children. In our proposal, we aimed at organizing 16 workshops and at interacting with 160 children. However, with the spike of COVID-19 and consequent contingency measures in the middle of our running grant, we were unable to further connect with children at the hospital and to reach our goal. In total, we organized 8 workshops, 5 of which were outside the *Inselspital* paediatrics clinic, and taught 64 participants about the importance of microbiota for health and disease. Nevertheless, we would like to focus our attention in the positive outcomes of our workshops rather than the number of attendants, for our results indicate we were able to create meaningful experiences that brought the public closer and connected to science (for more details please consult the section “4. Results”).

Communication to the wider public. Considering that one of our objectives was to promote discussion of ideas and interaction between people (researchers, medical doctors, patients, children and adults alike), we aimed at exhibiting art work of children that demonstrated the different aspects of microorganisms’ life, ecology and importance for health. In addition, we also submitted a proposal to the “Night of Research” event at the University of Bern that it should have taken place on September 5th, 2020. Unfortunately, due to the current pandemic situation, we were unable to organize the exhibition and to participate in the fourth edition of the public event (**Figure 1**). However, we plan to project our animated video and to bring our didactic material and flyers in the next “Night of Research” that is now planned for the beginning of September 2022, and estimates over 9.000 participants. During the running grant of our initiative we also published an article in EU Research journal – the Europe’s leader in research dissemination that has about 30.000 subscribers (**Supplementary Figure 3**).

Mind your gut heroes: Microbiota in health and disease

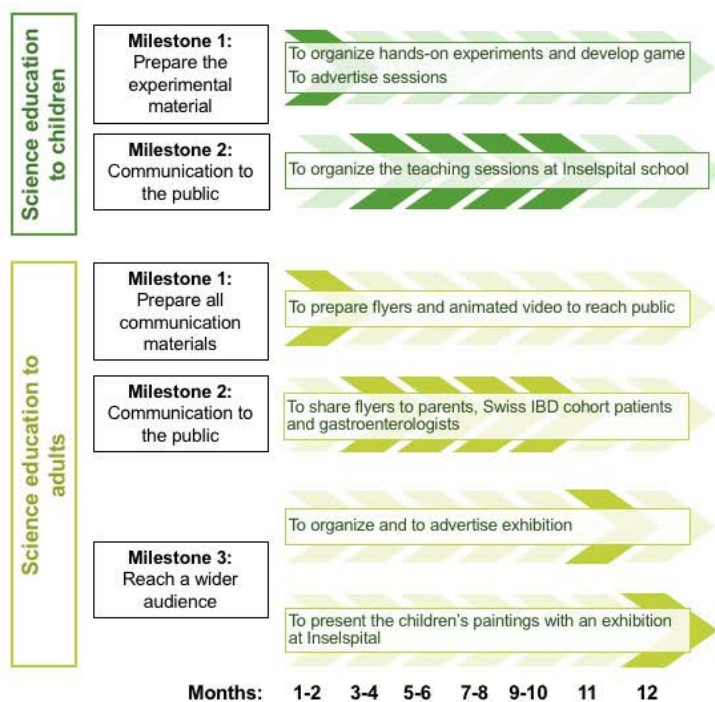


Figure 2. Timetable and milestones proposed in the project. We aimed at running this initiative for one year and bring science education to children (dark green) and to adults (light green). During the first two months we proposed to prepare all necessary material (Milestone 1). In the following eight months we aimed at communicating our information to the public (Milestone 2). During that time, we planned on teaching two sessions per month for children at *Inselspital* school, and at providing flyers and animated video to parents, to Swiss IBD Cohort patients and gastroenterologists. Eleven months after the beginning of this outreach initiative we anticipated to organize and advertise exhibition of children's paintings. Drawings will be displayed for one month at the entrance of the hospital (Milestone 3).

