

Whole Mouth Health

The Next Generation of Everyday
Prevention for Oral Health



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Colgate-Palmolive Company
300 Park Avenue
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Foreword

Colgate is committed to offering everyone a future to smile about. We hold that such a future requires taking responsibility to improve oral health in the world. To realize this goal, Colgate not only continuously works to develop best-in-class oral care technologies, but also creates and promotes a broad framework of education, increased awareness and prevention activities related to oral health.

The evolving understanding of mouth biology, modern patient demands and advances in oral care technology drive the need to consider what will be “the next generation of prevention” to achieve and maintain oral health. Colgate believes this need is best met by a Whole Mouth Health approach that elevates the importance of oral prevention and of achieving better oral health outcomes for all patients.

We define “Whole Mouth Health” as a holistic approach that brings together perspectives and insights from oral biology, behavioral sciences, practice management and public health coupled with advanced oral care technologies. Whole Mouth Health takes into consideration a new paradigm of adopting patient-centered dentistry, which can help dental practitioners yield personalized and participatory care focused on patient empowerment and everyday prevention.

A partnership between leaders in dental, medical and behavioral sciences and Colgate developed this white paper, *Whole Mouth Health – The Next Generation of Everyday Prevention for Oral Health*. These experts informed both the structure and content of this white paper.

We hope this white paper will inspire dental teams to take a proactive approach about prevention in practice and empower all their patients to achieve Whole Mouth Health.

Whole Mouth Health

The Next Generation of Everyday Prevention for Oral Health

Abstract

Clinical studies well document that patients can prevent tooth decay and periodontal disease when engaged in good oral hygiene practices.¹ However, the continued high global prevalence of these oral diseases, with accompanying significant public health burdens, demonstrates that tooth brushing alone for most people may be insufficient intervention to achieve and maintain good oral health. Therefore, patients' comprehension of oral hygiene must go beyond tooth cleaning goals. Indeed, a more effective approach to everyday prevention of dental diseases may be achieved by the adoption of a Whole Mouth Health model. This prevention-focused model is consistent with: 1) the recognition that oral health is a component of overall systemic health and well-being; 2) the adoption of patient-centered dentistry as a best-practice; 3) the prioritization of improved patient outcomes via prevention. This new paradigm also would involve the development and use of next-generation therapeutic oral care products that help manage the oral microbiome and control of biofilms on all mouth surfaces—the teeth, tongue, cheeks and gingiva—to augment the established effectiveness of routine mechanical oral hygiene practices. By encompassing these definitions, concepts, behaviors as well as evidence-based oral care products, Whole Mouth Health can become a new and holistic standard to achieve and maintain oral health.

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Oral Health Diseases Remain a Public Health Burden

One in two: Around the world, about half of the population, some 3.5 billion people (48 percent), has tooth decay, periodontal disease or tooth loss.² This substantial public health burden has remained mostly static in the last 25 years,² despite known prevention practices and goals to reduce the impact of oral diseases by 2020 set by the World Health Organization (WHO), International Association for Dental Research and the Fédération Dentaire Internationale (FDI)³ World Dental Federation Assembly.

In 2012, WHO declared that almost all adults have dental caries, as did 60 to 90 percent of school-aged children.⁴ Untreated decay of permanent teeth is the most widespread noncommunicable global health condition – affecting about one in three people worldwide for a total of 2.52 billion, according to WHO’s 2015 Global Burden of Disease Study, which ranked 291 conditions.^{2,5} Decay of deciduous teeth affects 573 million globally (7.8 percent), severe periodontitis, 538 million (7.4 percent), and tooth loss, 276 million (4.1 percent) per the same 2015 study.² Notably, almost a fourth of adults older than 70 (23.7 percent) around the world lost some or most of their teeth.²

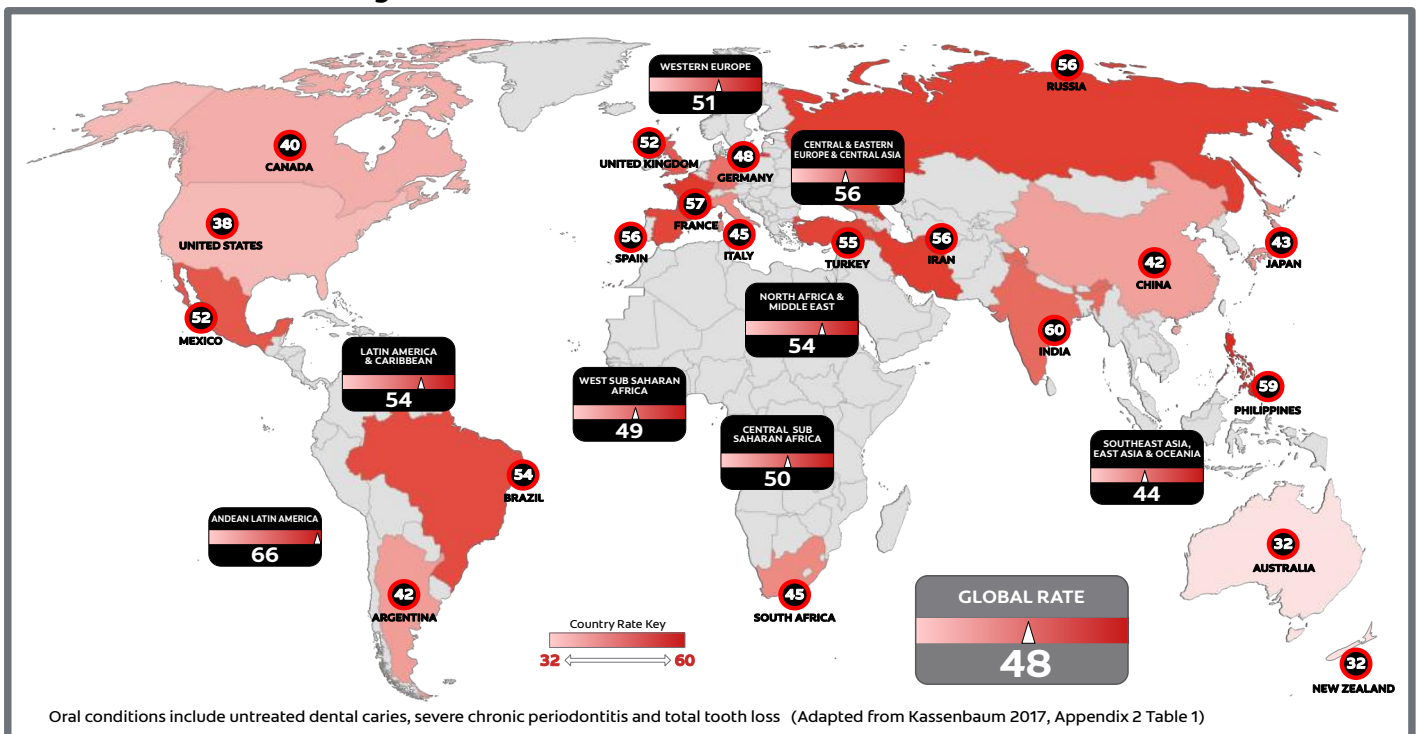
Because of these high rates, global health loss stemming from oral conditions outranks that of 34 types of cancer and is comparable to health loss due to schizophrenia, hypertensive heart disease and all maternal conditions together.² Country-level tallies of oral conditions vary because of several factors including social-economic circumstances, behavior and health risks, and deficiencies in data collection.^{5,6} While oral conditions are more prevalent in low- and middle-income countries, poor and disadvantaged popu-

