



## Commentary

## Diversity and bias in oral microbiome research: A commentary

S Nath<sup>a</sup>, M Handsley-Davis<sup>a</sup>, LS Weyrich<sup>b</sup>, LM Jamieson<sup>a,\*</sup><sup>a</sup> University of Adelaide, Adelaide, South Australia, Australia<sup>b</sup> Penn State University Abington-Ogontz Campus: Penn State Abington, PA, USA

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The oral cavity has the second largest and most diverse microbiota of the human body, harbouring over 700 microbial species [1]. Oral microbial communities are dominated by bacteria, but also contain archaea, viruses, and eukaryotes, whose roles in oral health and disease are less well understood [2]. Lifestyle, diet, and other host-related factors, such as ethnicity or ancestry, are associated with the composition of these microbial communities, and oral microbiome variation may affect the assessment, response, and effectiveness of disease interventions [3,4]. Therefore, it is necessary to understand how oral microbiome traits are associated with oral health in diverse human populations. Currently, microbiome research is dominated by gut microbiome studies and is strongly biased towards populations of European descent [5]. Such populations, by definition, provide a poor basis from which to understand microbiome-health relationships in under-studied populations, including groups who carry the highest burdens of disease.

A similar bias is present in the oral microbiome research field. Many oral microbiome studies are conducted primarily on people living in industrialized countries, such as the United States and China. These countries maintain large funding allocations for biomedical research; for example, the United States National Institutes of Health (NIH) invested approximately USD \$728 M in human microbiome research over a five-year period (2012-2016), of which \$48 M was utilized for oral microbiome research [6]. Nevertheless, oral microbiome research within the United States has produced relatively few studies that include people from non-European backgrounds (e.g. African Americans or people of Asian or Indigenous ancestry), and even fewer of these specifically investigate non-bacterial members of the oral microbiota. The NIH Revitalization Act mandates the inclusion of racial and ethnic minorities in federally funded biomedical research, but the implementation of this mandate has been problematic [7]. In the global context, it is not unusual to observe oral microbiome studies using inconsistent or problematic racial and ethnic categories, or failing to mention participants' race, ethnicity or

ancestry entirely [4]. Hence, studies do not reflect the diversity of ancestries even within industrialized nations that dominate the field, nor those who are most likely to benefit from improvements in oral health therapies based on microbiome research. If this pattern continues, oral microbiome research is likely to reinforce existing oral health disparities, which often fall along racial lines [8]. While racial categories do not represent biological reality, they intersect with factors relevant to the microbiome and oral health, such as ancestry, experience of racism, and socioeconomic status. It follows that more research should focus on underrepresented groups who experience poor oral health and could benefit most from new therapeutics. Increasing diversity in oral microbiome research could also benefit groups who are currently well-represented. For example, transitions from hunter-gatherer to agricultural or industrialized lifeways have been linked to oral health deterioration [9], so understanding the mechanisms that shift oral microbiomes more broadly could provide insights that improve oral health in industrialized societies.

Several barriers likely contribute to the underrepresentation of minority groups in oral microbiome research. From a research perspective, including diverse communities in the study design can pose cultural and linguistic obstacles, as researchers may be insufficiently trained to design and implement studies in these communities. Studies may also take longer to complete, and resources to recruit and retain a sufficient number of participants across different backgrounds may be limited [7]. From the participant perspective, participants may be justifiably reluctant to participate in biomedical research studies due to fear of exploitation, based on histories or personal experience of unethical practices, and may feel distrust toward field researchers or recruiters [10]. Hence, the goal of increasing diversity in oral microbiome research can only be pursued with the full consent and appropriate involvement of all stakeholders and should include equal sharing of financial and non-financial benefits arising from research.

There is no quick fix or single solution to these disparities. As a general principle, underrepresented communities or stakeholder groups should be involved in decision making, planning and

E-mail address:

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conducting the research wherever possible, to help guard against inappropriate research practices and align research projects with community priorities. Some practical approaches to improve participation of currently underrepresented groups in oral microbiome research include positioning study sites in areas of diverse residents, employing recruitment staff with whom participants can communicate in their own language, providing travel support for participants who lack access to transportation, and creating culturally sensitive resources describing how the samples and data will be collected and stored. Researchers also need to be aware of the importance of recording race and ethnicity when planning a study [4]. In the longer term, a more systematic approach to tackling this bias could be increasing the diversity in investigators/researchers, as well as grant reviewers. By drawing on these approaches, researchers and communities can find ways to redress inequalities and ensure that everyone benefits from oral microbiome research.

#### Declaration of Competing Interest

The authors have nothing to disclose.

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