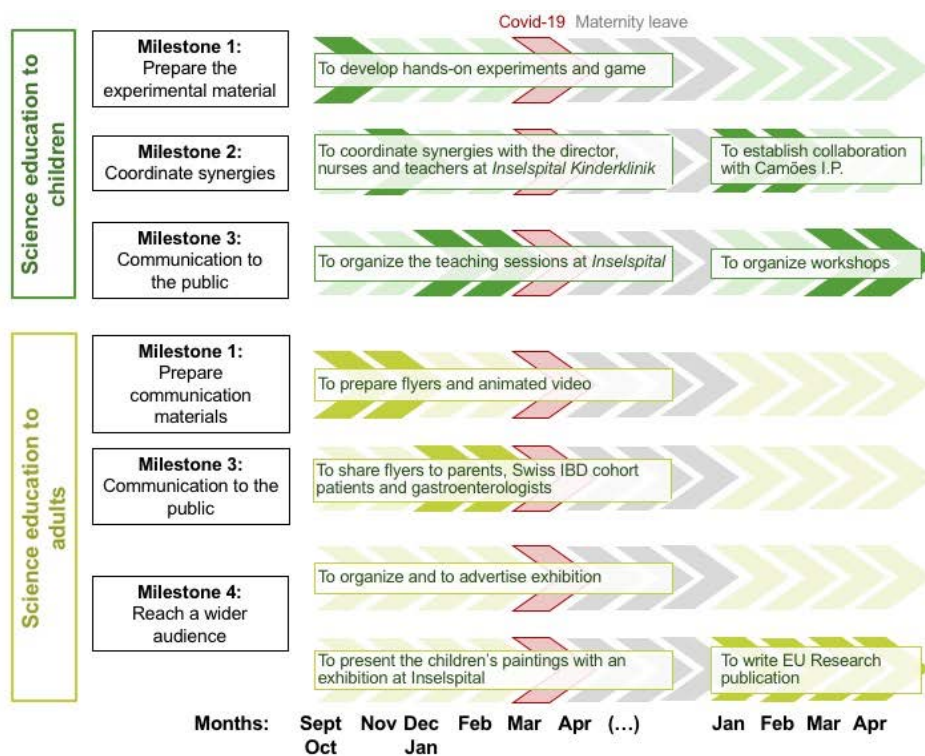


Figure 3. Final timetable and milestones. We run this initiative for one year and brought science education to children (dark green) and to adults (light green). During the first two months we prepared all necessary material for the workshops to children but the graphic animation took longer than initially planned due to schedule constraints of all people involved (Milestone 1). A key step of our initiative was to coordinate synergies and establish relationships based on trust with all stakeholders (Milestone 2). For three months we were able

Mind your gut heroes: Microbiota in health and disease

to organize workshops for children at *Inselspital*; with the outbreak of COVID-19 we moved our sessions to other venues (*Vorkindergarten im Park* and *Camões I.P.* classes). In the meantime, we provided flyers and animated video to parents, to Swiss IBD Cohort patients and gastroenterologists (Milestone 3). Our exhibition to present children's paintings at *Inselspital* was cancelled but in order to complete our Milestone 4 we wrote an article for the EU Research magazine and applied to attend the University of Bern "Night of Research".

2.3. A brief description of the contributions made by our SNSF collaborators

The initial team of this initiative was composed by three people: Dr. Yilmaz (main applicant), Dr. Marialva (project partner) and Dr. Sokollik (collaborator). Dr. Sokollik was directly engaged with us to promote this initiative in the paediatric clinic and her help was crucial to establish synergies with other workers at *Inselspital*. Later, we also collaborated with Dr. Gonçalves (coordinator for the teaching of Portuguese as heritage language in Switzerland) to bring our workshops to the *Camões I.P.* students learning Portuguese as heritage language in Switzerland.

4. Results

4.1. Communication to children

The participants of our workshops were 60% boys and 40% girls (**Figure 4a**); 7% preferentially spoke English, 24% German and 33% Portuguese (**Figure 4b**). Although the initial plan of the project was to solely interact with children admitted at the *Inselspital* paediatrics clinic with workshops taught in German, the COVID-19 outbreak forced us to find alternatives. Since we advocate that education and scientific knowledge should be for everyone – regardless of age, social status, nationality and gender – we decided to further focus our work on migrant children that usually have little access to science communication initiatives². We taught one workshop in English and three in Portuguese (as the Portuguese community in Switzerland represents the third largest migrant group right after people originally from Italy and Germany).