Prevention in Focus

The FDI notes that for reductions in oral conditions and the related expenditures, oral health must be fully integrated into disease prevention and health promotion strategies addressing entire populations who also require access to care.⁶

Recognizing what oral health is and its relationship to systemic health as well as having a strong focus on preventative oral health measures are vital to such initiatives and changing the oral disease

Age-standardized per-capita rate for all oral conditions (selected countries & regions)



lation groups experience higher oral health burdens in all countries, notes the WHO.⁵

The burden is particularly notable in children because early caries experience has life-long consequences. More than one in four surveyed countries, 27 percent of 209 nations, reported average DMFT* scores in 12 year-olds of greater than 3 to the WHO in 2015, some 245 million teeth.⁷ Regionally, DMFT ranged from a high 2.97 in South-East Asia to a low of 1.06 in Western Pacific in 2015,⁸ but SCI* scores reveal greater ranges in severity, such as 3.7 in Germany, 3.6 in the US, 4.3 in South Africa, 7.5 in Honduras and 7.1 in China.⁹

With such considerable oral disease burden, the impact on health care budgets is significant. Caries can account for 5 to 10 percent of healthcare budgets in industrialized countries.⁵ Worldwide dental diseases cost \$356.80 billion directly and another \$187.61 billion indirectly in 2015.¹⁰ Regionally, high-income North America, Australasia, Western Europe, High-income Asia Pacific and East Asia spend the most on dental expenses, while productivity losses related to dental disease are highest in Western Europe, Australasia, High-income North America, High-income Asia Pacific, and Central Europe.¹⁰ Because of such a substantial public health burden, modifying current approaches to preventive oral health care is necessary.

The Growing Burden of Periodontal Disease

Periodontal disease is widespread in both developing and developed countries — affecting about 20-50% of the world's population.¹¹

Factors such as population growth and risk factor trends are likely to increase the socio-economic burden of periodontitis that has been equated with 3.5 million years lived by people with disability, \$54 billion per year in lost productivity and a major portion of the annual global cost for the treatment of oral diseases.¹²

Oral Health is Integral to General Health and Well-being

In 2000, the U.S. Department of Health and Human Services stated oral disease and conditions can “...undermine self-image and self-esteem, discourage normal social interaction, cause other health problems and lead to chronic stress and depression as well as incur great financial cost. They may also interfere with vital functions such as breathing, food selection, eating, swallowing and speaking, and with activities of daily living such as work, school, and family interactions.”¹⁴

Moreover, untreated tooth decay and periodontal disease have follow-on health effects that can cause harm beyond the oral cavity. Tooth loss impacts the ability to eat and, hence, nutrition, which, for example, in children can be detrimental to growth.⁶ Periodontal disease can increase the risk of complications in people with diabetes and may be associated with cardiovascular disease, gastrointestinal and pancreatic cancers, and, in pregnant women, with increased risk for preterm or low-birth-weight babies.⁶

These implications are addressed by the breadth of a new definition of oral health. In 2016, FDI received global approval and acceptance for their effort to bring precision and clarity to the diverse aspects of defining oral health, including related research, education, practice, policy and advocacy.¹³ The definition states: “Oral health is multifaceted and includes the ability to speak, smile, smell, taste, touch, chew, swallow, and convey a range of emotions through facial expressions with confidence and without pain, discomfort, and disease of the craniofacial complex.”

“Whole mouth health is the absence of oral disease, which is good for your general health, too.”

—Mariano Sanz, MD, DDS
Professor of Periodontology,
Complutense University, Spain

Significantly, this definition also notes the importance of oral health as “a fundamental component of health and physical and mental

*The DMFT index records the number of decayed (D), missing (M) and filled (F) teeth (T) and is a measure used to calculate population-based estimates of oral health status, frequently among children aged 12 years. A point is added for each of the 32 adult teeth that is either decayed, missing or filled. The Significant Caries Index (SCI) represents an estimate of severity that averages the DMFT score for the third of a country's population with the highest DMFT scores.¹³

well-being. It reflects the physiological, social, and psychological attributes that are essential to quality of life; [and] it is influenced by the person's changing experiences, perceptions, expectations, and ability to adapt to circumstances."¹³ This specificity, while recognizing the different aspects of oral health, reinforces that oral health is not isolated from overall health.¹⁴ The description also enables dentistry to consider and support patients in their entirety while striving to preserve and maintain health.¹

Oral Health Requires Empowering All Patients

To succeed in improving patients' adoption of preventive oral care, dental health professionals can and should go beyond providing just routine care and instead engage patients as coaches helping to motivate and optimize their behavior. This approach is a hallmark of patient-centered care (PCC), which is "providing care that is respectful of and responsive to individual patient preferences, needs, and values, and ensuring that patient values guide all clinical decisions."¹⁵ PCC arose from the field of medicine and is gaining adoption as a best-practice in dentistry, as it's foundation of good communication and shared decision making leads to high-quality care and improved oral outcomes in patients.^{16,17}

"We know that drilling and filling cavities is only relieving the symptoms, not really curing the disease. Prevention of caries and periodontal disease, or their progression, are the keys to maintaining health"

—Elmar Reich, DDS, DMD, PhD,
Professor,
ZAHNprofiLAXE-Praxis, Germany

PCC is fueled by what is known as the P4 approach to health care, so named for its four attributes: predictive, preventive, personalized and participatory.¹⁸ To be predictive, P4 uses data analytics and the resulting insights into health can lead to preventive care designed to improve patient health, rather than a sole focus on treating acute illness. Personalized and participatory care means a customized approach to informing the patient and enabling his or her decision making to optimize care. In adapting PCC for dentistry, several models have developed fundamental principles that address respectful interactions with patients for both their physical and emotional support and in consideration of how information is relayed,

understood and acted upon.¹⁹ In general, these can be summarized as:^{20,21}

The disease context: What is the nature of the oral disease and how is the patient experiencing it?

The patient as a whole person context: How is the oral disease manifesting within the patient's own biosocial circumstance?

The dental team-patient relationship: How is the empathy and compassion expressed by the dental team developing a long-term trusting relationship with the patient that will enhance decision-making?

The dental team-patient shared responsibility: How do both the dental team and patient conceptualize the patient's oral health experience?

What is P4?

P4 is named for its four attributes: predictive, preventive, personalized and participatory.

P4 medicine proactively uses systems biology and digital technology to gather and analyze data from and for clinical practice, with an emphasis on "quantifying wellness and demystifying disease for the well-being of the individual."¹⁸ Because these explorations involve the calculation and modeling of health and disease at population and patient levels, practitioners can apply and translate the resulting learnings and insights to their individual patients. Moreover, because P4 considers the complex biological interactions underlying health and disease states, its practice is holistic, comprehensive and requires a focus on the entire patient, not just his or her symptoms.

"The modern patient wants to build a relationship with the dentist, hygienist, the assistant and receptionist, so he or she can ask questions and have open communication with the healthcare professional, whomever it is on the team"

—Lisa Knowles, DDS
Consultant and Founder,
Beyond 32 Teeth, USA

Understanding these principles helps dental practices enlist every employee as a member of a coaching team that can surround and engage a patient. Through thoughtful discussions and active

listening, dental professionals can understand their patients better, meet their information needs and address related concerns while supporting their adoption of preventive care that can ultimately improve their oral health and well-being.

One key area of preventive care in dentistry is focused on supporting the patient to adopt and maintain an effective daily oral care routine. To address this, the dental team can use proven behavioral approaches to help their patients realize why they might want to change or optimize with their self-care routines to achieve and maintain oral health.²² This engagement can lead to patients setting and agreeing to commit to personal goals. Decision-making that resides with patients is a known motivator in aiding oral care compliance. Such positive communication outcomes lead to patient empowerment and feeling valued.¹⁶ Also, dental professionals who incorporate understanding, empathy and non-judgmental interactions into their conversations build a trusting relationship with patients.¹⁶ Praise from dental professionals can help patients experience feelings of positive accomplishments, which acts as a reinforcement and links their time in the dental chair to rewarding interactions with the dental team, rather than feelings of dread or failure.

“An important aspect of behavioral reinforcement is having a reward directly linked to the behavior that you’re trying to reinforce. Like people realizing that tooth brushing takes away the fuzzy teeth feeling, which is the biofilm, and creates a clean mouth feeling, a reward itself that reinforces the desired oral care behavior”

—Eleanor Putnam-Farr, PhD, MBA
Assistant Professor of Marketing,
Rice University, USA

When successful, the use of PCC principles in chairside connections helps patients become open to the dental team sharing and reinforcing prevention-based oral hygiene standards and behaviors, beyond the basic “tooth brushing conversation.” Helping patients to recognize that both hard (teeth) and soft (tongue, cheeks and gingiva) tissue surfaces play roles in the mouth’s complex ecosystem can increase their understanding of the value of preventative oral care. Dental professionals can further share information on oral health risks and disease, assist in real time with optimized techniques and instruct on oral care product benefits. They should also be pre-

pared to provide further knowledge resources, such as a website link, as part of the visit. In this age of immediate information, many patients want instant access to explanations or statistics while pursuing answers to their questions.

Through this dialogue, the dental team can readily evaluate whether patients fully grasp the importance of a daily self-care routine, while also helping patients assess if they can execute related tasks with precision or completeness.¹ Additionally, patients should be helped to develop a fuller appreciation of the impact of behavioral factors on their oral health, such as the need to reduce dietary sugar, tobacco smoking or unhealthy use of alcohol or improve a poor diet.^{1,6}



In sum, such discussions help patients in two major ways: they become open to investing in their oral health every day to benefit their overall health and they improve their health literacy, which influences their ability to comply with guidance and engage in effective self-care practices.¹ Of note, these conversations and general PCC approaches should extend to all types of patients because of the strong effects that the “expert” information transferred by the dental team can have on future, long-term behavior.²³

When successful, patient-centric care results in dental patients who recognize the importance of oral health in their general well-being, comprehend how their overall health and behaviors influence their oral health, and adopt good preventive oral care as part of their everyday health.^{15,16} Long-term clinical studies document that PCC activities and communications combined with regular professional dental cleanings and effective plaque removal through improved self-care with appropriate oral care products do result in improved oral health.²⁴

How to Engage Patients in their Daily Oral Health

- 1 Ask questions to elicit patient's personal oral health goals.
- 2 Provide one or two specific personalized recommendations.
- 3 Explain clear and perceptible benefits of these recommendations.
- 4 Work to gain the patient's commitment to his or her oral health goals.
- 5 Provide appropriate oral care product samples that relate to patient needs.

Oral Health Relies on Daily Self-Care

Twice-daily tooth brushing, and maybe flossing, for some patients is just a cleaning behavior – food debris is cleared, teeth feel cleaned and breath is freshened. Their greater recognition of the role of daily oral care as prevention against common oral diseases may not be significant let alone their appreciation of its impact on their overall health and quality of life.

Patients' daily self-care to manage oral biofilms, and simultaneously prevent common oral diseases like caries and periodontal diseases, should entail brushing with fluoride toothpaste supplemented by additional effective antimicrobial agents.²⁵

Toothpastes are ideal because of their ubiquitous availability in a variety of formulations devised to deliver actives and employ features patient expect, such as a pleasant taste, that also aid compliance.^{26,27}

The evolution of toothpastes has incorporated ingredients to improve oral health and provide a variety of functions. Ancient toothpastes, dating to 5000 BCE Egypt, varied in ingredients from pow-

dered ox hooves' ashes to burnt eggshells to pumice to crushed oyster shells.²⁸ Modern toothpastes and mouthwashes add ingredients to help prevent or treat specific oral diseases and conditions beyond keeping teeth and gingiva clean, such as decreasing tooth sensitivity or enhancing tooth whiteness.²⁸

Fluoride has been added to toothpastes to help prevent dental decay since 1914.²⁸ Fluoride inhibits formation and halts progression of caries and helps reverse those at an early stage.²⁹ Successful studies of fluoride-enhanced water supplies in the US and Canada led to recommendations for fluoride incorporation into public water supplies by the U.S. Public Health Service in the 1940s and 1950s.²⁹ The efficacy of water fluoridation in preventing and controlling dental caries spurred a variety of fluoride-incorporating oral care products.²⁹ Studies document that fluoride concentrations of 1,000 to 1,500 parts per million in toothpaste renders tooth enamel less susceptible to the deleterious cavity-causing oral bacteria in dental plaque, reducing caries by 20 to 30 percent.³⁰

Augmenting toothpaste formulations with antimicrobial actives has aided in reducing the growth and metabolic activity of gingiva-dwelling harmful bacteria to thwart biofilms and dental disease.²⁵ For example, a toothpaste containing fluoride and an antibacterial has been shown in clinical studies to significantly reduce plaque, gingivitis, bleeding gingiva and tooth decay³¹ as well as the regrowth of plaque biofilm.^{32,33}

Since the incorporation of fluoride and antimicrobials into toothpastes, new research of the oral bacterial population's diversity and function has added to the understanding of the oral microbiome and revealed the opportunity for optimized use of antibacterials. Today, many mechanisms might explain why agents have limited efficacy in controlling the mouth's microbes when formed into biofilms vs. floating more freely in the oral cavity. These mechanisms include the microbe's slow growth rates, their responses to stress and their biological development to tolerate agents, as well as the ability of the biofilm structure to prevent the agent's penetration.^{34,35}

New knowledge about the oral microbiome is informing the development of next-generation oral care products aimed at sufficiently reducing the bacteria to control the risk of dental disease while creating and supporting their beneficial functions consistent with health. Such antibacterial product

designs, when successful, would likely manage biofilm and promote oral health through subtle, more targeted effects.