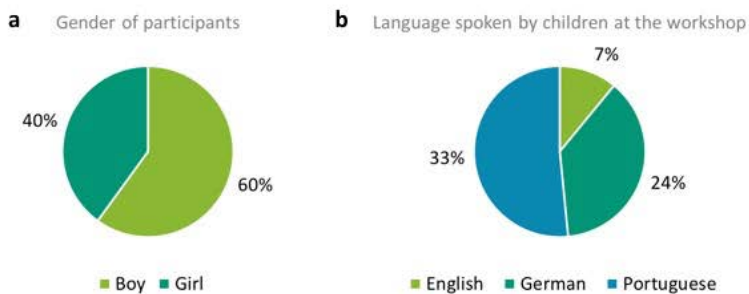


Figure 4. Characterization of the target group. We taught our workshops to children including 60% boys and 40% girls (a) of those 7% spoke English, 24% German and 33% Portuguese.

At the end of the workshop, we used a feeling faces chart to assess students' emotions about the activities taught (**Figure 5a**). Most participants (77%) felt very happy, 20% felt happy, only 3% felt neither good or bad and none of the pupils felt unhappy (**Figure 5b**). Afterwards, we also received messages from the parents expressing their appreciation for the workshop including their children's testimonies about the session. Sentences such as "I want to go again!", "It was really good", "It was very cool" and "It was very interesting" show the success of our methodology in creating a meaningful experience that brought young minds closer to science.

Mind your gut heroes: Microbiota in health and disease



Figure 5. How participants felt at the end of the workshop. At the end of the workshops to children, participants were asked to highlight anonymously how they felt about the activities done (a); 77% of pupils felt very happy, 20% happy and only 3% felt neither good or bad.

To have a deeper understanding about the success of our hands-on science session, we asked parents to answer, anonymously and voluntarily, to four simple questions. Interestingly, we observed that for most of the participants this was the first time they interacted with scientific material (Figure 6a) and felt enthusiastic about the concepts learned in the class (Figure 6b). Some attendants also felt happy after the workshop, but none expressed negative feelings (e.g. feeling unhappy, disappointed or confused). The majority of the parents (83%) also assessed their child's understanding about the main concepts taught to be very good or good (Figure 6c) and evaluated the general quality of the workshop as very good (Figure 6d). Please see below some of the comments that highlight how parents felt about the whole experience:

"We are enthusiastic about the workshop and very much hope that there will be more - thank you very much !!!"

"Fantastically done!"

"Keep up the great work!"

"Excellent event! CONGRATULATIONS! My daughter really enjoyed the workshop. And was happy I breast fed her, so she got points in the game???"

"It was a great event!"

"Thanks for all the effort you put into this workshop. My kid enjoyed it A LOT and couldn't stop talking about it and he learnt so many interesting things and became more aware about the "bad bacteria" as he said."

"We would be very happy if more workshops were offered! Many thanks to the organization team!"

"It would be great if there were more workshops like this! For girls in particular, early, playful access to the world of science is ideal."

Mind your gut heroes: Microbiota in health and disease

“Great job! Thank you so much!”

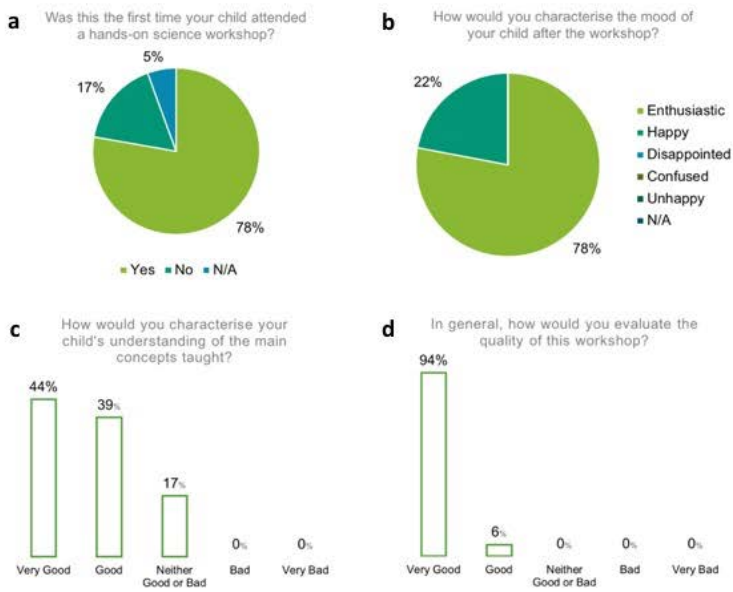


Figure 6. Parents' impressions about the quality of our workshop. At the end of the workshops to children, we sent four questions to parents that they could answer anonymously, to assess whether this was the first time our participants attended a hands-on science session (a), and how did they feel at the end of the workshop (b). Parents were also asked to characterize the understanding of their child about the concepts taught (c) and to evaluate the general quality of the workshop (d).

As mentioned above, we also taught the workshop at the classes of two *Camões I.P.* teachers for Portuguese as heritage language in Switzerland. Interestingly, not only both teachers felt very happy with the result of the workshop but also used it as a starting point for further activities to explore new vocabulary in what became a real Language and Science integrated learning (Figure 7).

Mind your gut heroes: Microbiota in health and disease



Figure 7. Pictures of activities done at *Camões I.P.* classes as a follow up to our workshop.

4.2. Communication to adults

In our communication to adults, we aimed at sending flyers to the 3.000 voluntary IBD patients that have donated their samples to research. Therefore, we sent our material to seven medical doctors (500 flyers to each) that work in network with the remaining gastroenterologists that have been taking care of these IBD patients (**Figure 8**). Additionally, our graphic animation was promoted on social media (Twitter, LinkedIn and Facebook) using the accounts of Dr. Yilmaz, Dr. Marialva and Ginkgo-Educa. We observed that the video (with English, French or German subtitles) appeared 8.224 times on those networks, and 526 people actively interacted with it (**Figure 9**).

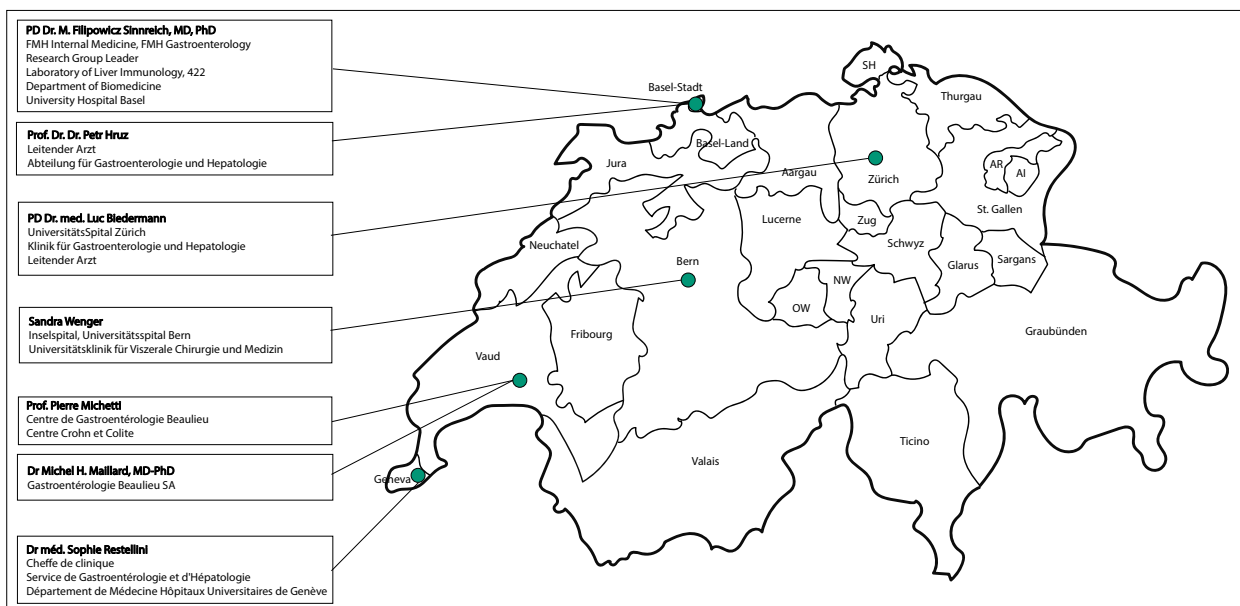


Figure 8. Gastroenterologists that received our flyers.