Oral Health Must Consider the Microbiome

The human microbiome is the community of microorganisms that exist on and within the human body, usually harmoniously.³⁶ These organisms obtain food or other benefits from people via a symbiotic and commensal relationship. In return, they play a defining role in overall human health,³⁷ including digestive track maintenance, host defense and anti-inflammation activity among other tasks.³⁶

Human microbial cohabitants comprise a very large community, almost the same in number as the body's cells. Overwhelmingly, these corporal residents are different strains of bacteria,³⁸ but also include varieties of fungi, viruses, protozoa and other microorganisms.³⁹

Recent studies, newer technologies like genetic sequencing and mapping, and data analytics escalate both the amount of data available about the dynamic nature of the human microbiome as well as the understanding of its participation in human health status.³⁶ For example, the large public-private collaboration of several U.S. federal agencies, academic institutions and nonprofit organizations participating in the National Microbiome Initiative supports interdisciplinary studies addressing the fundamental questions about microbiomes in humans and other ecosystems.⁴⁰ The Initiative also develops platforms to analyze large data sets and share the information and resulting insights,⁴⁰ revealing new perspectives of the dynamic role of the microbiome in health and disease.

Understanding the Oral Microbiome

Awareness of the human oral cavity microbiome traces back to van Leeuwenhoek's 1683 report of observing animalcules in his tooth plaque, "white matter, which is as thick as if 'twere batter."⁴¹ Since then, nearly 5,000 peer-review publications have shared the results of oral microbiome research, more than 40 percent of which have appeared since 2011.³⁹

Catalyzing such investigations are a variety of efforts, notably the Human Microbiome Project (HMP) of the U.S. National Institutes of Health,

which is characterizing the microbiomes of the oral cavity and four other body areas of healthy people.⁴² Data from the HMP and other programs has informed the Human Oral Microbiome Database, a project of the U.S. National Institute of Dental and Craniofacial Research (NIDCR). The NIDCR has already tallied more than 770 species in the human upper digestive and upper respiratory tracts, including that dwelling in the oral cavity, pharynx, nasal passages, sinuses and esophagus.⁴³

In the human oral cavity, billions of microbes comprise an ecosystem that colonizes both the hard tooth surfaces as well as the soft mucosa tissues.³⁶ When this ecosystem is in balance, health usually prevails. However, hygiene, diet, tobacco use, stress and other factors can lead to imbalances with associated detrimental health effects.^{36,44}

Helpful and Harmful Biofilms

Most oral bacteria exist in a complex community called a biofilm, which plays a significant role in dental disease. Biofilms occur when heterogeneous bacteria weave into an integrated matrix by attaching to each other or oral surfaces and adhering to the polymer-like substances they produce.⁴⁵

The properties of biofilms are more than just the sum of their constituent species. These properties result from the synergistic or antagonistic effect of their multi-species bacterial communities and can be helpful or harmful to oral health. Biofilms possess their own rate of growth, genetic activity and functionality⁴⁴ different from other planktonic oral microbiome occupants.

In a healthy state, biofilms form on the teeth and soft tissues from benign, "friendly" bacteria that include those of the genera *Neisseria*, *Streptococcus*, *Veillonella*, *Granulicatella*, *Gemella*, *Prevotella*, *Rothia*, *Fusobacterium* and *Actinomyces*.^{44,46} Beneficial biofilms shield against non-oral microbes and restrict the growth of pathogenic microorganisms associated with common oral diseases like caries and periodontal diseases. By maintaining a neutral pH that balances acid and alkali production, for example, symbiotic biofilms help create a balance between the microbiome and oral cavity tissues.^{35,36,44,46,47}

However, if a healthy oral microbiome is perturbed by changes in an individual's phys-

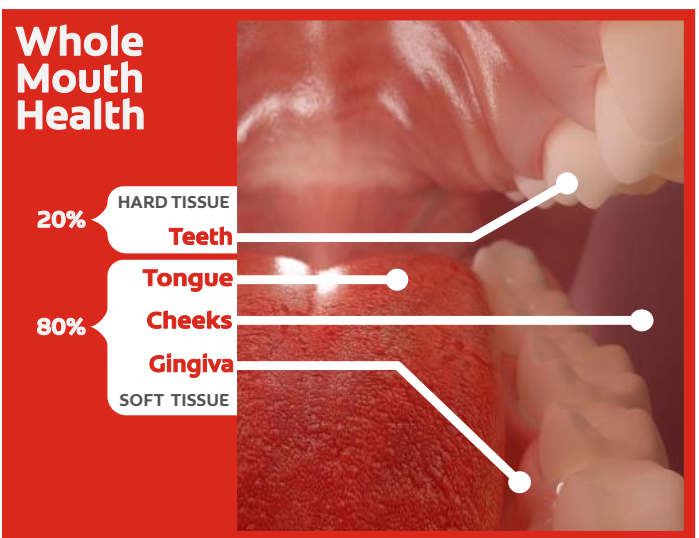
iology or behavior, detrimental oral biofilms develop and contribute to common concerns like oral malodor, generated when certain bacteria metabolize the proteins and amino acids left behind after eating and drinking into air-borne sulfur compounds such as hydrogen sulfide and methyl mercaptan.¹

“In a healthy mouth, ‘good’ bacteria are predominant with a sparse population of ‘bad’ bacteria. But when bad bacteria actually reign over good bacteria, this microbiome is in a state of dysbiosis, which is harmful to oral health”

—**Lakshman Samaranayake, DDS, Hon DSc**
Professor Emeritus of Oral Microbiology,
The Hong Kong University, Hong Kong

In an enduring unbalanced state, detrimental biofilm progression at the gingival margin can lead to gingivitis inflammation and changes in the bacterial population, favoring *Porphyromonas gingivalis*, *Treponema denticola*, *Tannerella forsythia* and *Aggregatibacter actinomycetemcomitans*. These bacterial strains undermine and inhibit the response of the immune system, further increasing bacterial diversity^{35,36,44,46,47} and resulting in infection and possible destruction of the bones and tissue supporting teeth.^{44,48}

The predominance of detrimental biofilms may also promote cariogenic bacteria. For example, frequent contact with dietary sugars prompts ongoing bacterial-enabled conversion to acid, shifting the oral environment to favor growth of decay-causing bacteria such as *Streptococcus mutans*.⁴⁴ Moreover, some bacteria decrease their



The teeth make up only 20% of the total surface area of the mouth

production of acid-neutralizing alkalis,⁴⁹ reducing their protective effect on dental caries.^{50,52}

Due to these detrimental effects, promoting a healthy balance in the oral microbiome is a key goal of proactive oral care. Dental professionals need to help patients understand that overall biofilm control—removing the “fuzzy coating” from their teeth—via brushing paired with the use of appropriate oral care products is an accessible and effective way to control and manage bacteria throughout the whole mouth, specifically on teeth, tongue, cheeks and gingiva.

Oral Health Needs Next-Generation Oral Care Products

Numerous studies support that decreasing bacteria in the whole mouth correlates with significant reductions in plaque, gingivitis, and other harmful biofilm-related oral diseases. Antibacterial control, combined with other components, can also contribute benefits such as whiter teeth and fresher breath.⁵³⁻⁵⁸

Given the recent advances in understanding the role of microbiome oral health, as well as the various factors that may lead to a detrimental, unbalanced state, the demands for new oral care products with improved effectiveness are expanding. The action of dentifrice ingredients now must be broader than simply enhancing mechanical plaque control.

Periodontal Disease Diversity

Periodontal disease may not be a single disorder. Rather, it may be a group of harmful conditions, each with a distinct genetic, bacterial and inflammatory signature, according to NIDCR-funded genome-wide association study, which analyzed DNA from about 1,000 people with different severities of periodontal disease.⁴⁸

Despite this diversity, effective biofilm control through daily oral hygiene remains a key strategy towards preventing occurrence and progression of periodontal disease.

“I like the idea of a product that could address biofilm on all mouth surfaces, not just the teeth or gingival, but also on the cheeks and the tongue.”

—Ann Eshenaur Spolarich, PhD, RDH
Professor of Clinical Medicine and Pharmacology,
Director of Research,
A.T. Still University
School of Dentistry and Oral Health, USA

Moreover, antimicrobial ingredients should be made available beyond the tooth structure to address the diverse microbes that occupy the 80 percent of the mouth comprised of soft tissues.⁵⁸ Even patients who routinely brush and floss effectively harbor soft tissue biofilms reservoirs in the oral mucosa. Oral care products must also retain two baseline performance criteria: efficient delivery of active agents to both hard and soft tissues in the mouth during brushing and sustained action and retention on these surfaces.^{26,27,59}

A recently developed formulation with promising performance against these criteria contains a specifically designed combination of stannous fluoride and zinc phosphate.

Solving the Problem of Stannous Fluoride

Stannous fluoride (SnF_2) has been used in toothpaste for several decades because it is active in preventing dental caries. In addition, SnF_2 has been shown to have antibacterial activity leading to reduced plaque formation and gingivitis, and can occlude open dentin tubules leading to reductions in dentin hypersensitivity. However, stannous fluoride has been associated with poor taste, and oxidation of the tin (stannous) from Sn^{2+} ion to a Sn^{4+} ion state leading to tooth staining and a decrease in the bioavailability of the Sn^{2+} ion and consequent reduction in the antibacterial effect of the toothpaste.

To reduce the negative effects of the oxidation process, scientists have endeavored to increase the stability of SnF_2 in toothpaste formulations by reducing water content, adding additional stannous salts to act as a sacrificial source of stannous ions (which can lead to a greater risk of staining and poor taste) or by adding other stabilizing agents. All of these approaches bring limitations to the formulation. Low water formulations typically

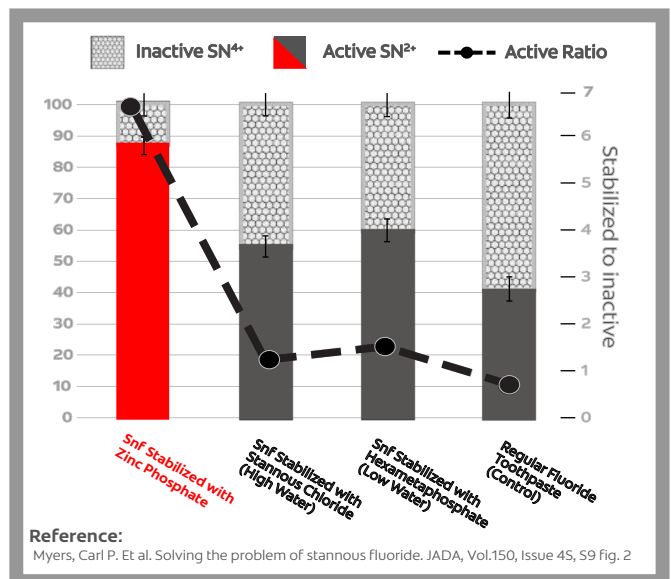
have poor esthetics, including foaming limitations and poor taste and texture, making them less likely to be used regularly by patients.

However, the recent innovative use of zinc phosphate to effectively stabilize the SnF_2 in the $^{2+}$ active state allows a high water formulation to be developed and precludes the need for sacrificial sources of stannous. The resulting improved dentifrice provides enhanced efficacy as well as a positive consumer experience, which is critical for compliance.⁵⁹⁻⁶⁴

Reducing Oxidation Boosts Clinical Efficacy

To demonstrate the superior availability of active tin, X-ray absorption spectroscopy (XAS) was used to determine the oxidative states of tin in the new zinc phosphate stabilized formulation as well as other commercially available stannous fluoride-containing toothpastes (see *table below*). The data from XAS demonstrated that the new formulation had significantly greater proportions of active Sn^{2+} than the other toothpastes measured.⁶³

The reduction of oxidation and consequent greater availability of active Sn^{2+} in the toothpaste boosts the efficacy of a stannous fluoride formulation (including reductions in plaque, gingivitis and dentin hypersensitivity) while at the same time reducing the negative drawbacks associated with stannous, which can limit patient compliance — making this



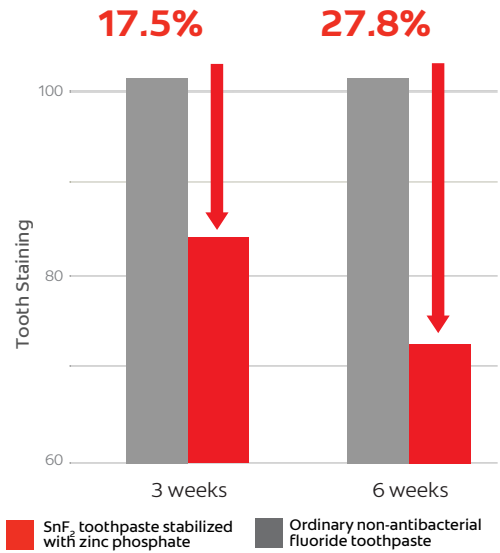
innovative formulation an excellent new tool for patient self care for the achievement of whole mouth health.

In an 8-week clinical study, the antimicrobial effects of the stannous fluoride formulation stabilized by zinc phosphate vs. a control toothpaste were measured by taking samples from the plaque, saliva, buccal mucosa, gingivae and tongue. The new formulations provided reductions in bacteria in all oral micro-environments which increased over time. After eight weeks of regular use, the new stannous fluoride toothpaste formulation stabilized by zinc phosphate showed reductions in bacteria ranging from 33 to 61 percent compared with the control toothpaste.⁵⁹

In the second randomized controlled clinical trial, zinc phosphate-stabilized stannous formulations were compared to non-antibacterial fluoride toothpaste and a currently-marketed advanced stannous fluoride formulation. Both stannous fluoride formulations demonstrated improvements in plaque control and reductions in gingivitis compared to non-antibacterial toothpaste. Results for zinc phosphate-stabilized stannous fluoride formulation were directionally, but not significantly, better than the more traditional stannous fluoride formulation, demonstrating that stabilization with zinc phosphate is at least as effective as traditional methods.⁶⁰

Tooth staining is a well-known drawback of poorly stabilized stannous fluoride toothpaste and a significant concern for both dental professionals and patients. For dental professionals, staining leads to longer chair time and less satisfied patients. Patients

Superior reductions in staining vs. ordinary non-antibacterial fluoride toothpaste*