Mind your gut heroes: Microbiota in health and disease

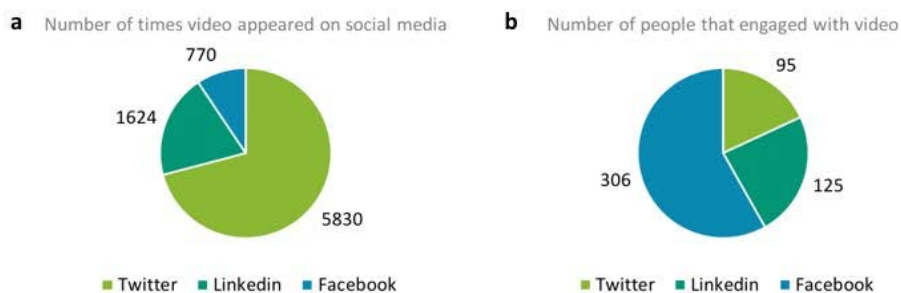


Figure 9. Impact of the graphic animation on social media. Number of times video appeared on social media (a), and number of people that engaged with it (b). We show a sum of results obtained for the publications on Dr. Yilmaz, Dr. Marialva and Ginkgo-Educa social media accounts (Twitter, LinkedIn and Facebook) including the three versions of the video (English, German and French subtitles).

5. Discussion

The rising access to unreliable information erodes the value that society gives to facts and cause the degradation of public trust in the integrity and validity of scientific research. This highlights the emerging needs of science education specifically in children more than ever before. Although this is a global problem, much remains unknown regarding the vulnerabilities of individuals, institutions, and societies for manipulations. A new system of safeguards is urgently required. This is where the scientific community, the critical player of this matter, should intervene to tackle this issue. The science communication and direct interaction with the public appear as an innovative and urgently needed approach to improve public trust in researchers and recognition of scientific discoveries for progress and health. Additionally, outreach initiatives promote critical thinking that is a requisite to build the foundations for a better society. However, science dissemination initiatives usually target specific segments of the society that include people *a priori* interested in research. Various underserved audiences including children with prolonged health issues and migrant communities are detached from it and feel left out. With our initiative, we were able to organize meaningful activities that brought those groups closer to, and therefore more interested in, science. The numbers speak for themselves: for 78% of the children this was the first time they interacted with scientific material, and all participants felt either enthusiastic or happy at the end of the workshop. Additionally, our classes for the Portuguese community living in Switzerland, worked as a starting point for a real Language and Science integrated learning. This multidisciplinary approach to teaching, where pupils become active players in their learning process, is known to improve their self-esteem and motivation not only to learn a language of heritage but also science². Therefore, this project is proof that building a more equitable world, where everyone has access to quality of education regardless of social status, age, nationality or gender is attainable, and we hope to further continue the work.

This outreach initiative also aimed at breaking the walls between different groups of people (child-parent, doctor-patient, scientist-doctor) by promoting meaningful experiences and engagement in science. The testimonies that we received from parents tell about those type of interactions, where the spark of joy light up during our workshop illuminated their homes with enthusiastic discussions about the whole experience and concepts learned. As for the flyers provided to IBD patients, we hope that they too worked to ignite fruitful conversations between doctor and patient.