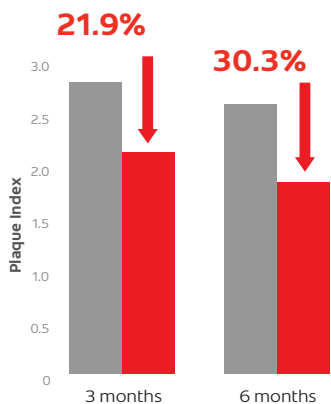
Reference:
*Li, Yiming et al. Solving the problem with stannous fluoride. The Journal of the American Dental Association, Volume 150, Issue 4S, S38 - S46)

are less likely to comply with a home-care regimen when there are negative side effects such as tooth staining. In a six-week stain removal clinical study, participants using the zinc phosphate-stabilized stannous fluoride formulation demonstrated statistically significant reductions in extrinsic stain of 17.5 percent at three weeks and 27.8 percent

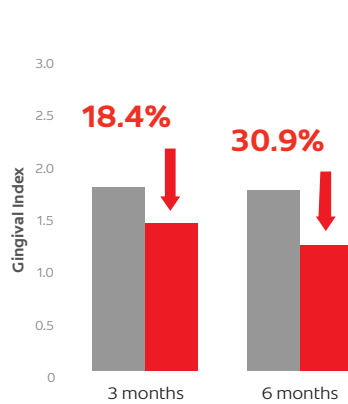
at six weeks, compared to regular fluoride toothpaste.⁶¹ Rather than cause staining, the zinc phosphate-stabilized stannous fluoride toothpaste reduced staining when used regularly over a six-week period.⁶¹

Another benefit of a stannous fluoride dentifrice, beyond caries protection and antibacterial activity, is its ability to provide pro-

Superior reductions in plaque vs. ordinary non-antibacterial fluoride toothpaste*



Superior reductions in gingival bleeding vs. ordinary non-antibacterial fluoride toothpaste*



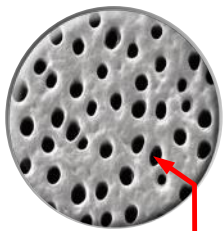
Legend:
■ SnF₂ toothpaste stabilized with zinc phosphate
■ Ordinary non-antibacterial fluoride toothpaste

*Seriwatanachai, Dutmanee et al. Effect of stannous fluoride and zinc phosphate dentifrice on dental plaque and gingivitis. The Journal of the American Dental Association, Volume 150, Issue 4S, S25 - S31)

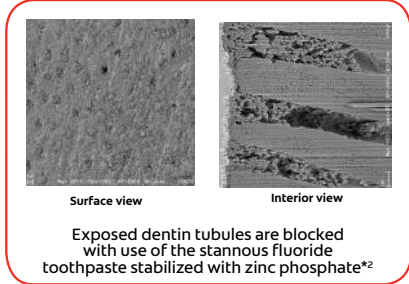
Superior reductions in dentin hypersensitivity vs. ordinary non-antibacterial fluoride toothpaste*

The new stannous fluoride toothpaste, stabilized by zinc phosphate to reduce the effects of oxidation, provides much higher availability of active SnF₂. As a result, this innovative formulation has been shown to provide statistically higher hypersensitivity reduction to both tactile and air blast assessments versus a negative control toothpaste at both four and eight weeks.

Compared to the control groups, subjects using the test dentifrice experienced statistical (P<0.001) decreases in tactile hypersensitivity of 27.8% and air blast hypersensitivity of 21.4% at 4 weeks. The statistical improvements (P<0.001) measured for hypersensitivity continued at 8 weeks where tactile hypersensitivity was measured at 42.0% and air blast hypersensitivity was measured at 32.3%



Exposed dentin tubules remain open with ordinary non-antibacterial fluoride toothpaste



Exposed dentin tubules are blocked with use of the stannous fluoride toothpaste stabilized with zinc phosphate⁶²

Sensitivity Reduction

Air blast
32.3%

Tactile
42.0%

*As measured in an 8 week clinical study. After 4 weeks air blast 21.5% and tactile 27.8%.

Reference:

Hines, Deon et al. Effect of a stannous fluoride toothpaste on dental hypersensitivity. The Journal of the American Dental Association, Volume 150, Issue 4S, S47 - S59)

holistic standard-of-care focused on whole mouth prevention.

This approach requires state-of-the-science tools, such as next-generation therapeutic oral care products capable of maintaining a healthy oral microbiome, particularly the control of bacteria and biofilms on all mouth surfaces. A dentifrice containing stannous fluoride combined with zinc phosphate as a stabilizing agent was shown to be efficacious in clinical studies and provides biofilm management for the prevention of common oral diseases.^{60,64}

By adopting such toothpastes into daily oral hygiene regimens, patients should achieve better whole mouth protection resulting in clinically meaningful reductions in common oral diseases, tooth sensitivity, whiter teeth, and fresher breath.

This new paradigm will be effective by shifting the focus of dentistry from a “cure” approach centered on teeth to a “care” approach centered on prevention and patients, recognizing their

health, behaviors and beliefs. Practices that team together to coach patients enable their comprehension of the relationship between

tection against dentin hypersensitivity by occluding dentin tubules. The results of a randomized clinical trial showed that the zinc phosphate-stabilized formulation provided a statistically significant reduction in dentin hypersensitivity over a period of eight weeks, compared to regular fluoride toothpaste.⁶²

Oral Health is Whole Mouth Health

The ongoing unmet global need for improved oral health requires a proactive approach to prevention that includes optimized oral care products. The improved understanding of mouth chemistry and biology and the principle that oral health is essential to an individual’s general health and well-being are driving a new

Works in Two Ways

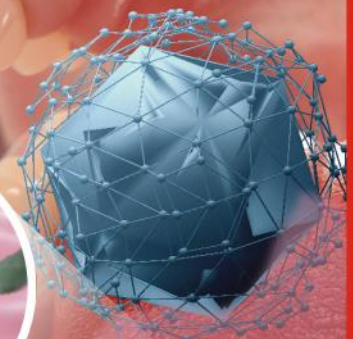
Kills harmful bacteria on the teeth, tongue, cheeks, gums and saliva.

This reduces the overall bacterial load, which can lead to reductions in plaque build-up and oral care problems.

Fortifies the soft tissue’s natural defense by creating a protective barrier on the whole mouth



Stabilized Stannous Fluoride



preventive care and preserved health and encourage their empowerment to make adequate self-care decisions. Joint professional-patient prioritization of improved long-term oral outcomes over immediate delivery of routine cleanings and acute oral care will also sustain and grow mutual efforts toward durable oral health goals.

With prevention as a defining direction, this approach is well positioned to make health of the whole mouth — teeth, tongue, cheeks and gingiva — an achievable new and holistic standard of everyday prevention in oral health.

Elements of Whole Mouth Health

- Whole Mouth Health is an achievable holistic standard for oral health.
- Oral health is a component of overall, systemic health and well-being.
- Oral hygiene means preventive care for the whole mouth — the teeth, tongue, cheeks and gingiva.
- Preventive oral care improves patient outcomes.
- Patient-centered dentistry is effective to empower patients to enhance their oral care.
- New oral product technologies should help control bacteria and biofilm on of all mouth surfaces.