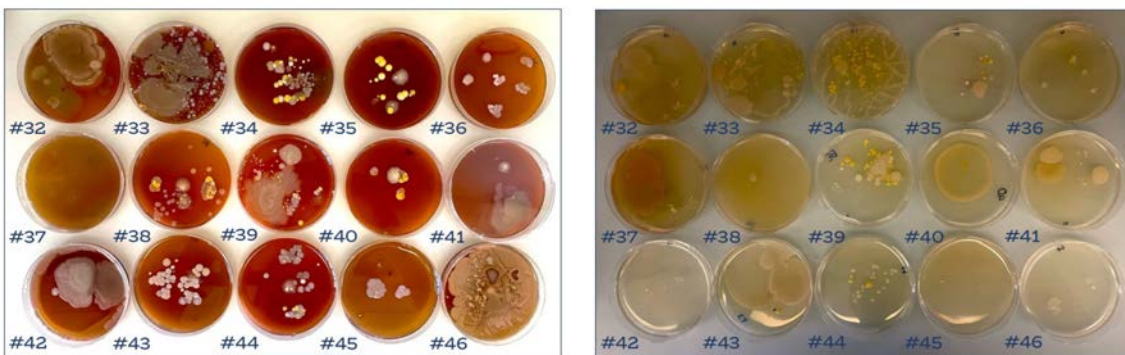
As a conclusion, our data indicate that we were able to promote scientific literacy and achieve a public understanding about the importance of microbiota in health and disease. Most importantly, by building bridges between the underserved public and science through meaningful and engaging experiences, we are constructing the foundations for a more just and equitable world for all.

6. Bibliography

Mind your gut heroes: Microbiota in health and disease

- 1 Yilmaz, B.; J., P.; Oyas, O.; Ramon, C.; Bravo, F.; Franc, Y.; Fournier, N.; Geuking, M.; Michetti, P.; Mueller, C.; Pitter, V.; Maillard, M.; Rogler, G.; Wiest, R.; Stelling, J.; Macpherson, A.J. Microbial network disturbances in relapsing refractory Crohn's disease. *Nature medicine* (2018).
- 2 Marialva, M.; Yilmaz, B.; Gonçalves, M. L. Hands-on science to promote language learning in bilingual contexts. In Levrini, O. & Tasquier, G. (Eds.) (2019).
- 3 Pittet, V. *et al.* Cohort profile: the Swiss Inflammatory Bowel Disease Cohort Study (SIBDCS). *Int J Epidemiol* **38**, 922-931, doi:10.1093/ije/dyn180 (2009).
- 4 Yilmaz, B., Schibli, S., Macpherson, A. J. & Sokollik, C. D-lactic Acidosis: Successful Suppression of D-lactate-Producing *Lactobacillus* by Probiotics. *Pediatrics*, doi:10.1542/peds.2018-0337 (2018).

7. Supplementary Figures



Supplementary Figure 1. Diversity of skin microbiota grown in blood and LB agar media.

You are not, and will never be alone

A multitude of tiny guests live in your body and make 90% of our total cells: we call them **microbiota**.

But, like in any successful relationship, our mutualistic partnership can also turn sour, especially in our most heavily colonized organ: the **intestine!**

The lack of healthy gut microbiota can result in **Inflammatory Bowel Diseases** with nasty symptoms and culminating in a poor quality of life.

English

Tu n'es pas seul(e) et ne le sera jamais

Une multitude de petits habitants vit dans ton corps et représente 90% de toutes tes cellules: On les appelle **le microbiote**.

Mais, comme toute relation à succès, notre partenariat mutuel peut mal tourner, en particulier dans notre organe le plus colonisé: **les intestins!**

L'absence d'un microbiote sain peut induire une **maladie inflammatoire intestinale** avec des symptômes très désagréables et une perte de qualité de vie.

French

Du bist nicht alleine und wirst es nie sein

In deinem Körper hast du viele kleine Mitbewohner, die über 90% deiner Zellen ausmachen. **Wir nennen sie das Mikrobiom.**

Wie in jeder erfolgreichen Zusammenarbeit, kann sich unsere gegenseitige Partnerschaft auch zum Schlimmsten entwickeln. Besonders im meist besiedelten Organ: unserem **Darm.**

Ein Mangel an guten Darmbakterien kann zu einer **chronisch-entzündlichen Darmerkrankung** führen. Diese ist oft mit schlimmen Symptomen und einer verminderten Lebensqualität verbunden.

German

Supplementary Figure 2. Flyers to communicate to adults. Flyers in English, French and German show details about most recent discoveries regarding the importance of a healthy microbiota for recovery from IBD.

Mind your gut heroes: Microbiota in health and disease

Mind your microbiota, the heroes of the gut

A lot of progress has been made over recent years in identifying the different microbiota in the gut, and how relative proportions are an important indicator of individual health. We spoke to **Dr. Bahiyar Yilmaz** and **Dr. Marta Mariálva** about their work in both researching the different microbiota in the gut and also in communicating its importance to the wider public.