References

- 1 Cummins D, Marsh, D. Changing the paradigm of daily prevention to achieve whole mouth health in the 21st century. *J Clin Dent* 2018;29 (Spec Iss A):A1-9 .
- 2 Kassebaum NJ, Smith AGC, Barnabe E, Fleming TD, Reynolds AE, Vos T, Murray CJL, Marcenes W. Global Burden of Disease 2015 Oral Health Collaborators. Global, regional, and national prevalence, incidence, and disability-adjusted life years for oral conditions in 195 countries, 1990-2015: A systematic analysis for the global burden of disease, injuries and risk factors. *J Dent Res* 2017;96:380-87.
- 3 Fédération Dentaire Internationale. <https://www.fdiworlddental.org/about-fdi/history> World Health Organization. Oral Health Factsheet. <http://www.who.int/news-room/fact-sheets/detail/oral-health>, retrieved September 2018.
- 4 World Health Organization. Sugars and dental caries. WHO Technical Information Note October 2017. <https://www.who.int/nutrition/publications/nutrientrequirements/sugars-dental-caries-keyfacts/en/>, retrieved September 2018.
- 5 FDI World Dental Federation. The Challenge of Oral Disease – A call for global action. The Oral Health Atlas. 2nd ed. Geneva: the Federation; 2015 https://www.fdiworlddental.org/sites/default/files/media/documents/complete_oh_atlas.pdf.
- 6 World Health Organization. Global burden of caries disease. Country Oral Health Country/Area Profile Programme. https://www.mah.se/CAPP/Country-Oral-Health- Profiles/Global_burden_of_caries_disease/, retrieved September 2018.
- 7 World Health Organization. Significant Caries Index. Country Oral Health Country/Area Profile Programme. https://www.mah.se/CAPP/Country-Oral-Health- Profiles/Global_burden_of_caries_disease/. retrieved September 2018
- 8 World Health Organization. SIC (selected countries). Country Oral Health Country/Area Profile Programme. <https://www.mah.se/CAPP/Methods-and-Indices/for-Measurement-of-dental-diseases/Significant-Caries-Index/Significant-Caries-Index-selected-countries/>. retrieved September 2018
- 9 Righolt AJ, Jevdjevic M, Marcenes W, Listl S. Global-, Regional-, and Country-Level Economic Impacts of Dental Diseases in 2015. *J Dent Res* 2018;97(5):501-07.
- 10 World Health Organization. Methods and Indices. [https://www.mah.se/CAPP/Methods-and- Indices/](https://www.mah.se/CAPP/Methods-and-Indices/). retrieved September 2018
- 11 Nazir M., Prevalence of periodontal disease, its association with systemic diseases and prevention, *Int J Health Sci (Qassim)*. 2017 Apr-Jun; 11(2): 72–80.
- 12 Tonetti M., Impact of the global burden of periodontal diseases on health, nutrition and wellbeing of mankind: A call for global action, *J Clin Periodontol*. 2017;1–7
- 13 FDI World Dental Federation. FDI unveils new universally applicable definition of 'oral health' <https://www.fdiworlddental.org/news/press-releases/20160906/fdi-unveils-new-universally-applicable-definition-of-oral-health>, retrieved September 2018
- 14 U.S. Department of Health and Human Services. Oral Health in America: A Report of the Surgeon General. Rockville, MD: U.S. Department of Health and Human Services, National Institute of Dental and Craniofacial Research, National Institutes of Health, 2000. Accessed at https://oralcancerfoundation.org/wp-content/uploads/2016/09/oral_health_in_america.pdf. retrieved September 2018
- 15 Institute of Medicine. Crossing the quality chasm: a new health system for the 21st century. Washington, DC: National Academy Press, 2001.
- 16 Mills I, Frost J, Cooper C, Moles DR, Kay E. Patient-centred care in general dental practice – a systematic review of the literature. *BMC Oral Health* 2014;14:64.
- 17 Mills I, Frost J, Kay E, Moles DR. Person-centred care in dentistry the patients' perspective. *Br Dent J* 2015;218:407-13.
- 18 Hood L, Flores M. A personal view on systems medicine and the emergence of proactive P4 medicine: predictive, preventive, personalized and participatory. *N Biotechnol* 2012;29:613– 24.
- 19 Picker Institute: The Eight Principles of Patient-Centered Care. <https://www.picker.org/about-us/picker-principles-of-person-centred-care/> retrieved September 2018
- 20 Scambler S, Gupta A, Asimakopoulou K. Patient-centred care--what is it and how is it practised in the dental surgery? *Health Expect* 2014;18(6):2549-58.
- 21 Scambler S, Delgado M, Asimakopoulou K. Defining patient-centred care in dentistry? A systematic review of the dental literature. *Br Dent J* 2016;221(8):477-84.
- 22 Yevlahova D, Satur J. Models for individual oral health promotion and their effectiveness: a systematic review. *Aust Dent J* 2009;54:190-97.
- 23 Butterworth G. Principles of developmental psychology: an introduction. New York: Psychology Press, 2014.

- ²⁴ Axelsson P, Nyström B, Lindhe J. The long-term effect of a plaque control program on tooth mortality, caries and periodontal disease in adults: Results after 30 years of maintenance. *J Clin Periodontol* 2004;31:740-57.
- ²⁵ Jepsen S, Blanco J, Buchalla W, Carvalho JC, Dietrich T, Dörfer C, Eaton KA, Figuero E, Frencken JE, Graziani F, Higham S,M, Kocher T, Maltz M, Ortiz-Vigon A, Schmoekel J, Sculean A, Tenuta LMA, van der Veen MH, Machiulskiene V. Prevention and control of dental caries and periodontal diseases at individual and population level: consensus report of group 3 of the joint EPR/ORCA workshop on the boundaries between caries and periodontal diseases. *J Clin Periodontol*. 2017; 44 (Suppl 18): S85-S93. .
- ²⁶ Cummins D, Creeth JE. Delivery of antiplaque agents from dentifrices, gels and mouthwashes. *J Dent Res* 1992;71:1439-49.
- ²⁷ Cummins D. Vehicles: How to deliver the goods. *Periodontol* 2000 1997;15:84-99.
- ²⁸ Colgate History of Toothbrushes and Toothpastes. 2006. <https://www.colgate.com/en-us/oral-health/basics/brushing-and-flossing/history-of-toothbrushes-and-toothpastes> retrieved September 2018.
- ²⁹ Centers for Disease Control and Prevention. Recommendations for using fluoride to prevent and control dental caries in the United States. *MMWR Recomm Rep* (2001) 50:1-42. <https://www.cdc.gov/mmwr/preview/mmwrhtml/rr5014a1.htm>, retrieved September 2018
- ³⁰ Marinho VCC, Higgins JPT, Logan S, Sheiham A. Fluoride toothpastes for preventing dental caries in children and adolescents. *The Cochrane Database of Systematic Reviews* 2003;(1). *Cochrane Library*. Art no: CD002278.
- ³¹ Riley P, Lamont T. Triclosan / copolymer containing toothpastes for oral health (Review). *The Cochrane Database of Systematic Reviews* 2013(12) *Cochrane Library*. Art no: CD010514.
- ³² Jenkins S, Addy M, Newcombe R. Toothpastes containing 0.3% and 0.5% triclosan. I. Effects on 4-day plaque regrowth. *Am J Dent* 1989;2(Spec No):211-14.
- ³³ Jenkins S, Addy M, Newcombe R. The effects of 0.5% chlorhexidine and 0.2% triclosan containing toothpastes on salivary bacterial counts. *J Clin Periodontol* 1990;17:85-9.
- ³⁴ Donlan R M, Costerton J W. Biofilms: survival mechanisms of clinically relevant microorganisms. *Clin Microbiol Rev* 2002;15: 167-93.
- ³⁵ Marsh PD, Head DA, Devine DA. Ecological approaches to oral biofilm: control without killing. *Caries Res* 2015;49 (Suppl 1): 46-54.
- ³⁶ Kilian M, Chapple IL, Hannig M, Marsh PD, Meuric V, Pedersen AM, Tonetti MS, Wade WG, Zaura E. The oral microbiome - an update for oral healthcare professionals. *Br Dent J* 2016;221(10):657-66.
- ³⁷ Lederberg J, McCray A. Ome Sweet 'Omics – a Genealogical Treasury of Words. *The Scientist* 2001;17(7):9-10.
- ³⁸ Sender, R, Fuchs S, Milo R. Are We Really Vastly Outnumbered? Revisiting the Ratio of Bacterial to Host Cells in Humans. *Cell* 2016;164(3):337-40.
- ³⁹ Lloyd-Price J, Abu-Ali G, Huttenhower C. The healthy human microbiome. *Genome Medicine* 2016;8(1):51.
- ⁴⁰ White House Office of Science and Technology Policy. Fact Sheet: Announcing the National Microbiome Initiative. May 13, 2016.
- ⁴¹ Dobell, Clifford. Antony van Leeuwenhoek and his Little animals; being some account of the father of protozoology and bacteriology and his multifarious discoveries in these disciplines. New York, Harcourt, Brace and company. 1932. ISBN132940017409138.
- ⁴² NIH Common Fund Human Microbiome Project (HMP). <https://hmpdacc.org/hmp/>, retrieved September 2018
- ⁴³ Chen T, Yu WH, Izard J, Baranova OV, Lakshmanan A, Dewhirst FE. The human oral microbiome database: a web accessible resource for investigating oral microbe taxonomic and genomic information. *Database (Oxford)* 2010;2010:baq013.
- ⁴⁴ Sanz M, Beighton D, Curtis MA, Cury JA, Dige I, Dommisch H, et al. Role of microbial biofilms in the maintenance of oral health and in the development of dental caries and periodontal diseases. Consensus report of group 1 of the Joint EFP/ORCA workshop on the boundaries between caries and periodontal disease. *J Clin Periodontol*. 2017;44 Suppl 18:S5- S11. 10.1111/jcpe.12682. DOI: 10.1111/jcpe.12682.
- ⁴⁵ Donlan R M, Costerton J W. Biofilms: survival mechanisms of clinically relevant microorganisms. *Clin Microbiol Rev* 2002;15: 167-93.
- ⁴⁶ Mira A, Simon-Soro A, Curtis MA. Role of microbial communities in the pathogenesis of periodontal diseases and caries. *J Clin Periodontol* 2017; 44 (Suppl 18): S23-S38.
- ⁴⁷ Marsh PD. Contemporary perspective on plaque control. *Brit Dent J* 2012;212: 601-606.
- ⁴⁸ Department of Health and Human Services, National Institutes of Health, National Institute of Dental and Craniofacial Research. Congressional Justification for FY2018. <https://www.nidcr.nih.gov/sites/default/files/2017-09/nidcr-congressional-justification-2018.pdf>.

- ⁴⁹ Burne RA, Zeng I, Ahn SJ, Palmer SR, Liu Y, Lefebure T, Stanhope MJ, Nascimento MM. Progress in dissecting the oral microbiome in caries and health. *Adv Dent Res* 2012;24:77-80.
- ⁵⁰ Tagahashi CT. Oral microbiome metabolism: From "Who are they?" to "What are they doing?" *J Dent Res* 2015;94:1628-37.
- ⁵¹ Reyes E, Martin J, Moncado G, Neira M, Palma P, Gordon V, Oyarzo F, Yevenes I. Caries-free subjects have high levels of urease and arginine deiminase activity. *J Appl Oral Biol* 2014;22:235-40.
- ⁵² Nascimento MM, Liu Y, Kalra R, Perry S, Adewumi A, Xu X, Primosch RE, Burne RA. Oral arginine metabolism may decrease the risk for dental caries in children. *J Dent Res* 2013;92:604-8.
- ⁵³ Riley P, Lamont T. Triclosan / copolymer containing toothpastes for oral health (Review). *The Cochrane Database of Systematic Reviews*. 2013;12. *Cochrane Library*. Art no: CD010514.
- ⁵⁴ Mankodi S, Wachs GN, Petrone DM, Chaknis P, Petrone M, DeVizio W, Volpe AR. Comparison of the clinical efficacy of a new manual toothbrush on gingivitis reduction and plaque removal. *Compend Contin Educ Dent* 2004;10(Suppl 2):28-36.
- ⁵⁵ Nathoo S, Chaknis P, Petrone M, DeVizio W, Volpe AR. A clinical comparison of gingivitis reduction and plaque removal efficacy of a new manual toothbrush *Compend Contin Educ Dent* 2004;10(Suppl 2):37- 45.
- ⁵⁶ Williams M, Vazquez J, Cummins D. Clinical comparison of a new manual toothbrush on breath volatile sulfur compounds. *Compend Contin Educ Dent* 2004;10(Suppl 2):22-27.
- ⁵⁷ Fine DH, Sreenivasan PK, McKiernan M, Tischio-Beresci D, Furgang D. Whole mouth anti-microbial effects after oral hygiene: comparison of three dentifrice formulations. *J Clin Periodontol* 2012;39:1056- 64.
- ⁵⁸ Panagakos FS, Volpe AR, Petrone M, Morrison BM Jr, DeVizio W, Proskin HM. Advanced oral antibacterial/anti-inflammatory technology: A comprehensive review of clinical benefits of a triclosan/copolymer/fluoride dentifrice. *J Clin Dent* 2014;25(Suppl):S1-30.
- ⁵⁹ Haraszthy, Violet I. et al. Antimicrobial effects of a stannous fluoride toothpaste in distinct oral microenvironments. *The Journal of the American Dental Association* , Volume 150 , Issue 4S , S14 - S24
- ⁶⁰ Seriwatanachai, Dutmanee et al. Effect of stannous fluoride and zinc phosphate dentifrice on dental plaque and gingivitis. *The Journal of the American Dental Association* , Volume 150 , Issue 4S , S25 - S31)
- ⁶¹ Li, Yiming et al. Solving the problem with stannous fluoride. *The Journal of the American Dental Association* , Volume 150 , Issue 4S , S38 - S46)
- ⁶² Hines, Deon et al. Effect of a stannous fluoride toothpaste on dentinal hypersensitivity. *The Journal of the American Dental Association* , Volume 150 , Issue 4S , S47 - S59)
- ⁶³ Myers, Carl P. et al. Solving the problem with stannous fluoride. *The Journal of the American Dental Association* , Volume 150 , Issue 4S , S5 - S13
- ⁶⁴ Hu, Deyu et al. Evaluation of a stabilized stannous fluoride dentifrice on dental plaque and gingivitis in a randomized controlled trial with 6-month follow-up. *The Journal of the American Dental Association* , Volume 150 , Issue 4S , S32 - S37)

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