The balance between the different microbiota found inside the gastro-intestinal tract exerts a significant influence on human health. In particular, the relative proportions of two main phyla called Bacteroidetes and Firmicutes are an important indicator of an individual's health. "If the level of Firmicutes is high there may be a high risk of obesity for example, while Bacteroidetes is low there may be a susceptibility to developing inflammatory bowel disease (IBD)," explains Dr. Bahiyar Yilmaz, a senior researcher at the University of Bern. This is a topic Dr. Yilmaz is exploring in the group of Prof. Dr. Andrew Marchesoni who is the clinical director of Gastroenterology at the University Hospital of Bern (Inselspital). "In the study we aimed to identify specific bacteria profiles associated with clinical features and treatment responsiveness of these very heterogeneous diseases over time (up to 17 years) in a large patient cohort," he continues. "The first question we aimed to answer was the difference between the microbiota found in healthy people and the microbiota in patients with IBD."

Mind Your Gut Heroes: The Research
The study centred on research using two different cohorts of patients, from which Dr. Yilmaz hoped to gain deeper insights into the impact of gut microbes on individual health. The patients themselves were mainly Swiss residents from different parts of the country, and while the cohorts were quite diverse, it was still possible to identify certain patterns. "We see the same kind of profile within the healthy people or those with diseases and that the same types of bacteria are reduced in people with a specific disease status, or who have undergone similar treatment," says Dr. Yilmaz. A variety of different drugs are used to treat IBD, and if a patient doesn't respond then they have to undergo surgery to remove the active disease segment. Dr. Yilmaz tried to understand the influence of gut microbiota on such clinical outcomes. "How much do the microbiota change upon certain treatment and why do some patients relapse after surgery?" he asks. "We now know that patients with a severe course of disease and who fail to heal with medication have particular bacteria, and that this microbiota signature is also characteristic of patients in remission following surgery who have an almost inexorable probability of relapse." Dr. Yilmaz believes that they are in the right path and is hopeful that one day they can achieve sustainable deep remission of the disease by manipulating the intestinal bacteria in personalized therapy.

Following this study, Dr. Yilmaz's research has involved investigating questions around the evolution of the gut microbiota in IBD patients, a study funded by the Ambizione

of the Swiss National Science Foundation (SNSF). Alongside looking at how the relative abundance of these bacteria change over time, Dr. Yilmaz also plans to study the evolution of their genomes. "Do these bacteria accumulate specific mutations over time that make them more resilient? Or does this make them more vulnerable, reducing their abundance in the gut?" he reflects. This represents a new area of study. "We are looking to the genomes of specific bacteria and asking how they change. These changes occur primarily because of their interactions with other microbes, and an individual's diet is an important factor," continues Dr. Yilmaz. "Some parts of the diet are utilized more effectively by some bacteria than others, so they then start to be more dominant. This leads to a reduction in the other bacteria as there is competition in the gut for what we call the ecological niche."

This is an important factor in terms of maintaining a healthy balance of bacteria. There are thought to be more than 1,500 different species of bacteria in our gut, and Dr. Yilmaz's study shows that a healthy gut is characterized by a high level of bacterial diversity. "There should be a lot of different bacteria in the gut, it's not healthy if one or two particular types dominate," he says. The importance of gut microbes to health is not widely recognized however, so Dr. Yilmaz holds another SNSF grant with a large educational component. "They are working with kids in Switzerland to teach them about microbiota and their intestinal system. We aim to educate the public about how the gut microbiota, and to teach students about how they can keep themselves healthy," explains Dr. Yilmaz.

Mind Your Gut Heroes: Science Education
The idea here is to transform the role of the students in their own learning while previously students may have been expected to sit quietly and listen to their teacher. Dr. Marta Mariálva is taking a different approach to teaching in her role with Ginkgo-Educa, an educational NGO that she co-founded. "We believe that children have an active role in their learning, then their learning experience will be richer." So

It goes beyond the acquisition of knowledge – they actually acquire many skills," she explains. Ginkgo-Educa is involved in several different projects aimed to improve scientific literacy among both adults and children, which will help counter concerns about misinformation and fake news. "With issues like social media manipulation, it's more important than ever to get kids to think critically," stresses Dr. Mariálva. "We are preparing the students of today for an uncertain future."

Many of the jobs in the economy of the future don't exist yet, so technical skills and problem-solving capabilities will be highly valued. A practice-oriented science classroom can encourage the development of these skills, while it can also promote equity and encourage participation in under-represented groups, which is an important issue for Dr. Mariálva. "We are at an age science and experimentation is a tool to increase students' motivation, while at the same time also elevating their expectations and ambitions for their future," she says. In one project Dr. Mariálva works with the less-advantaged community in Switzerland, which has historically performed relatively poorly at school in comparison to their peers, while another initiative focuses specifically on girls. "Typically, girls have less interest in Science, Technology, Engineering, and Mathematics (STEM) subjects at school, which then affects their subsequent career options," she says.

The "Mind your gut heroes: Microbiota in health and disease" project funded under the SNSF Agora Rolling Call provides a way

to illustrate the value of science to these groups and its importance to our everyday lives. Through her work with children, mainly between the ages of 6-12, Dr. Mariálva hopes to instill a spirit of curiosity and confidence. "I think it's particularly important to know the core skills, the scientific method and how questions are answered," she stresses. The main focus of this project is to provide science education for young people in hospital, which will not only provide a distraction from their treatment but also help them develop their skills. "The idea is to assess what they know about a subject, and to use this knowledge as a way to discuss and deconstruct some of the incorrect ideas that they may have," explains Dr. Mariálva. "We want to make sure that by the end of the conversation children understand that bacteria are everywhere – some may be good for us, some may be bad."

Parents can also participate and the ultimate aim here is to build a greater degree of scientific engagement among the wider public. "We want to make the point that science directly affects our lives," outlines Dr. Mariálva. "This doesn't mean just applied research, but also basic science driven simply by our curiosity. We need to have basic science, and we need to communicate the importance of it."

We observe the bacteria in our mouth through a microscope

We grow bacteria that live on our skin

We find out what happens in our body when we ingest food

Around 90 percent of the cells in our body are made from microbiota, and Dr. Mariálva has come up with a number of novel ways to illustrate this and other scientific concepts to students. In one task students distribute coloured beans into a glass representing the human body which shows that bacteria

We want to make sure that by the end of the conversation children understand that bacteria are everywhere – some may be good for us, some may be bad.

MIND YOUR GUT HEROES
Microbiota in health and disease

Project Objectives
The intention in the project is to heighten awareness of the importance of microbial communities to health, and to communicate the message that entire communities should be treated rather than individual bacterial strains. The project aims to bring all parties involved into the research – researchers, medical doctors and patients – to show the importance of collaborative work to a successful scientific output.

Project Funding
The project is funded by the Swiss National Science Foundation SNSF Agora Rolling Grant (SNF-RP_180323 to Dr. Bahiyar Yilmaz).

Project Partners
Dr. Christine Scahill (University Children's Hospital, Inselspital, University of Bern, Bern, Switzerland)

Contact Details
Dr. Marta Mariálva
Principal Investigator
Ginkgo Educa
Ginkgostrasse 47
3008 Bern
E: marta.mariálva@ginkgo-educa.com
W: <http://ginkgo-educa.com/microbiota/>




Dr. Bahiyar Yilmaz works with Professor Andrew Marchesoni on understanding the role of intestinal microbial communities in patients diagnosed with chronic inflammation in the intestines. He holds a Ph.D. in Immunology and recently created his own research study supported by a SNSF Ambizione Grant and Novartis Grant for biomedical research.

Dr. Marta Mariálva holds a Ph.D. in Evolutionary Biology and is the co-founder of Ginkgo-Educa, a non-profit organization that uses hands-on science activities as a tool to promote critical thinking in young minds.




EU Research

www.euresearcher.com

Supplementary Figure 3. Publication in EU Research journal. EU Research is an open access journal specialized in science dissemination to the wider public and currently has 30,000 subscribers. This publication is accessible for everyone here: https://issuu.com/euresearcher/docs/mind_your_gut_heroes_eur27_h_res